Salmon life cycle

9.2

"... the fish is as clever as any creature could be in its position."
— Richard Jeffries

Eggs

The life cycle of a salmon or other **anadromous** fish begins when **eggs** are deposited and fertilized in the gravel of a stream. Successful reproduction depends on an adequate supply of gravel with low sediment content. The gravel protects eggs during incubation.

About one month after being deposited (although this varies, depending upon water temperature), eyes begin to show. During incubation, water flow (to deliver oxygen and carry away waste products) and temperature (40°F to 65°F) must be suitable. **Salmonids** are cold-water fish and generally cannot tolerate temperatures above 68°F. The greatest mortality in a salmon's life cycle occurs during the egg-to-fry stage.

Alevins

In late winter or spring, the eggs hatch. Young fish, called **alevins**, rapidly grow under the gravel for one to three months. An alevin is a fragile creature with huge eyes and a large yolk sac protruding from its belly. The orange sac contains a completely balanced diet that lasts for several months. The **vitelline vein** runs through the center of the sac and picks up oxygen from water.

Fish at this stage are protected from most predators and other hazards by remaining under the gravel. A flow of water is critical to alevin survival. Porous gravel provides a stable streambed and allows good percolation of oxygen-rich water.

Fry

Alevins absorb their yolk sacs and emerge from the gravel as **fry** in late spring and summer. About an inch long, they are easy prey for larger fish. Chinook, sockeye, coho salmon and steelhead may spend a year or more in streams or lakes, while chum salmon begin to migrate directly to the sea.

The greatest mortality in a salmon's life cycle occurs during the egg-to-fry stage.

Fry feed on plankton and small insects. At this stage, streamside cover is needed for protection from predators and temperature extremes and as a source of food.

Vocabulary

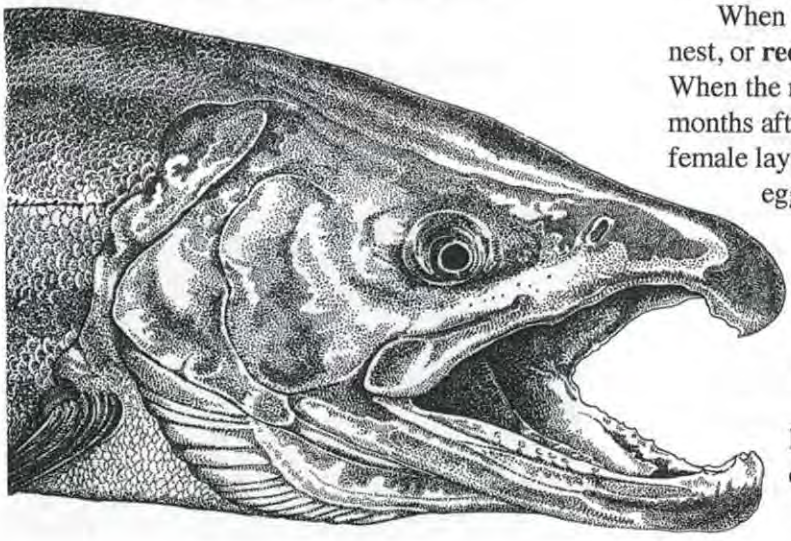
alevins	redd
anadromous	salmonids
eggs	smoltification
fry	smolts
milt	spawn
parr marks	vitelline vein

Smolts

After spending time in freshwater, the 4- to 6-inch fish, known as **smolts**, head to the sea with fall or spring freshets. **Smoltification** requires physiological changes enabling the fish to survive the drastic change from fresh to salt water. In addition, the **parr marks** disappear as the smolt becomes silvery and more distinctly counter-shaded (dark above, light below) to survive ocean conditions. Water flow is again a critical factor during downstream smolt migration.

High flows mean higher survival rates. On some streams, dams alter the natural flows of river systems as they store spring runoff. Decreased flows can increase the amount of time it takes smolts to reach the ocean and affect their ability to adjust to salt water conditions. A delay can increase their susceptibility to predators and disease. Smolts are also lost as a result of passing into unscreened irrigation ditches, becoming stranded in a field. Smolts can also be injured or killed as they pass through hydroelectric facilities or fail to find passageways at dams.

Anadromous salmonids spend varied amounts of time in the sea, up to five years, depending on the species. While in the ocean, usually near the Gulf of Alaska, salmon grow rapidly by feeding on the rich, available food supply. Plankton makes up their first food source. As the fish grow, shrimp, anchovies and herring make up the majority of their diet.



Sharks, marine mammals and other predators take a portion of the maturing salmon as food. Commercial and sports fisheries also harvest fish.

Adult salmon

Usually in early summer of their maturing year, salmon begin to head back to their home streams. While their exact method of navigation is not fully understood, researchers believe salmonids navigate by electromagnetic signals, the moon and stars, the smell of their home stream, or a combination of these factors. Salmon stop feeding when they enter fresh water and live on stored body fats for the rest of the trip.

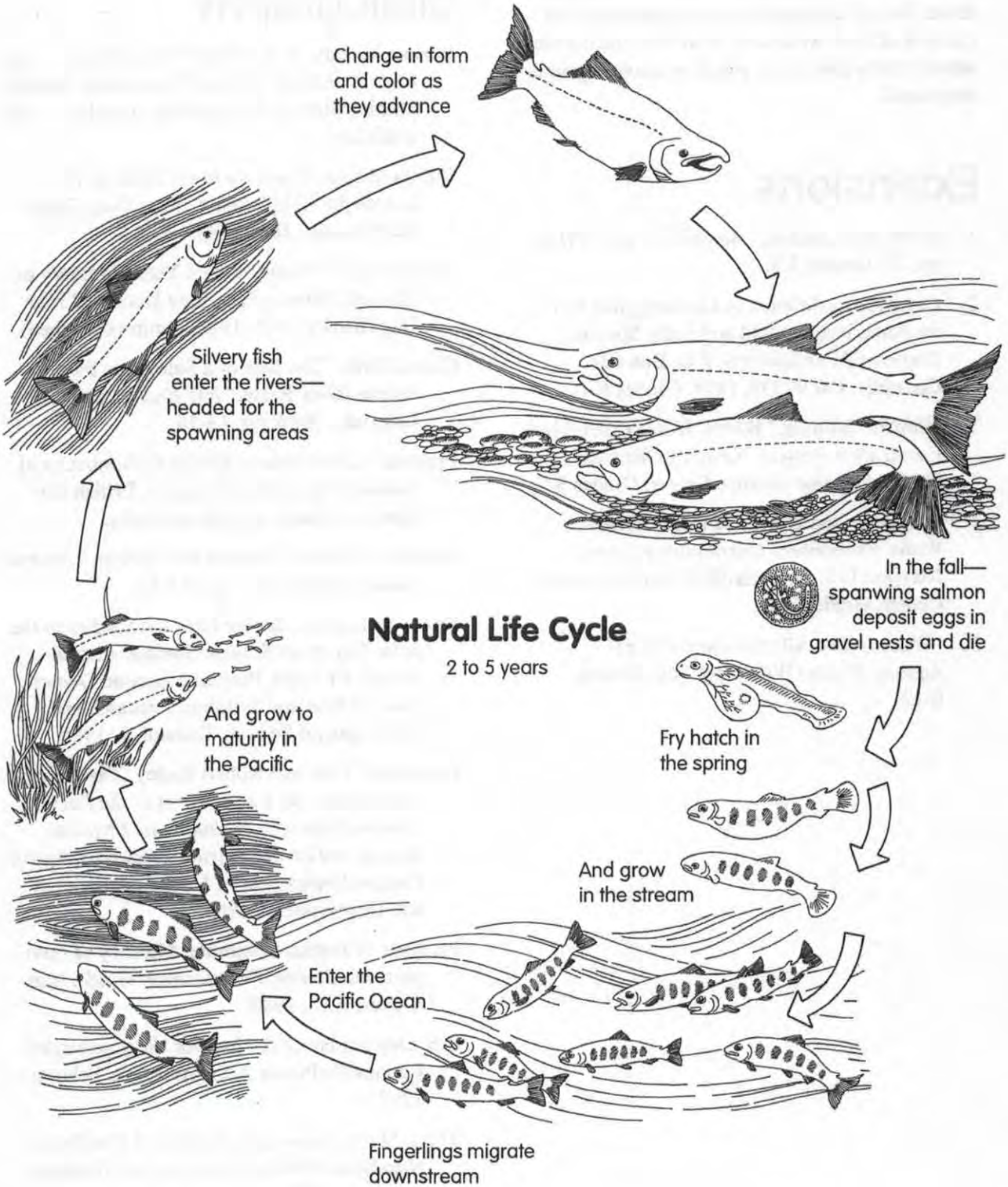
Anglers, natural predators, and other hazards continue to reduce salmon numbers on their way to the spawning beds of their home stream.

Hydroelectric dams block passage upriver. Most dams now have fish passages, but finding them uses part of the salmon's limited energy supply. Log jams, landslides or other obstructions occasionally restrict passage. Waterfalls, road culverts and velocity barriers also create migration problems for salmon.

When flows are too low for upstream movement, water temperatures can become quite warm in the holding pools and cause conditions promoting disease outbreaks. Restricted flows can hold salmon for too long, reducing their chances for successful spawning when they finally reach the spawning beds.

When ready to **spawn**, the female digs a nest, or **redd**, up to 16 inches deep in the gravel. When the nest is ready, which can be weeks or months after they reach the gravel beds, the female lays her eggs. She deposits 3,000 to 8,000 eggs in the redd. The male fertilizes the eggs by covering them with **milt**, a milky substance that contains sperm. The female covers the eggs with gravel to complete the spawning process.

After spawning, the adult salmon's life is finished. Within a short time it dies, and the carcass drifts downstream, decaying and contributing its



Length of life cycle varies with species and consitions

nutrients to the stream from which it originally arose. Not all steelhead die after spawning, but because of their weakened condition, the percentage of adults that live to return to spawn again is very small.

Extensions

1. "Hooks and Ladders," *Aquatic Project WILD*, pp. 43. Grades 3-9.
2. *Discovering Salmon: A Learning and Activity Book,* Nancy Field and Sally Machlis, Dog-eared Publications, P.O. Box 814, Corvallis, OR 97339, 1984. Grades K-6.
3. "Sniffin' Salmon," *Water, Water Everywhere Curriculum Project*, Newport OR: OSU Hatfield Marine Science Center. Grades 3-9.
4. "Comings and Goings of Coho" *Water, Water Everywhere Curriculum Project*, Newport OR: OSU Hatfield Marine Science Center. Grades 3-9.
5. "Where Have All the Salmon Gone?" *Aquatic Project WILD*, pp. 166. Grades 6-12.

Bibliography

Borton, Wendy, et al. *Clean Water, Streams, and Fish: A Holistic View of Watersheds*. Seattle: Municipality of Metropolitan Seattle, no date available.

Brown, Bruce. *Mountain in the Clouds: The Search for Wild Salmon*. New York: Simon and Schuster, Inc., 1982.

Claire, Errol. "Twenty-Seven Year Summary of Chinook Salmon Spawning Density." John Day District, 1959-1986," (mimeographed).

Curtis, Ruth. "The Life of a Salmon in the Columbia River Basin." *NW Energy News*, June/July, 1986, pp. 13-16.

Fisheries Association of British Columbia, et al. *Salmon: The Living Resource*. British Columbia, Canada, no date available.

Harrison, George. "Journey of a Stream." *Sports Afield*, March, 1987, pp. 52-54.

Knox, W.J., et al., *Spring Chinook Studies in the John Day River Salmon Studies*. Annual Report FY 1984, Portland: Oregon Department of Fish and Wildlife, Research and Development Section, December, 1984.

Parmenter, Tish, and Robert Bailey. *The Oregon Oceanbook: An Introduction to the Pacific Ocean off Oregon Including its Physical Setting and Living Marine Resources*. Salem: Oregon Department of Land Conservation and Development, 1985.

Province of British Columbia, Ministry of Environment. *Stream Enhancement Guide*. Vancouver, B.C., 1980.

U.S. Department of the Interior. *Backgrounder*. Bonneville Power Administration, February, 1987.

Yates, Steve. *Adopting A Stream: A Northwest Handbook*. Seattle: University of Washington Press, 1989.

Salmon language crossword puzzle

Activity Education Standards: *Note alignment with Oregon Academic Content Standards beginning on p. 483.*

Objectives

The student will demonstrate understanding of the basic concepts of the salmon life cycle by completing the crossword puzzle.

Method

Students will complete the crossword puzzle, with or without the accompanying word list at the teacher's discretion.

For younger students

1. In most cases, younger students will require the word list. Using an overhead transparency of the salmon life cycle while discussing the important concepts as a group may enhance this exercise.
2. Work in pairs or as a group to solve the puzzle. Add the "Going Further" activities to help younger students grasp the concepts.

Materials

- crossword puzzle (pp. 369-371), list of clues, and word list (optional)

Background

Do you know . . .

All Pacific salmon are **anadromous**. They begin their lives in freshwater, migrate to the ocean, and return to freshwater to spawn and die. Salmon are important to Oregon's commercial and recreational fisheries.

The salmon life cycle begins when eggs are deposited and fertilized in the gravel of cool, clean rivers and streams.

In late winter or spring, the eggs hatch. The young fish, called **alevins**, are less than one inch long. During this time they are fed from a **yolk sac** that protrudes from their bellies. As the yolk sacs are used up, the fish, now called **fry**, emerge from the gravel in late spring or summer, approximately one to three months after hatching.

The fry of some species head directly for the sea, but others might stay in freshwater for a few months to a few years. Aquatic invertebrates provide most of the food for salmon fry.

When they are ready to migrate to the sea, they go through a physiological change and are known as **smolts**. Once in the sea some spend up to five years feeding and growing before they are ready to return to fresh water.

Salmon return to spawn in the same stream where they hatched. Weeks or months after they have reached the gravel beds, the female digs a nest, or **redd**. Here she deposits up to 5,000 eggs. The male fertilizes the eggs by covering them with **milt**, a milky substance that contains the sperm. The female finishes the spawning process by covering the eggs with gravel. After spawning, the salmon's life is finished. Within a short time, it dies and the carcass drifts downstream, decaying and contributing its nutrients to the stream from which it originally came.

Procedure

Now it's your turn . . .

Do you understand how the salmon life cycle fits into the "watershed" picture? Can you name and describe the major steps of the salmon life cycle? Use the following crossword puzzle to test your knowledge about the salmon life cycle and to practice the new words you have learned.

Salmon Language Crossword Clues

Across

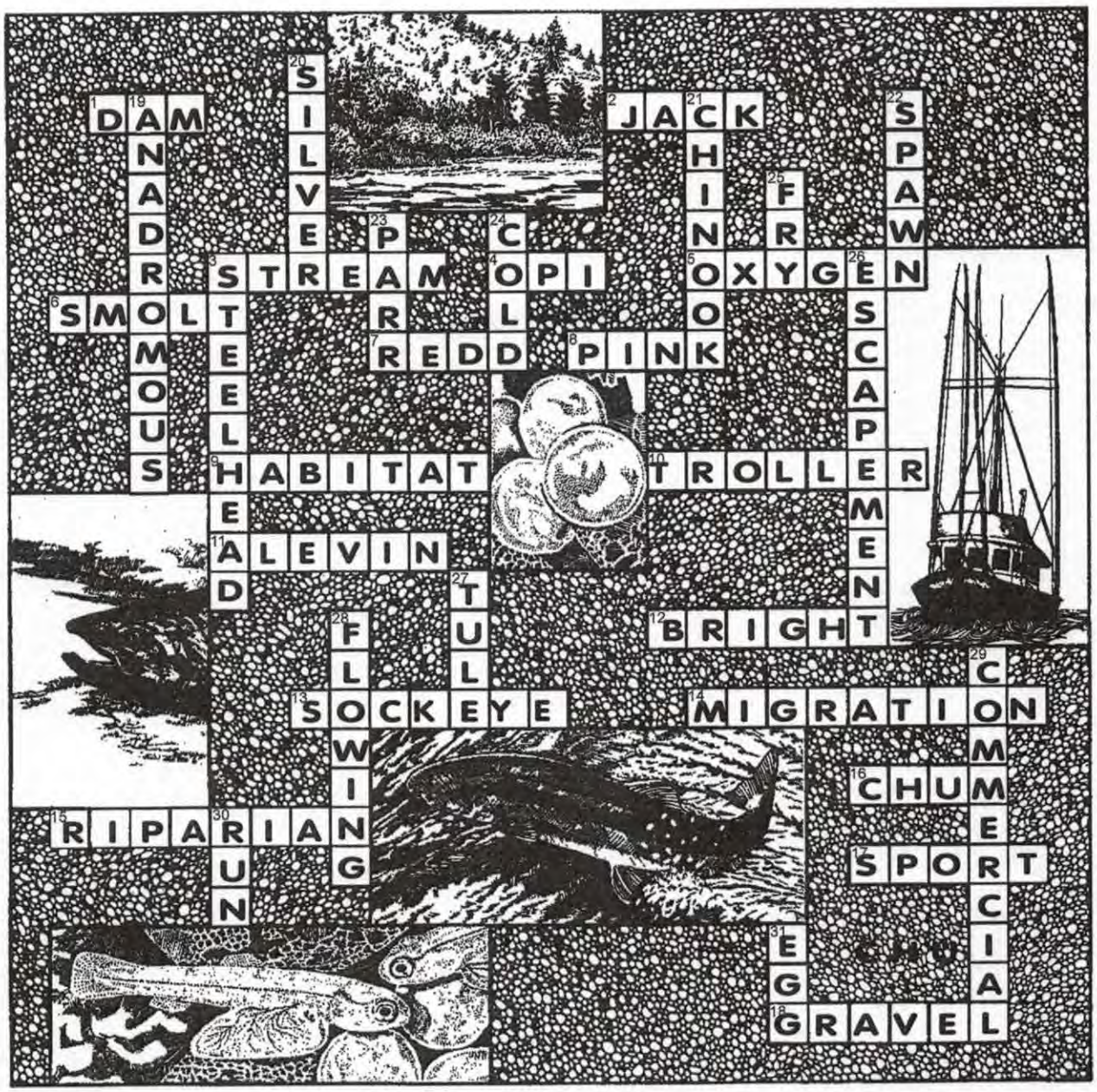
1. A major barrier to the migration of salmon and steelhead.
2. Early maturing, two-year-old coho (silver) salmon that return to spawn a year earlier than normal.
3. A healthy____ is required to produce healthy juvenile chinook and coho salmon.
4. Abbreviation for Oregon Production Index, a mathematical model used to predict the size of runs of coho salmon (based on the return of two-year-old jack salmon).
5. Salmon eggs, juveniles, and adults must have _____dissolved in the water to survive.
6. A juvenile salmon that is ready to migrate to sea is called a_____.
7. A salmon nest where eggs are deposited.
8. The shortest-lived and smallest of the Pacific salmon. The males develop a large humpback during spawning.
9. For salmon, cold water, plenty of food and good cover is excellent _____.
10. The term for commercial fishing boats and fishermen that fish for ocean salmon.
11. A newly hatched salmon with the unabsorbed yolk sac still attached.
12. Upper Columbia and Snake River fall spawning chinook salmon stocks which enter the river in excellent condition.
13. Species of salmon that usually spawn in streams having lakes in their watershed and are related to kokanee.
14. The ____ of the salmon has puzzled humans for centuries.
15. Healthy streamsides, called _____ zones, are essential for good natural salmon production.
16. Another name for dog salmon.
17. When salmon are caught for recreation and personal use, it is called ____ fishing.
18. Good spawning sites always have ____ for salmon to build redds in.

Down

3. A rainbow trout that spends much of its life in the ocean.
19. Fish that migrate from the sea to spawn in fresh water are called _____ fishes.
20. Another name for the coho salmon.
21. The largest salmon, also called a "king."
22. Term used to describe the laying of eggs by the female salmon and their fertilization by the male.
23. An older juvenile salmon with dark, oblong bars along each side is called a _____.
24. Water in which salmon live must be fairly _____.
25. Salmon that have absorbed their yolk sacs, emerged from the gravel, and are ready to feed.
26. Those salmon that are *not* caught by commercial or sport fisheries and escape to spawn in streams or hatcheries.
27. A stock of chinook salmon used in many lower Columbia River hatcheries.
28. _____ water is required around salmon eggs to deliver oxygen and carry away waste products.
29. When fish are caught and sold for profit, it is called _____ fishing.
30. The salmon entering a river system during a specific time of year are called that river's _____.
31. The ____ to fry stage in the salmon's life cycle is the period of greatest mortality.

Going further

1. After working the crossword puzzle, alphabetize all the words.
2. Write one complete sentence using each word in the crossword puzzle



Word list

alevin	cold	flowing	migration	redd	sockeye	troller
anadromous	commercial	fry	OPI	riparian	spawn	tule
bright	dam	gravel	oxygen	run	sport	
chinook	egg	habitat	parr	silver	steelhead	
chum	escapement	jack	pink	smolt	stream	

Name

Salmon language crossword puzzle

Do you know . . .

All Pacific salmon are **anadromous**. They begin their lives in freshwater, migrate to the ocean, and return to freshwater to spawn and die. Salmon are important to Oregon's commercial and recreational fisheries.

The salmon life cycle begins when eggs are deposited and fertilized in the gravel of cool, clean rivers and streams.

In late winter or spring, the eggs hatch. The young fish, called **alevins**, are less than one inch long. During this time they are fed from a **yolk sac** that protrudes from their bellies. As the yolk sacs are used up, the fish, now called **fry**, emerge from the gravel in late spring or summer, approximately one to three months after hatching.

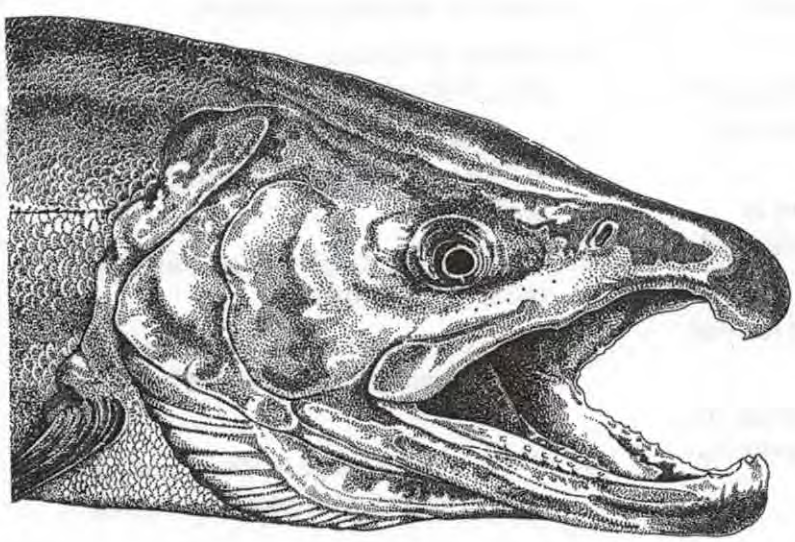
The fry of some species head directly for the sea, but others might stay in freshwater for a few months to a few years. Aquatic invertebrates provide most of the food for salmon fry.

When they are ready to migrate to the sea, they go through a physiological change and are known as **smolts**. Once in the sea some spend up to five years feeding and growing before they are ready to return to fresh water.

Salmon return to spawn in the same stream where they hatched. Weeks or months after they have reached the gravel beds, the female digs a nest, or **redd**. Here she deposits up to 5,000 eggs. The male fertilizes the eggs by covering them with **milt**, a milky substance that contains the sperm. The female finishes the spawning process by covering the eggs with gravel. After spawning, the salmon's life is finished. Within a short time, it dies and the carcass drifts downstream, decaying and contributing its nutrients to the stream from which it originally came.

Now it's your turn . . .

Do you understand how the salmon life cycle fits into the "watershed" picture? Can you name and describe the major steps of the salmon life cycle? Use the following crossword puzzle to test your knowledge about the salmon life cycle and to practice the new words you have learned.



Student sheet

Salmon Language Crossword Clues

Across

1. A major barrier to the migration of salmon and steelhead.
2. Early maturing, two-year-old coho (silver) salmon that return to spawn a year earlier than normal.
3. A healthy____ is required to produce healthy juvenile chinook and coho salmon.
4. Abbreviation for Oregon Production Index, a mathematical model used to predict the size of runs of coho salmon (based on the return of two-year-old jack salmon).
5. Salmon eggs, juveniles, and adults must have _____dissolved in the water to survive.
6. A juvenile salmon that is ready to migrate to sea is called a_____.
7. A salmon nest where eggs are deposited.
8. The shortest-lived and smallest of the Pacific salmon. The males develop a large humpback during spawning.
9. For salmon, cold water, plenty of food and good cover is excellent _____.
10. The term for commercial fishing boats and fishermen that fish for ocean salmon.
11. A newly hatched salmon with the unabsorbed yolk sac still attached.
12. Upper Columbia and Snake River fall spawning chinook salmon stocks which enter the river in excellent condition.
13. Species of salmon that usually spawn in streams having lakes in their watershed and are related to kokanee.
14. The ____ of the salmon has puzzled humans for centuries.
15. Healthy streamsides, called _____ zones, are essential for good natural salmon production.
16. Another name for dog salmon.
17. When salmon are caught for recreation and personal use, it is called ____ fishing.
18. Good spawning sites always have ____ for salmon to build redds in.

Down

3. A rainbow trout that spends much of its life in the ocean.
19. Fish that migrate from the sea to spawn in fresh water are called _____ fishes.
20. Another name for the coho salmon.
21. The largest salmon, also called a "king."
22. Term used to describe the laying of eggs by the female salmon and their fertilization by the male.
23. An older juvenile salmon with dark, oblong bars along each side is called a _____.
24. Water in which salmon live must be fairly _____.
25. Salmon that have absorbed their yolk sacs, emerged from the gravel, and are ready to feed.
26. Those salmon that are *not* caught by commercial or sport fisheries and escape to spawn in streams or hatcheries.
27. A stock of chinook salmon used in many lower Columbia River hatcheries.
28. _____ water is required around salmon eggs to deliver oxygen and carry away waste products.
29. When fish are caught and sold for profit, it is called _____ fishing.
30. The salmon entering a river system during a specific time of year are called that river's _____.
31. The ____ to fry stage in the salmon's life cycle is the period of greatest mortality.

Student sheet

Table 4. Salmonids and Physical Stream Characteristics

Physical stream characteristics useful in differentiating habitat preferences of salmonids.

Habitat preference	Species: Coho	Chinook	Steelhead	Cutthroat
% pools	50-80	50-100	< 50	40-60
% gradient	<3	< 2	>1-5	1-20
Stream order	2-5	≥ 5	2-5	> 2
Maximum temperature	<65°F 18°C	< 68°F 20°C	< 73°F 23°C	< 65°F 18°C

Physical stream characteristics useful in evaluating stream quality preferences for salmonids.

Characteristics				
Cover	woody structure	pool depth	boulders & wood	wood, volume, boulders
Channel profile	flat	moderately flat	steep	undercut banks
Riparian	Presence of riparian vegetation important for all species. Vegetation type (fir, alder) and age of vegetation determine quality.			

Limiting factors

Limiting factors must be considered for all phases of a salmonid's life cycle. The quantity and quality of riffle areas and spawning gravels in a stream limit spawning production. The quantity and quality of juvenile nursery areas or pools is a limiting factor for rearing juvenile salmonids and producing smolts ready for migration to the ocean.

When spawning habitat is limited, excessive numbers of adults on the spawning beds dislodge previously deposited eggs. If too many juveniles exist in rearing areas, competition for food and space force some to move into less suitable areas. These areas may have limited food and shelter from predators.

Limiting factors establish the salmonid carrying capacity of a stream.

These limiting factors establish the salmonid **carrying capacity** of a stream. Within the limits of the available habitat, salmonid populations fluctuate from year to year because of varying environmental factors.

Streamflow, for example, causes wide variations in survival and production of coastal salmonid populations. Extended low flows may keep adults from moving into streams, drain their limited energy reserves and affect upstream distribution and spawning success. High winter flows can destroy eggs and alevins by scouring spawning beds or depositing sediments. Low stream flows during winter incubation periods can cause exposure and freezing of spawning beds. Low summer flows often allow stream temperatures to increase, which reduces rearing areas for juveniles.

Stream temperatures may also affect survival indirectly. Abnormally high temperature conditions during migration have contributed to

outbreaks of disease among adults, causing them to die before spawning. High winter temperatures increase the rate of development from egg to fry, and may cause fry to emerge from the gravel before the spring increase in food supplies.

A critical issue in eastern Oregon is the buildup of heavy ice (anchor ice) in streams. **Anchor ice** can trap fish in pockets where they freeze and die. Healthy riparian systems and stable streambanks help reduce heavy anchor ice and winter mortality of juvenile fish.

Recommended habitat conditions

As a stream is surveyed and analyzed, consider the habitat needs and stream quality references of the several salmonid species listed in Table 4 to ensure the best possible management of the resource.

Following is a list of other conditions that may improve the quality of fish habitat in streams. This list was prepared by the Riparian Habitat Subcommittee of the Oregon and Washington Interagency Wildlife Committee. Included is an explanation of how each contributes to salmonid health and survival.

Between 60% and 100% of a stream surface should be shaded from June to September during the hours of 10:00 A.M. to 4:00 P.M.

- Solar radiation is greatest during this season and time of day. Streamside vegetation provides shade to help keep water temperatures from becoming lethal during hot summer months. Streambank vegetation is also important habitat for terrestrial insects and is the main nutrient source for aquatic insects. These are both important sources of fish food. Shade is most important on small streams (less than 50 feet wide). Water depth and turbulence help compensate for the lack of shade on large streams.

Stream banks should have 80% or more of their total linear distance in a stable condition.

- Stable, well-vegetated streambanks help maintain stream channel integrity. They provide cover for fish and reduce temperature increases from solar radiation. In winter, they keep water temperatures slightly warmer, reducing ice buildup and decreasing winter mortality of juvenile fish. Sediments from streambanks are reduced, protecting the water quality of the entire system. Vegetation reduces bank erosion and helps hold the soil in place. Sediments are trapped and mature grasses and forbs form a strong sod.

No more than 15% of stream substrate should be covered by inorganic sediment.

- Aquatic insects, developing salmonid eggs and recently hatched fry still in the gravel depend on a continuous supply of cool, oxygen-rich water for survival. Large amounts of fine sediments clog the spaces between gravels. This prevents water from percolating through and causes fish and insect mortality. If pools are filled with sediments, rearing and hiding habitat is reduced or eliminated.

Bibliography

Borton, Wendy, et al. *Clean Water, Streams, and Fish: A Holistic View of Watersheds*. Seattle: Municipality of Metropolitan Seattle, no date available.

Claire, Errol. "Twenty-Seven Year Summary of Chinook Salmon Spawning Density, John Day District, 1959-1986." (mimeographed).

Adapted from: Province of British Columbia, Ministry of Environment, *Stream Enhancement Guide*, Vancouver, B.C., 1980; and Riparian Habitate Subcommittee of the Oregon/Washington Interagency Wildlife Committee, *Managing Riparian Ecosystems (Zones) for Fish and Wildlife in Eastern Oregon and Eastern Washington*, Portland, OR, December 12, 1978.

Harrison, George. "Journey of a Stream." *Sports Afield*, March, 1987, pp. 52-54.

Hughes, Dave. "Anatomy of a Trout Stream." *Outdoor Life*, June 1986, pp. 64, 110-112.

Johnson, Phillip. "Learning the Language of a Stream." *National Wildlife*, August-September 1986, pp. 30-35.

Kopec, John, and Stuart Lewis. *Stream Quality Monitoring*. Charleston, Oregon: Ohio Department of Natural Resources and Pacific Fisheries Enhancement, no date available.

McNally, Bob. "Fish the Magic Edges." *Outdoor Life*, April, 1982, pp. 41-43.

Maser, Chris, and James M. Trappe,. *The Seen and Unseen World of the Fallen Tree*. Washington, D.C.: U.S. Department of the Interior, Bureau of Land Management, 1984.

Oregon (formerly Governor's) Watershed Enhancement Board. *Oregon Aquatic Habitat Restoration and Enhancement Guide*. Oregon Plan for Salmon and Watersheds, Salem, Oregon, May 1999.

Perich, Shawn. "Sportsman's Guide to Reading a River." *Fins And Feathers*, June 1986, pp. 64-65.

Platts, William S., et al. *Methods for Evaluating Riparian Habitats with Applications to Management*. General Technical Report INT-221, U.S. Department of Agriculture, Forest Service, 1987.

Platts, William S., et al. *Methods For Evaluating Stream Riparian and Biotic Conditions*. Ogden, Utah: U.S. Department of Agriculture, 1983.

Province of British Columbia, Ministry of Environment. *Stream Enhancement Guide*. Vancouver, B.C.: 1980.

Reiser, D.W., and T.C. Bjornn. *Influence of Forests and Rangeland Management on Anadromous Fish Habitat in Western North America: Habitat Requirements of Anadromous Salmonids*. Portland: U.S. Department of Agriculture, Forest Service, 1979.

Riparian Habitat Subcommittee of the Oregon/ Washington Interagency Wildlife Committee. *Managing Riparian Ecosystems (Zones) for Fish and Wildlife in Eastern Oregon and Eastern Washington*. Portland, December 12, 1978.

Sedell, James R., and Karen J. Luchessa. "Using The Historical Record as an Aid to Salmonid Fish Habitat Enhancement." Presentation to Symposium on Aquisition and Utilization of Aquatic Habitat Inventory Information, Portland, Oregon, October 23-28, 1981.

Sedell, James R., et al. "Fish Habitat and Streamside Management: Past and Present." Presentation to Society of American Foresters, annual meeting, Bethesda, Maryland, September 27-30, 1981.

Stoker, Daniel G., et al. *A Guide to the Study of Fresh Water Ecology*. Englewood Cliffs, NJ: Prentice-Hall, 1972.

Triska, F.J., et al. "Coniferous Forest Streams." In Robert L. Edmonds, (ed.), *Analysis of Coniferous Forest Ecosystems in the Western United States*, Stroudsburg, PA: Hutchinson Ross Publishing Company, 1982.

U.S. Department of Agriculture, Forest Service, National Marine Fisheries Service, and Alaska Department of Fish and Game. *Fish in the Forest: Large Woody Debris in Streams: A New Management Approach to Fish Habitat*. R10-FR-1, September, 1986.

Home wet home . . .

Activity Education Standards: *Note alignment with Oregon Academic Content Standards beginning on p. 483.*

Objectives

The student will (1) recognize the habitat components necessary for salmonids in a stream, and (2) analyze and describe how each stream structure contributes to salmonid habitat needs.

Method

Students read background material, observe and analyze the stream diagram, and describe how each item noted develops or provides salmonid habitat.

For younger students

1. Consult extension activities at the end of each chapter to address the needs of younger students.
2. Read activity background information aloud to younger students or modify for your students' reading level.
3. This activity builds on knowledge from prior activities. Constructing a model stream where students can manipulate structures would be more effective for younger students.

Materials

- copies of student sheets (pp. 397-398)

Notes to the teacher

Because a number of fish species in Oregon are classified as threatened or endangered under the Endangered Species Act, fish restoration activities are closely monitored. Consult the *Oregon Aquatic Habitat Restoration and Enhancement Guide* for more specific information. You can get it from the Oregon (formerly Governor's) Watershed Enhancement Board (phone: 503-378-3589).

Background

Do you know . . .

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

Although a healthy natural habitat is preferred, fish biologists have developed many ways to improve degraded stream habitat to enhance fish survival. In some cases, biologists can produce a fishery where none was previously found.

The ecological requirements of salmonids are:

- cool, clear, well-oxygenated water,
- sections of gravel bottom for spawning,
- occasional pools for feeding and resting,

Vocabulary

boulder cluster	rip rap
cover logs	rock weir
cover tree	rock wing deflector
gravel bar	root wad
log sill	shade plantings
pool	streamside vegetation

- adequate food (aquatic and terrestrial insects, the latter usually falling from streamside vegetation), and
- cover for protection from predators.

Procedure

Now it's your turn . . .

How do you make a house a home? A house is just walls, a floor and a roof. But to make it a home, you have to arrange the furniture and hang the pictures. Structures like chairs, sofas, tables, beds, and your favorite wall hangings make the house more comfortable and livable.

Fish also need homes. A stream without structures like rocks, plants, logs, boulders, and gravel is just a "house." But with those structures in the stream and arranged just so, fish can live there comfortably.

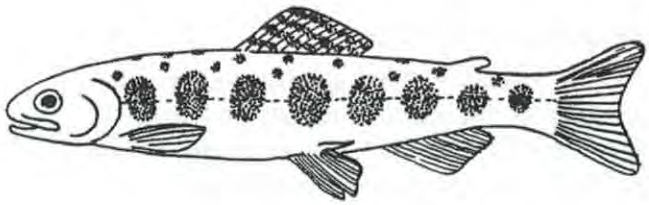
In a healthy stream, nature creates fish "homes" with all the right furnishings. But many streams today are not healthy and have lost their ability to serve as good homes for fish. So, fish biologists often build structures in and around streams to help restore fish habitat so that more fish can live there. They create pools, riffles, curves, and bends and grow plants along the stream. They also try to make the new changes look as natural as possible.

Following is a drawing of a stream that biologists have been working on. They have created each of the lettered structures. Can you tell how each structure helps fish live there? For instance, Item A—streamside vegetation—provides shade to keep the water cool and creates food (leaves) for insects that live in the water, which are in turn eaten by the fish.

Test your knowledge about fish habitat. Describe how each features serves as fish habitat in the space provided on the student answer sheet.

Going further

1. Repeat the "Temperature and Respiration Rate" experiment (pp. 265-268) using other species of fish (some warm water species and some cold water species). Compare the results. Based on your results, discuss why different species are found in completely different environments or in different parts of the same stream.
2. Design an experiment to measure the rate of flow in riffles and pools (and other habitat types including glides, rapids, and cascades.) Research the different types of fish habitat, including all kinds of slow-water and fast-water habitats. Consult with a fish habitat biologist to learn how each of the habitat types provides for the needs of fish. Prepare a report or display of your findings and present to the class.
3. Investigate the types of restoration work that are appropriate along a stream that has been severely damaged by flooding, heavy erosion, or other events. Explore the possibility of a work team from your school assisting others in the community to complete restoration work on a stream. Research who has responsibility for coordinating work projects of this type and the requirements necessary to proceed.
4. Have students build a stream table (model stream) to test different structures to control streamflow and erosion.



A. streamside vegetation

Provides cover in addition to shade for temperature regulation. In autumn, leaves drop into stream and eventually provide food for invertebrates that are eaten by fish.

B. rock weir

Slows the water, traps gravel for spawning, and creates pools.

C. root wad

Provides shade, cover, and resting areas, and produces spot scouring.

D. cover logs

Provides shade, cover, and resting areas, and produces spot scouring.

E. rip rap (rocks or vegetative)

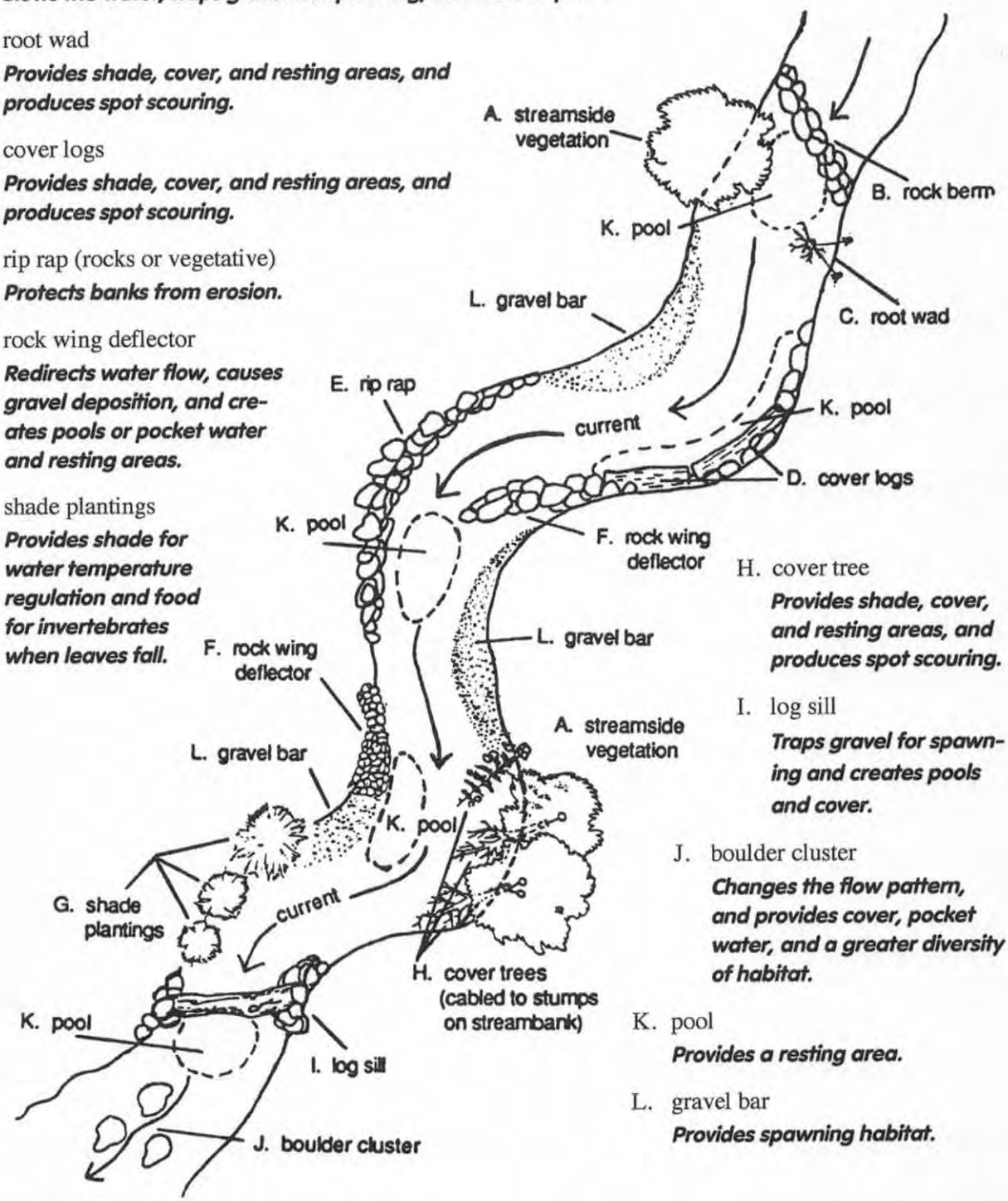
Protects banks from erosion.

F. rock wing deflector

Redirects water flow, causes gravel deposition, and creates pools or pocket water and resting areas.

G. shade plantings

Provides shade for water temperature regulation and food for invertebrates when leaves fall.



H. cover tree

Provides shade, cover, and resting areas, and produces spot scouring.

I. log sill

Traps gravel for spawning and creates pools and cover.

J. boulder cluster

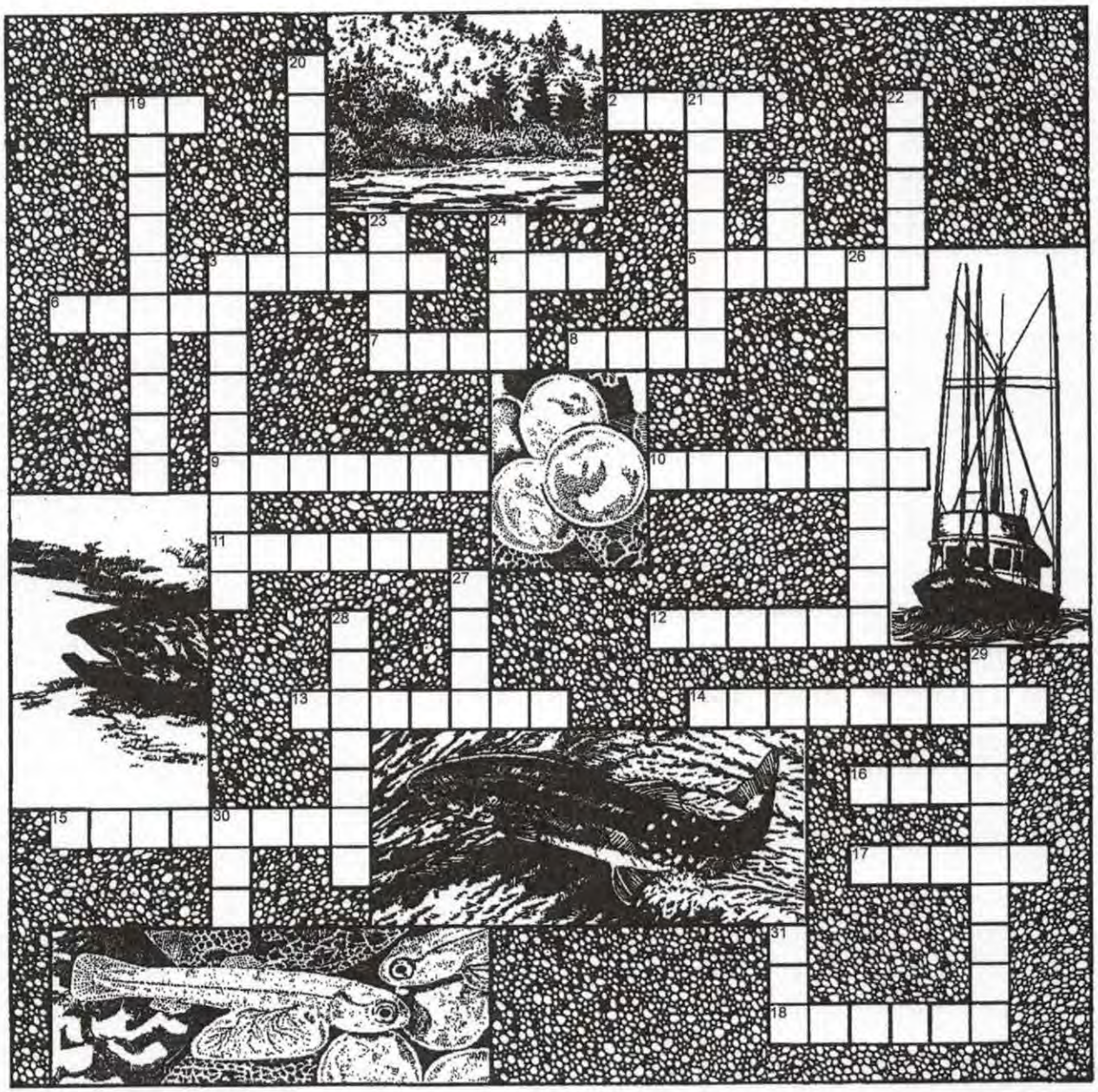
Changes the flow pattern, and provides cover, pocket water, and a greater diversity of habitat.

K. pool

Provides a resting area.

L. gravel bar

Provides spawning habitat.



Word list

gravel	cold	run	stream	redd	bright	jack
sockeye	anadromous	escapement	migration	smolt	commercial	dam
alevin	OPI	habitat	egg	spawn	fry	
flowing	sport	parr	tule	steelhead	chinook	
pink	riparian	oxygen	troller	chum	silver	

Student sheet

Fish habitat needs

9.3

"The falling waters led me, the foodful waters fed me."
— Ralph Waldo Emerson

Though the physical characteristics of a stream largely determine its ability to pro duce fish, survival of each new hatch is dependent upon many environmental factors. A relatively stable, pollutant-free water flow is important for a productive stream.

Anadromous salmonids use a variety of streams. Although each species has its own specific habitat requirements, some generalizations can be made.

Spawning habitat

Successful spawning and development from egg to fry require:

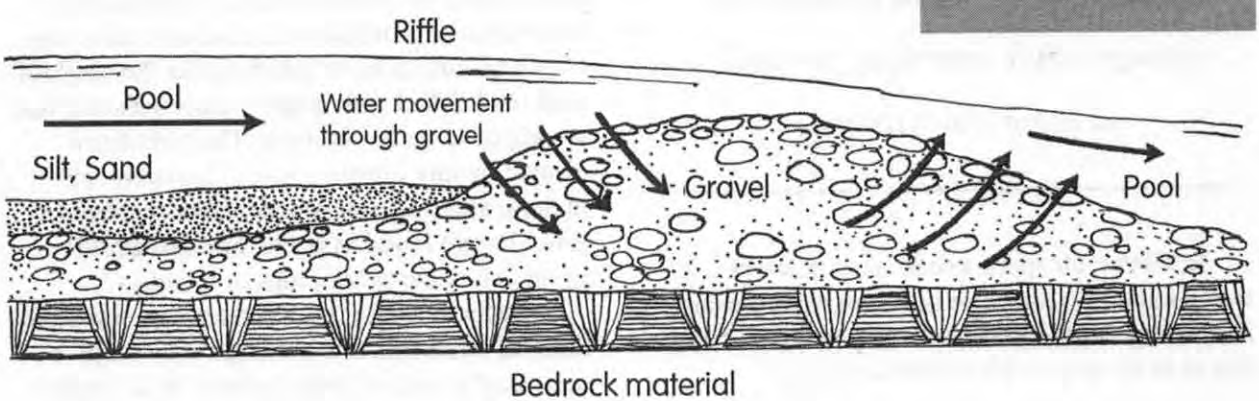
- absence of barriers to upstream migration of adults,
- spawning areas with sediment-free substrate and adequate water flows,
- a balance of pools to riffles that provides spawning areas and nearby escape cover, and
- a constant flow of cool, well-oxygenated water through the spawning gravel.

Anadromous fish must be able to move upstream to spawning areas. Log jams and other barriers can prevent this from happening. Fish can injure themselves trying to jump barriers or become weak and exhausted, reducing chances for successful spawning.

In ideal spawning habitat, cool, well-oxygenated water flows freely through sediment-free gravel areas. The cleanest gravel is usually found at the tailout, or downstream end, of a pool. Heavy flooding can disturb spawning beds in unstable channels.

Vocabulary

carrying capacity



Adapted from: Province of British Columbia, Ministry of Environment, *Stream Enhancement Guide*, Vancouver, B.C., 1980.

Rearing habitat

Young fry are vulnerable to predators, as they leave the gravel to seek food. High stream velocities can carry fry far downstream or strand them in floodplain pools. To enhance the survival of fry, pools for rearing, temperature regulation and cover should be close to each other. Productive juvenile rearing habitat requires:

- low to moderate slope and velocity;
- a balance of pool and riffle habitat;
- a variety of substrate types to provide hiding cover for juvenile fish and places for aquatic insects to live;
- undercut banks, stable natural debris such as fallen trees, and overhanging vegetation to provide cooling shade and protection for juvenile fish, and leaf litter for aquatic insect production; and
- sufficient nutrients to promote growth of naturally occurring plants and other organisms beneficial to the stream.

As young salmonids grow, they seek progressively higher velocities, often moving from the edge of a stream to midstream to take advantage of increased insect drift. Facing upstream or into the current allows a fish to conserve energy while watching for food drifting downstream.

Facing upstream or into the current allows a fish to conserve energy while watching for food drifting downstream.

In winter, all species seek areas of lower water velocity. This helps conserve energy while food and growing conditions are poorer, enabling fish to better cope with winter extremes.

Habitat preferences

Though basic requirements are the same, salmonid species differ in the types of habitat they use. For example, juvenile coho choose pool areas of moderate velocity in summer. They prefer eddies or backwaters near an undercut bank, root wad or log. In winter, they are found in slow, deep pools or side channel areas, seeking cover under rocks, logs and debris.

During winter, spring chinook salmon use riparian edges where vegetation has grown into a stream, providing cover and shelter. Streambanks must be covered with vegetation to provide this feature. Degraded streambanks do not provide suitable winter habitat for young fish. Rearing densities can increase dramatically where good streambank recovery has occurred.

Rearing densities can increase dramatically where good streambank recovery has occurred.

Juvenile steelhead spend from one to three years in fresh water, and their habitat needs must be considered throughout that time. In the first summer after hatching, young steelhead stay in relatively shallow, cobble-bottomed areas at the tail of a pool or shallow riffle. In winter, they hide under large boulders in shallow riffle areas.

Older steelhead juveniles prefer the heads of pools and riffles with large boulder substrate and woody cover in the summer. The turbulence created by this substrate is also important cover in these areas. During winter, older steelhead juveniles are found in pools, near streamside cover and under debris, logs or boulders.

Cutthroat habitat requirements are similar to those of steelhead, and although chinook juveniles tend to rear in large streams, their requirements parallel those of coho.

Name

Home wet home . . .

Do you know . . .

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

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

The ecological requirements of salmonids are:

- cool, clear, well-oxygenated water,
- sections of gravel bottom for spawning,
- occasional pools for feeding and resting,
- adequate food (aquatic and terrestrial insects, the latter usually falling from streamside vegetation), and
- cover for protection from predators.

Now it's your turn . . .

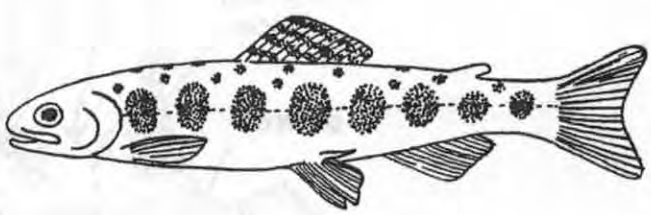
How do you make a house a home? A house is just walls, a floor and a roof. But to make it a home, you have to arrange the furniture and hang the pictures. Structures like chairs, sofas, tables, beds, and your favorite wall hangings make the house more comfortable and livable.

Fish also need homes. A stream without structures like rocks, plants, logs, boulders, and gravel is just a "house." But with those structures in the stream and arranged just so, fish can live there comfortably.

In a healthy stream, nature creates fish "homes" with all the right furnishings. But many streams today are not healthy and have lost their ability to serve as good homes for fish. So, fish biologists often build structures in and around streams to help restore fish habitat so that more fish can live there. They create pools, riffles, curves, and bends and grow plants along the stream. They also try to make the new changes look as natural as possible.

Following is a drawing of a stream that biologists have been working on. They have created each of the lettered structures. Can you tell how each structure helps fish live there? For instance, Item A—streamside vegetation—provides shade to keep the water cool and creates food (leaves) for insects that live in the water, which are in turn eaten by the fish.

Test your knowledge about fish habitat. Describe how each features serves as fish habitat in the space provided on the student answer sheet.



Vocabulary

boulder cluster	rip rap
cover logs	rock weir
cover tree	rock wing deflector
gravel bar	root wad
log sill	shade plantings
pool	streamside vegetation

Student sheet

A. streamside vegetation

B. rock weir

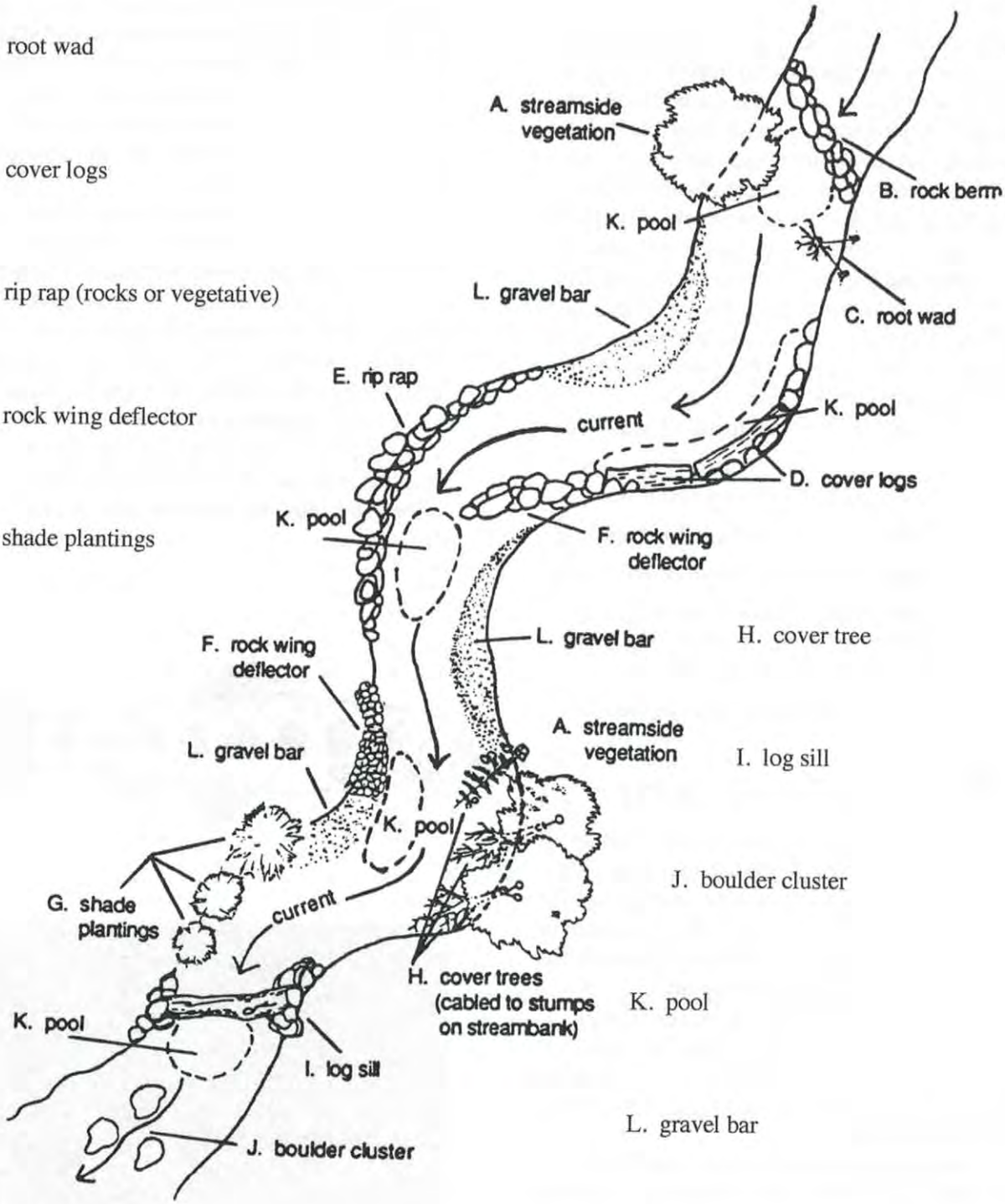
C. root wad

D. cover logs

E. rip rap (rocks or vegetative)

F. rock wing deflector

G. shade plantings



H. cover tree

I. log sill

J. boulder cluster

K. pool

L. gravel bar

Student sheet

Riffles and pools

Activity Education Standards: *Note alignment with Oregon Academic Content Standards beginning on p. 483.*

Objectives

The student will analyze and describe how riffles and pools meet the needs of salmon and trout.

Method

Students will apply concepts learned about habitat needs of salmonids during their life cycle by completing a work sheet analyzing riffles and pools.

For younger students

1. Consult extension activities at the end of each chapter to address the needs of younger students.
2. Read activity background information aloud to younger students or modify for your students' reading level.
3. Requires some vocabulary building.

Materials

- copies of student sheets (pp. 361-364)

Background

Do you know . . .

All Pacific salmon are **anadromous**. They begin their lives in freshwater, migrate to the ocean, and return to freshwater to spawn and die. Salmon are important to Oregon's commercial and recreational fisheries.

The salmon life cycle begins when eggs are deposited and fertilized in the gravel of cool, clean rivers and streams. Until they hatch, the cold (40°F to 65°F) water flowing through the gravel delivers oxygen and carries away wastes. The gravel itself protects the eggs from predators.

In late winter or spring, the eggs hatch. The young fish, called **alevins**, are less than one inch long. They still depend on cold, well-oxygenated water for their survival and stay in the gravel for shelter. During this time they are fed from a **yolk sac** that protrudes from their bellies. As the yolk sacs are used up, the fish, now called **fry**, emerge from the gravel in late spring or summer, approximately one to three months after hatching.

The fry of some species head directly for the sea, but others might stay in freshwater for a few months to a few years. Fry depend on streamside vegetation and the turbulent water at the beginning of pools for cover. Aquatic invertebrates provide most of the food for salmon fry.

When they are ready to migrate to the sea, they go through **smoltification**, a physiological change, and are known as **smolts**. Smolting prepares them for life in saltwater. Once in the sea they spend up to five years, depending upon the species, feeding and growing before they are ready to return to fresh water.

Salmon return to spawn in the same stream where they hatched. No one knows for certain how they find their way back to the same stream,

Adapted from *Clean Water, Streams and Fish*, Borton, et al., pp. 123-125, 136-137.

Vocabulary

alevins	milt
anadromous	redd
yolk sac	smoltification
fry	smolts

although one theory is that they can smell or actually taste the water chemistry of their home stream. When they enter fresh water, salmon stop feeding. Their journey upriver is made on the energy stored while living in the ocean.

Salmon spawning beds are generally found in the shallow headwaters of a stream and other suitable areas in the mainstems of streams. Weeks or months after they have reached the gravel beds, the female digs a nest, or **redd**. Here she deposits up to 5,000 eggs. The male fertilizes the eggs by covering them with **milt**, a milky substance that contains the sperm. The female finishes the spawning process by covering the eggs with gravel. After spawning, the salmon's life is finished. Within a short time, it dies and the carcass drifts downstream, decaying and contributing its nutrients to the stream from which it originally came.

Note: Trout, with the exception of steelhead and some cutthroat, are not anadromous. However, they are closely related to salmon and have needs similar to those of salmon during their time in fresh water.

Procedure

Now it's your turn . . .

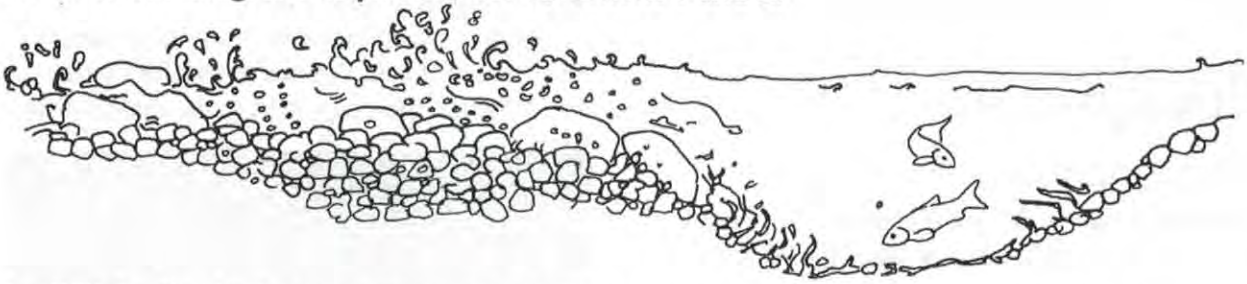
Think about the last time you were at a stream. Let's review some of the things you might have observed or remember about good fish habitat.

- What is dissolved oxygen? Why is it important to streams and fish?
- What are pools? What are riffles? What kind of habitat do they provide for fish? Since salmonids spawn in gravel, and gravel is usually found in riffles, riffles are often called "spawning habitat." The amount of good quality gravel and riffles in a stream determine the number of salmonids that can spawn. The areas of a stream that provide places to eat, rest, and hide are called "rearing habitat."
- Stonefly and other aquatic insect larvae live on, around, and under rocks in the bottom of a stream. Some are shredders, feeding on decomposing leaves. Others are scrapers, grazing on algae growing on the rocks. Still others are predators that eat other invertebrates. To move to new rocks these aquatic insects detach themselves and drift downstream. Because they are carried by the current, most are found where the current is strongest. Salmonid fry eat these larvae (or floating sandwiches) as they drift past.

Look carefully at the drawings. Answer the questions based on your own experience and the introductory information in this exercise.

Questions

Refer to this diagram as you answer Questions 1 and 2.

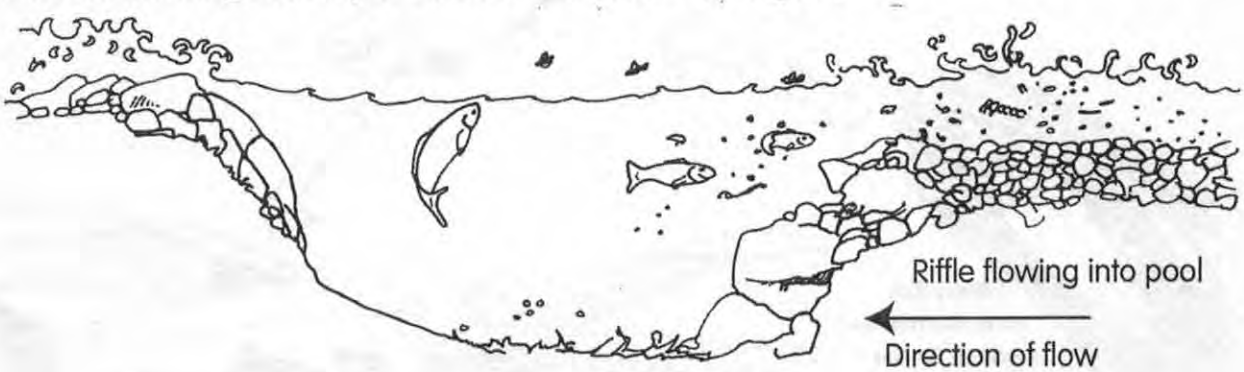


1. Will the dissolved oxygen concentration be higher at the bottom of the pools or in the riffles?

   Generally, riffles should have more dissolved oxygen than pools, as a result of air and water mixing in the more turbulent water of the riffles.

2. Which would give more shelter or protection to salmonid eggs, pools or riffles? Why?
   Riffles. The gravel usually found in the riffles would protect the eggs. Pools are more likely to have collections of fine sediments rather than gravels.

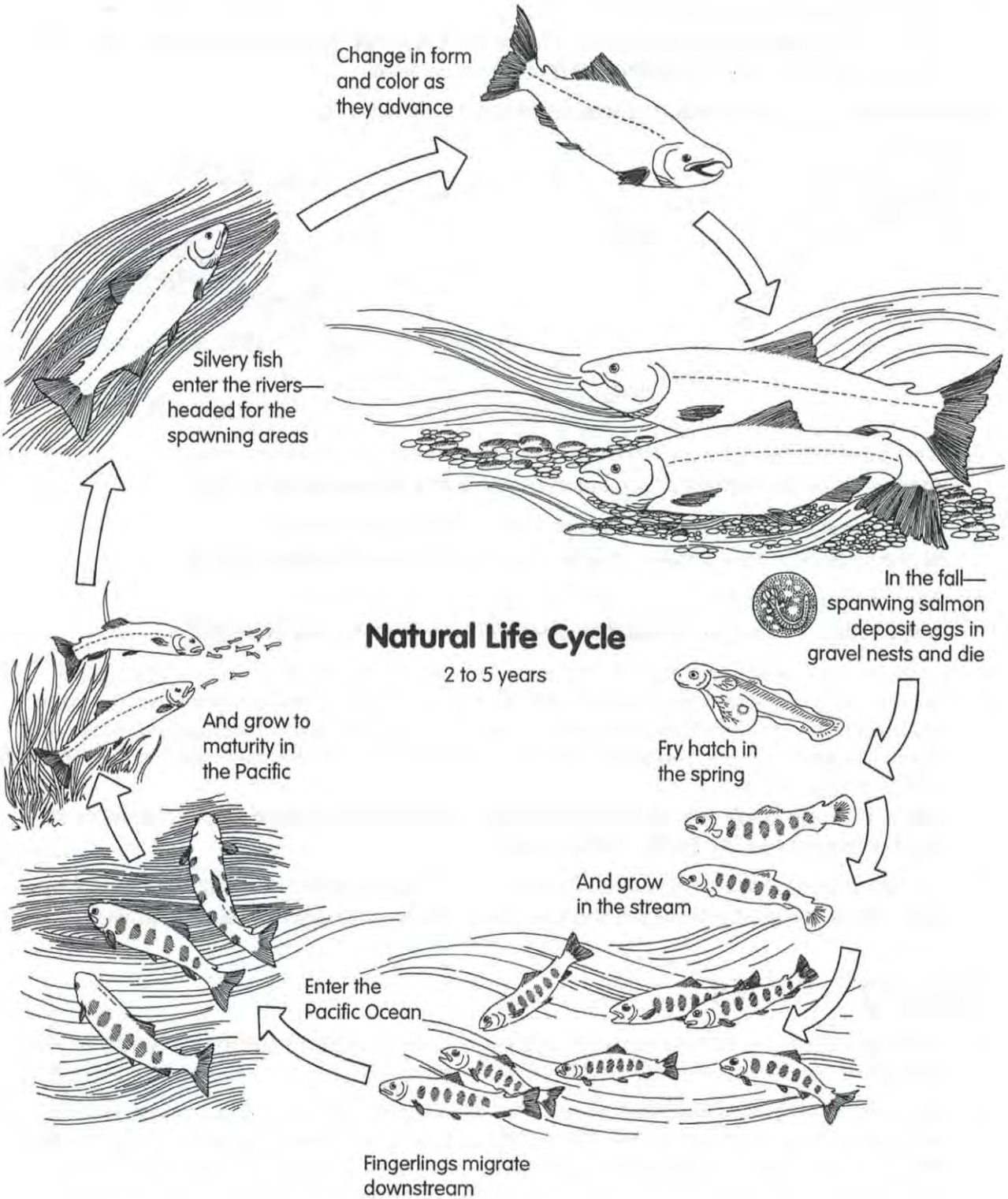
Refer to this diagram as you answer Questions 3 through 5.



3. What happens to aquatic insect larvae as the current enters a pool and slows down?
   They settle to the bottom or are eaten by predators (other insects or fish).
4. Where would be the best place for salmonid fry to wait for lunch? Why?
   At the head of a pool or tail of a riffle. To be first in line for drifting insects.
5. Where would salmonid fry use the most energy catching food? Why?
   In the riffles. It is harder to maintain position in the faster water of a riffle.
6. Chum fry only spend as much time in the stream as it takes to get to the ocean (one day to three weeks). Coho salmon juveniles live for a year in the stream before heading to the ocean. Steelhead and sea-run cutthroat juveniles live up to three years in the stream before heading to the ocean. If a stream has good spawning habitat but not much rearing habitat, will it be more likely to support chum or coho salmon fry? Why?
   Chum. Because chum salmon fry immediately begin moving toward the sea; they do not need extensive rearing habitat in the stream.
7. If a stream has both spawning and rearing habitat, which salmonid species might it support? Why?
   Both. Coho salmon fry could live there because of the availability of rearing habitat.

Going further

1. Design an experiment to compare oxygen content of agitated and still water. Based on your results, hypothesize what the value of one might be over the other.
2. Design an experiment to measure the rate of flow in riffles and pools (and other habitats including glides, rapids, and cascades). Research the different types of fish habitat, including all kinds of slow and fast water habitats. Consult with a fish habitat biologist to learn how each of the habitat types provides for the needs of fish. Prepare a report or display of your findings and present to the class.
3. Contact your local department of fish and wildlife or watershed council. Volunteer to assist with fish habitat surveys on streams in your area. Ask local experts to train you in data collection methods and data analysis. Consider recruiting other volunteers to assist with the project. Prepare a report and share this information with the class.



Length of life cycle varies with species and consitions

Name

Riffles and pools

Do you know . . .

All Pacific salmon are **anadromous**. They begin their lives in freshwater, migrate to the ocean, and return to freshwater to spawn and die. Salmon are important to Oregon's commercial and recreational fisheries.

The salmon life cycle begins when eggs are deposited and fertilized in the gravel of cool, clean rivers and streams. Until they hatch, the cold (40°F to 65°F) water flowing through the gravel delivers oxygen and carries away wastes. The gravel itself protects the eggs from predators.

In late winter or spring, the eggs hatch. The young fish, called **alevins**, are less than one inch long. They still depend on cold, well-oxygenated water for their survival and stay in the gravel for shelter. During this time they are fed from a **yolk sac** that protrudes from their bellies. As the yolk sacs are used up, the fish, now called **fry**, emerge from the gravel in late spring or summer, approximately one to three months after hatching.

The fry of some species head directly for the sea, but others might stay in freshwater for a few months to a few years. Fry depend on streamside vegetation and the turbulent water at the beginning of pools for cover. Aquatic invertebrates provide most of the food for salmon fry.

When they are ready to migrate to the sea, they go through **smoltification**, a physiological change, and are known as **smolts**. Smolting prepares them for life in saltwater. Once in the sea they spend up to five years, depending upon the species, feeding and growing before they are ready to return to fresh water.

Salmon return to spawn in the same stream where they hatched. No one knows for certain how they find their way back to the same stream, although one theory is that they can smell or actually taste the water chemistry of their home stream. When they enter fresh water, salmon stop feeding. Their journey upriver is made on the energy stored while living in the ocean.

Salmon spawning beds are generally found in the shallow headwaters of a stream and other suitable areas in the mainstems of streams. Weeks or months after they have reached the gravel beds, the female digs a nest, or **redd**. Here she deposits up to 5,000 eggs. The male fertilizes the eggs by covering them with **milt**, a milky substance that contains the sperm. The female finishes the spawning process by covering the eggs with gravel. After spawning, the salmon's life is finished. Within a short time, it dies and the carcass drifts downstream, decaying and contributing its nutrients to the stream from which it originally came.

Note: Trout, with the exception of steelhead and some cutthroat, are not anadromous. However, they are closely related to salmon and have needs similar to those of salmon during their time in fresh water.

Adapted from *Clean Water, Streams and Fish*, Borton, et al., pp. 123-125, 136-137.

Now it's your turn . . .

Think about the last time you were at a stream. Let's review some of the things you might have observed or remember about good fish habitat.

- What is dissolved oxygen? Why is it important to streams and fish?

Vocabulary

alevins	milt
anadromous	redd
yolk sac	smoltification
fry	smolts

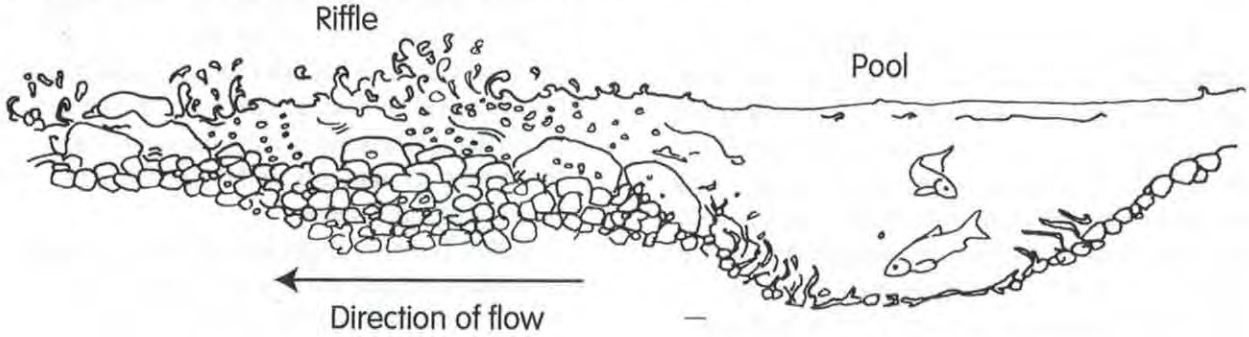
Student sheet

- What are pools? What are riffles? What kind of habitat do they provide for fish? Since salmonids spawn in gravel, and gravel is usually found in riffles, riffles are often called "spawning habitat." The amount of good quality gravel and riffles in a stream determine the number of salmonids that can spawn. The areas of a stream that provide places to eat, rest, and hide are called "rearing habitat."
- Stonefly and other aquatic insect larvae live on, around, and under rocks in the bottom of a stream. Some are shredders, feeding on decomposing leaves. Others are scrapers, grazing on algae growing on the rocks. Still others are predators that eat other invertebrates. To move to new rocks these aquatic insects detach themselves and drift downstream. Because they are carried by the current, most are found where the current is strongest. Salmonid fry eat these larvae (or floating sandwiches) as they drift past.

Look carefully at the drawings. Answer the questions based on your own experience and the introductory information in this exercise.

Questions

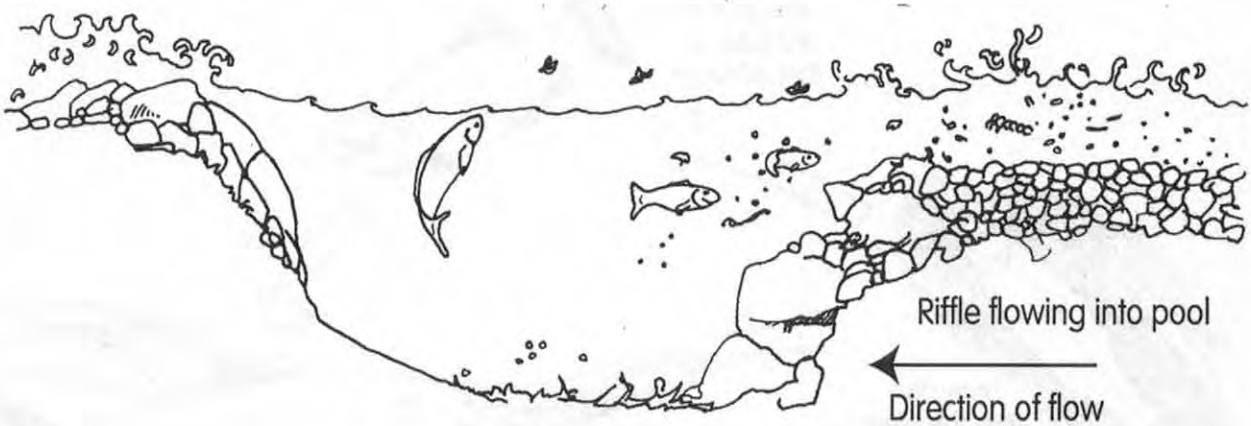
Refer to this diagram as you answer Questions 1 and 2.



1. Will the dissolved oxygen concentration be higher at the bottom of the pools or in the riffles?

2. Which would give more shelter or protection to salmonid eggs, pools or riffles? Why?

Refer to this diagram as you answer Questions 3 through 5.



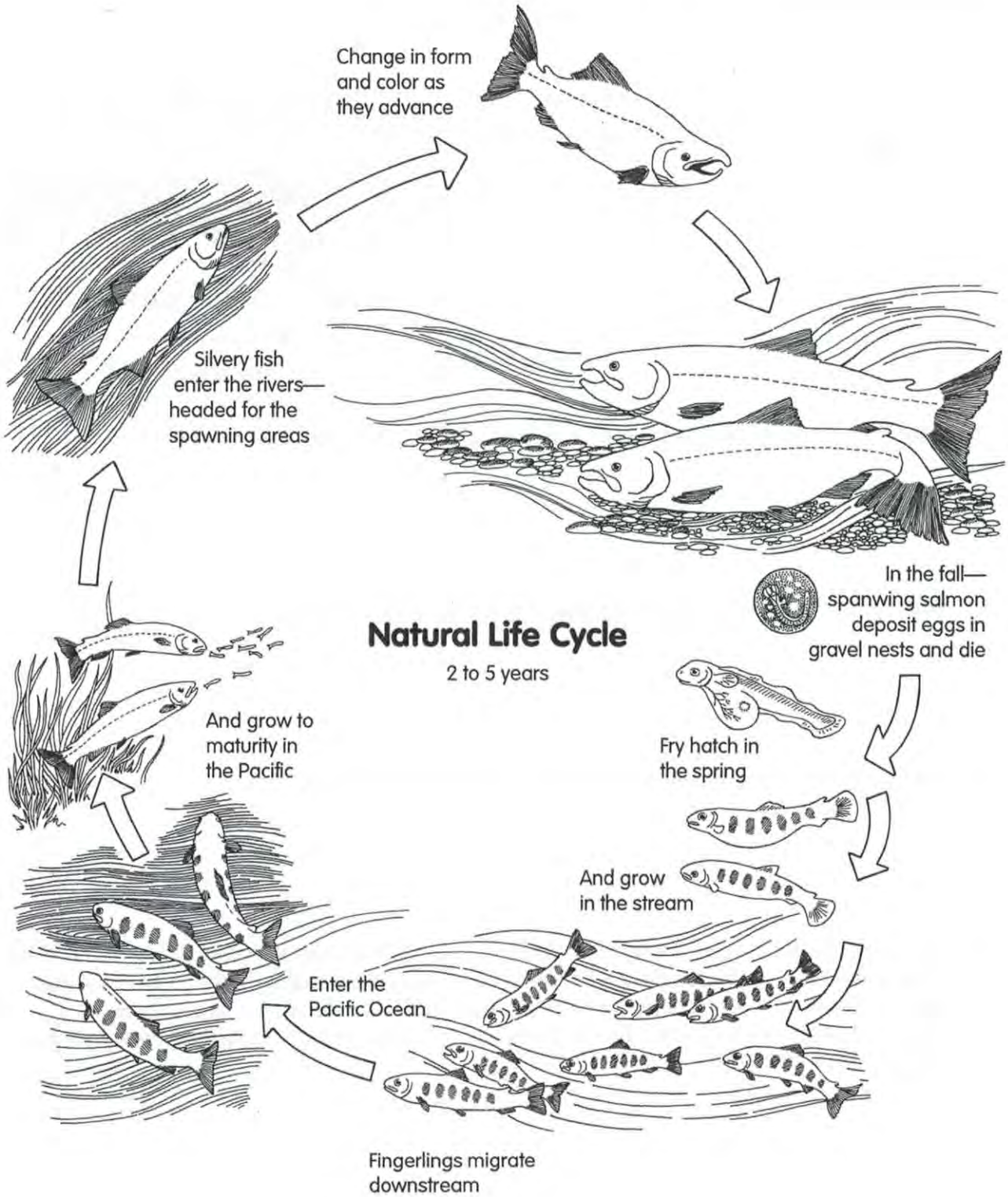
3. What happens to aquatic insect larvae as the current enters a pool and slows down?

4. Where would be the best place for salmonid fry to wait for lunch? Why?

5. Where would salmonid fry use the most energy catching food? Why?

6. Chum fry only spend as much time in the stream as it takes them to get to the ocean (one day to three weeks). Coho salmon juveniles live for a year in the stream before heading to the ocean. Steelhead and sea-run cutthroat juveniles live up to three years in the stream before heading to the ocean. If a stream has good spawning habitat but not much rearing habitat, will it be more likely to support chum or coho salmon fry? Why?

7. If a stream has both spawning and rearing habitat, which salmonid species might it support? Why?



Length of life cycle varies with species and consitions

Student sheet

Coming home!

Activity Education Standards: *Note alignment with Oregon Academic Content Standards beginning on p. 483.*

Objectives

Students will (1) identify a diversity of issues affecting watersheds and salmonid populations within those watersheds, (2) create an advertising campaign designed to encourage salmonids to return to their home stream, and (3) critique and score other teams' work to assess student understanding of key watershed and fish habitat concepts.

Method

Students will investigate, write, and produce an advertising campaign, in a poster format, that features reasons for salmonids to migrate to a specific stream to spawn.

For younger students

1. To initiate the activity use examples of advertising campaigns found in children's magazines rather than those for older children and adults.
2. Modify the requirements so younger students prepare their advertising campaign on butcher paper that can be displayed on room or hallway walls. Assign different parts of the campaign to different groups of students rather than each group completing the entire campaign.
3. Review key vocabulary and components of good fish habitat with students before starting the activity.

This activity is adapted from "Salmon Stream Advertisement" created by Patrick Griffiths, Pilot Butte Middle School, 1500 NE Penn, Bend, Oregon 97701, and used with permission. Portions of the activity content are adapted from *Small Streams*, a Salmonid Enhancement Program fact sheet, Department of Fisheries and Oceans, BC Ministry of Environment, 555 West Hastings Street, Vancouver, B.C. Canada V6B5G3.

Materials

- writing materials
- colored and white paper
- 24"×36" poster board or foam core board
- markers, color pencils, paints, crayons, and other art supplies
- computer/printer (optional)
- copies of student pages 381-386

Notes to the teacher

This activity is designed as the concluding exercise of a watershed, water quality and fish habitat unit. The activity incorporates an array of skills that include art ability, graphic sense, design capabilities, creative writing, composition, research, group process, and decision making to assess student understanding and retention of key concepts about watersheds, water quality, and fish habitat. Collaborate with instructors in other curriculum areas (art, English, journalism, careers) so students understand that the study of watersheds is not limited to science.

Although it is a generally accepted fact that most salmon return to the same stream in which they were spawned, some straying to nearby streams does occur. Straying, to some extent, has been responsible for reestablishment of fish populations in streams following catastrophic natural events. Historically, straying has also provided opportunities for the exchange of genetic resources among nearby populations, thus increasing the genetic diversity of the species.

Take the time to go over these general facts with your students prior to beginning the activity. Although not using the subject of straying directly, for the purposes of this exercise, students will use the concept of good habitat to "lure" a salmon to come to their stream to spawn rather than returning to the stream of their birth.

Background

Do you know . . .

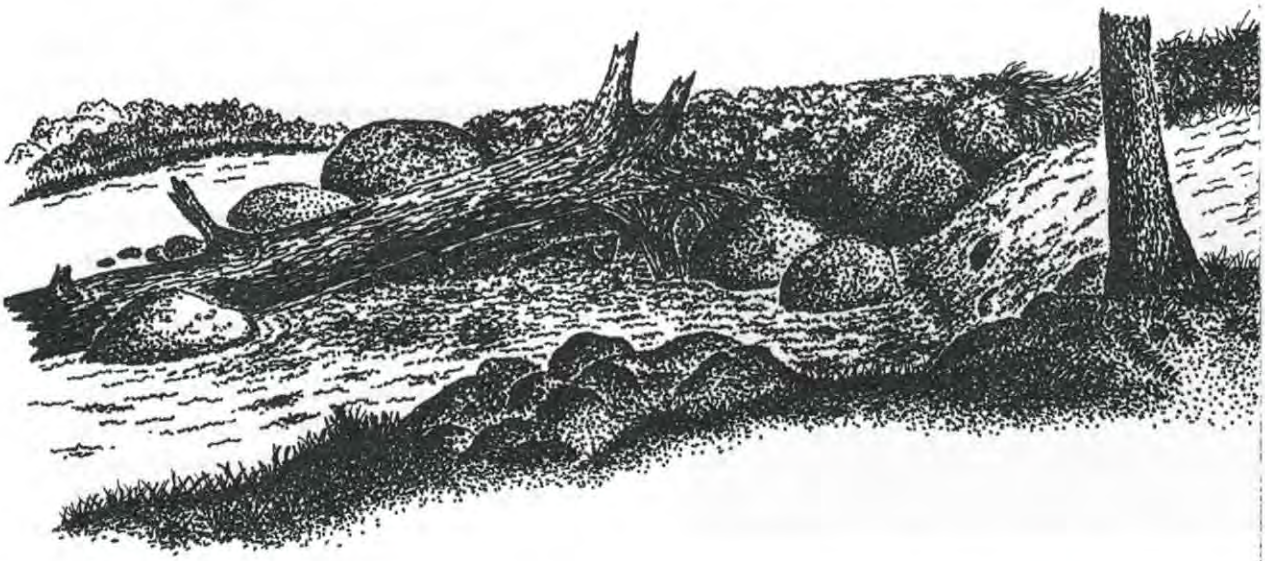
Most clean, healthy streams, no matter how small, can contribute to salmonid (salmon and trout) habitat. All salmonids—salmon, steelhead, and trout—spend at least a part of their life cycle in small streams. Some, like chum or pink salmon, may only spend a few weeks in the stream or the estuary before moving to the ocean, while others may spend three or more years before migrating. Young sockeye salmon move from small streams to rear in freshwater lakes for one or more years while still other species are permanent residents of large and small streams.

A single stream may appear insignificant as a producer of wild fish. But together, thousands of small streams throughout the Northwest account for a lot of fish production. Healthy streams are valuable, but they are fragile. They are easily damaged by poor agriculture and forestry practices, pollution, mining, and urban development.

Wild salmonids need certain stream conditions to survive. Salmonids need clean water for every stage of their life cycle. A healthy stream usually runs cool and clear over a clean gravel bottom. The silt present in cloudy water can coat incubating eggs and surrounding gravel, preventing oxygen from reaching the eggs. Without oxygen the eggs will die. In a healthy, natural stream, the flow of clean water usually remains steady. The land on both sides of a healthy stream acts as a giant sponge to soak up heavy rains. This water is then released slowly into the stream. Slow release of groundwater also prevents small streams from drying up during the warm summer months.

Aquatic organisms, including fish, have a relatively narrow temperature range for survival. Shade provided by trees and other plants that grow beside the stream helps keep the water cool and within that acceptable range. Insects that feed on the leaves and branches of these streamside plants sometimes fall into the water providing food for the fish. Mayflies and other insects that land on the water's surface to lay their eggs are also eaten by fish. Some insect eggs hatch and become part of the stream food chain. These aquatic forms of insects live on, around, and among the rocks of the streambed. These insect forms are often carried along by the water current where they become part of the menu for a fish waiting downstream.

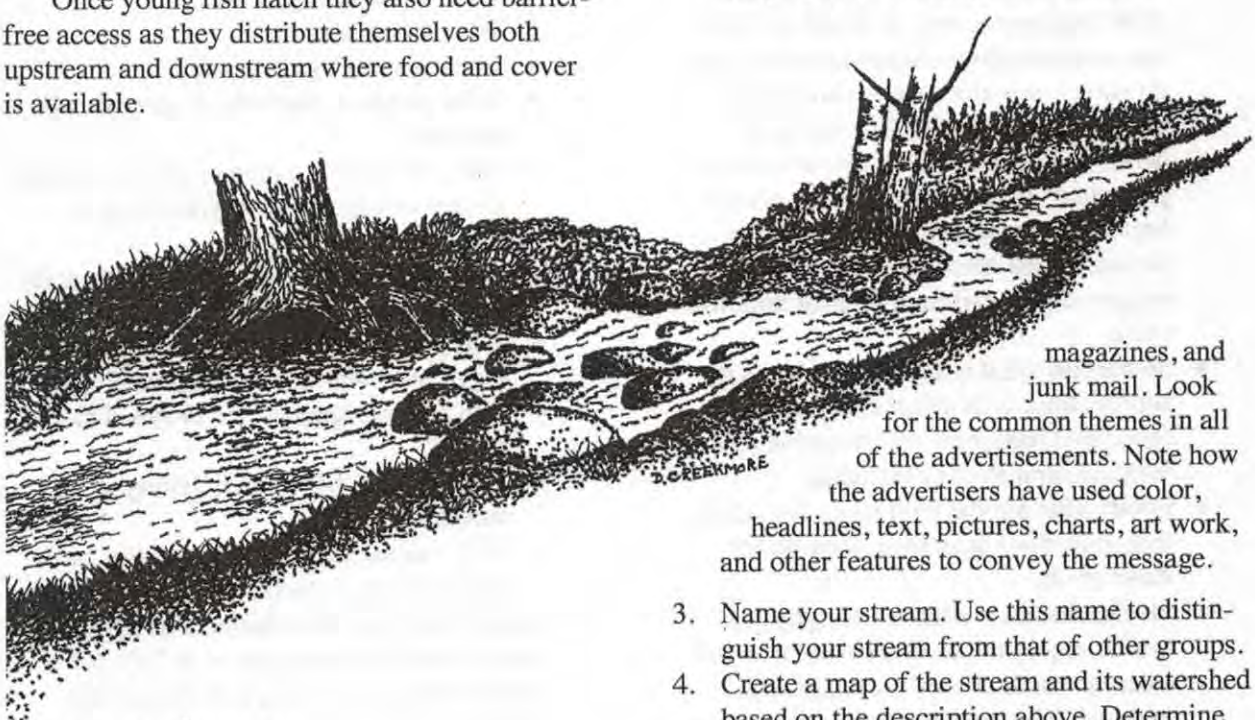
Small streams often contain natural debris such as root wads, fallen trees,



and boulders. Fish use these structures to hide from their enemies which include larger fish, birds, and small animals.

Adult migratory salmonids, like salmon and steelhead, need a barrier-free route to their spawning areas. They also need cover, both in the stream and alongside it, for protection from predators and for shaded resting areas. Salmon usually return to spawn in the same stream where they hatched. No one knows for certain how they find their way back to the same stream, although one theory is that they can smell or actually taste the water chemistry of their home stream. When they enter fresh water, salmon stop feeding. Their journey upriver is made on the energy stored while living in the ocean. Within days of spawning, adult salmon die, contributing the nutrients in their bodies to the stream from which it originally came.

Once young fish hatch they also need barrier-free access as they distribute themselves both upstream and downstream where food and cover is available.



Procedure

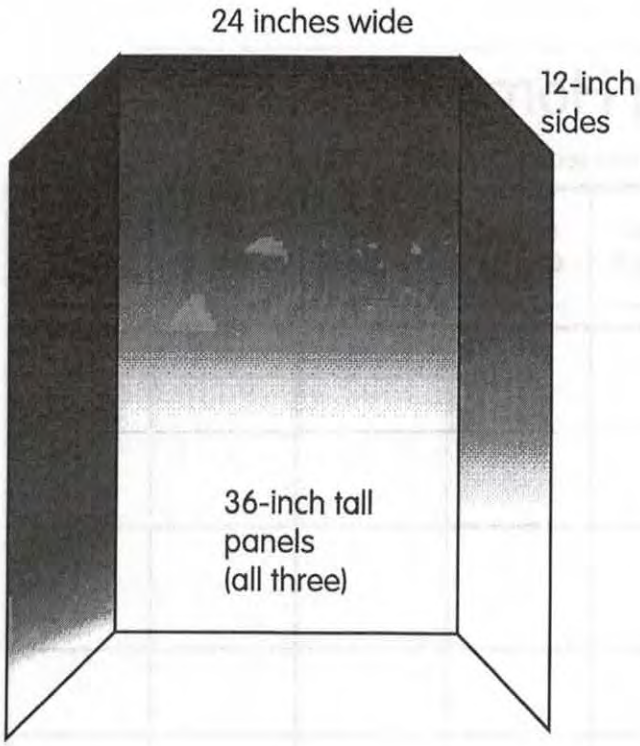
Now it's your turn . . .

You are an employee of an advertising firm that has been hired by the local watershed council. A local client has approached the watershed council for help in getting salmon to come back to the stream on his property. The stream begins in a wilderness headwater area, flows through farmland and finally through urban areas on its way to the Pacific Ocean. This stream needs salmon! You are going to break with tradition and see if you can get salmon to come back to this stream even though they did not originally grow up there. Your job is to create an advertisement that will attract salmon to this stream! The advertisement will tell salmon how great the stream is and why it is suitable place for salmon to live.

The ultimate goal of the advertisement is to communicate what salmon need to live and reproduce, impacts human activities have had on watersheds in the past, and how we can improve streams to attract salmon in the future.

1. Work in groups of three students.
2. As a group, look at examples of advertising campaigns in newspapers, a variety of magazines, and junk mail. Look for the common themes in all of the advertisements. Note how the advertisers have used color, headlines, text, pictures, charts, art work, and other features to convey the message.
3. Name your stream. Use this name to distinguish your stream from that of other groups.
4. Create a map of the stream and its watershed based on the description above. Determine where in the watershed the client wants salmon to spawn? Center your work in that area.
5. Organize your thoughts around the question "Why should salmon come and live in this stream?"

6. Create a planning guide around the main topics noted below. Use the questions following each topic to prepare for the advertising campaign and guide your research. Then, choose the points you want to emphasize in the advertisement.
   - **pH:** what is it, why is it important, how have humans altered the pH of streams, what range do salmon like best, how can humans keep pH within acceptable ranges.
   - **Temperature:** why are cool temperatures important to fish, how have human actions changed water temperatures in rivers and streams, what is the best temperature range for salmon, how can you protect a stream against drastic changes in temperature.
   - **Dissolved oxygen:** what is dissolved oxygen, why is it important to fish and other organisms, how do dissolved oxygen concentrations change naturally, how do human activities change dissolved oxygen concentrations (for worse or better) in streams, how is dissolved oxygen related to temperature, what are the best levels for salmon, and do salmon need different amounts of dissolved oxygen during different parts of their life cycle.
   - **Sediment:** what is sediment, what is it source, what is its effect on a stream (good and bad), how are excessive sediment accumulations controlled.
   - **Food:** what are the food needs for salmonids, how does the stream provide for these needs.
   - **Stream habitat:** what are the physical habitat requirements of a stream that will meet the needs of various stages of a salmon's life cycle, how will your stream keep sediment in check.
   - **Pollutants:** how might fertilizers, pesticides, or other pollutants get into a stream and how might they harm a river or stream, how are pollutant problems solved.
   - **Watershed land use activities:** how might watershed activities like mining, forestry, ranching, and farming practices, commercial and recreational fishing, dams, and urban development affect rivers and streams and salmon (good and bad), what are some alternatives, how can watershed management activities be designed to be salmon-friendly
   - **What does a healthy stream look like:** in the forest, passing through a farm, passing through a city?
7. Use butcher paper or other large pieces of paper to prepare a rough draft of the advertisement. Consider the following as you plan the display.
   - What key information will you include?
   - Where will you place the key inforamtion on the poster?
   - What colors will you use?
   - Who is your audience?
   - What are you trying to sell?
   - What graphics, pictures, or artwork will you use?
   - Will you include a map or picture of your stream to help illustrate your ideas or solutions?
   - Will you use cut-away drawings or tables and charts?
   - Will you use handwritten or typed headings? What will the headings say?
   - Will you use handwritten or typed blocks of text?
   - Will you add 3-D models? Hanging or attached?
   - Will you use interactive parts (flip cards with answers or facts) on the display?
8. Prepare the final advertisement as a tri-fold poster made from two pieces of 24"×36" poster board or ¼" foam core board. See diagram.
9. A successful project will include:
   - The stream name in a prominent location.
   - Appropriate stream, fish and watershed words.
   - Effective layout and promotional features, (quotes from visitors, headlines, etc.).



- Pictures, diagrams, artwork, and photographs to help tell the story.
- Well-organized information so that the message and the effect is clear and attractive.
- Specific methods used to improve past stream habitat problems.

10. Set up your advertisement for display. Obtain a copy of the grading sheet. Write the name of your stream in the box provided. List group member's names on the back of the grading sheet. Place the grading sheet in a location close to your advertisement. Move around the room viewing the advertisements produced by other groups. Choose two, other than your own, to score. As a group complete the grading sheet for each advertisement you have chosen. When four different groups have scored your advertisement, turn in the grading sheet to the teacher.
11. Answer the following questions.

Stream Name _____

Grading Sheet: Coming Home

Points Possible: 20 out of 20 or 10 out of 10 is a perfect score. There are very few perfect projects

Category Description	Points possible: Group # >	Grader Group # _____	Grader Group # _____	Grader Group # _____	Grader Group # _____	Teacher Grade _____
Followed directions: see instructions: size, shape, format.	20					
Appropriate words: examples connected to lessons	20					
Is the advertisement easy to read? Does it help "sell" the stream. Does it make you want to go there?	20					
Is the advertisement clear and attractive?	20					
Do pictures, diagrams or other graphics help the advertisement without confusing the message?	10					
Are improvement methods shown? (for making or keeping the stream in good shape?)	10					
Is specific information included about watershed activities? Is the information accurate?	10					
Is specific information included about physical habitat requirements? Is it accurate?	10					
Total	120					

Grader's Group #	What did you like best about this advertisement?	Were any items missing from this advertisement? Any other suggestions?

Questions

1. What did you like most about this activity? What did you like least? Why?
   Answers will vary.
2. How did this activity help you complete your study of watersheds and fish habitat?
   Answers will vary, but should include some thoughts to show an understanding that all parts of a watershed are connected and that what happens in the upper part of a watershed affects what is going on downstream. Students should recognize that healthy fish habitat must meet the four basic needs —food, water, shelter, and space.
3. What would you change if you were to do this activity again? Why?
   Answers will vary.
4. What were the main sources of information used to complete your research?
   Answers will vary.
5. What was the most interesting thing you learned about advertising as a means of persuasion?
   Answers will vary.

Going further

1. Convert the advertisement idea to a newspaper format. Use the ideas in "Aquatic Times," *Aquatic Project WILD* pp. 126-128 to set up the activity. Assign students to write newspaper articles about different parts of procedure 6 above, then arrange them in a newspaper format. Ask staff from the school newspaper to give a presentation about the key features of a newspaper.
2. Ask students with an interest in art to create appropriate graphics for illustrating key components of this activity. Contact the local fish and wildlife agency or other natural resource agency to see if they are interested in artwork for their programs.
3. Arrange for a "salmon fair" or other event to spotlight the needs of salmon. Ask groups to volunteer to share their advertising displays and to prepare a verbal presentation about what they have learned as a result of the activity.

Name

Coming home!

Do you know . . .

Most clean, healthy streams, no matter how small, can contribute to salmonid (salmon and trout) habitat. All salmonids—salmon, steelhead, and trout—spend at least a part of their life cycle in small streams. Some, like chum or pink salmon, may only spend a few weeks in the stream or the estuary before moving to the ocean, while others may spend three or more years before migrating. Young sockeye salmon move from small streams to rear in freshwater lakes for one or more years while still other species are permanent residents of large and small streams.

A single stream may appear insignificant as a producer of wild fish. But together, thousands of small streams throughout the Northwest account for a lot of fish production. Healthy streams are valuable, but they are fragile. They are easily damaged by poor agriculture and forestry practices, pollution, mining, and urban development.

Wild salmonids need certain stream conditions to survive. Salmonids need clean water for every stage of their life cycle. A healthy stream usually runs cool and clear over a clean gravel bottom. The silt present in cloudy water can coat incubating eggs and surrounding gravel, preventing oxygen from reaching the eggs. Without oxygen the eggs will die. In a healthy, natural stream, the flow of clean water usually remains steady. The land on both sides of a healthy stream acts as a giant sponge to soak up heavy rains. This water is then released slowly into the stream. Slow release of groundwater also prevents small streams from drying up during the warm summer months.

Aquatic organisms, including fish, have a relatively narrow temperature range for survival. Shade provided by trees and other plants that grow beside the stream helps keep the water cool and within that acceptable range. Insects that feed on the leaves and branches of these streamside plants sometimes fall into the water providing food for the fish. Mayflies and other insects that land on the water's surface to lay their eggs are also eaten by fish. Some insect eggs hatch and become part of the stream food chain. These aquatic forms of insects live on, around, and among the rocks of the streambed. These insect forms are often carried along by the water current where they become part of the menu for a fish waiting downstream.

Small streams often contain natural debris such as root wads, fallen trees, and boulders. Fish use these structures to hide from their enemies which include larger fish, birds, and small animals.

Adult migratory salmonids, like salmon and steelhead, need a barrier-free route to their spawning areas. They also need cover, both in the stream and alongside it, for protection from predators and for shaded resting areas. Salmon usually return to spawn in the same stream where they hatched. No one knows for certain how they find their way back to the same stream, although one theory is that they can smell or actually taste the water chemistry of their home stream. When they enter fresh water, salmon stop feeding. Their journey upriver is made on the energy stored while living in the ocean. Within days of spawning, adult salmon die, contributing the nutrients in their bodies to the stream from which it originally came.

This activity is adapted from "Salmon Stream Advertisement" created by Patrick Griffiths, Pilot Butte Middle School, 1500 NE Penn, Bend, Oregon 97701, and used with permission. Portions of the activity content are adapted from *Small Streams*, a Salmonid Enhancement Program fact sheet, Department of Fisheries and Oceans, BC Ministry of Environment, 555 West Hastings Street, Vancouver, B.C. Canada V6B5G3.

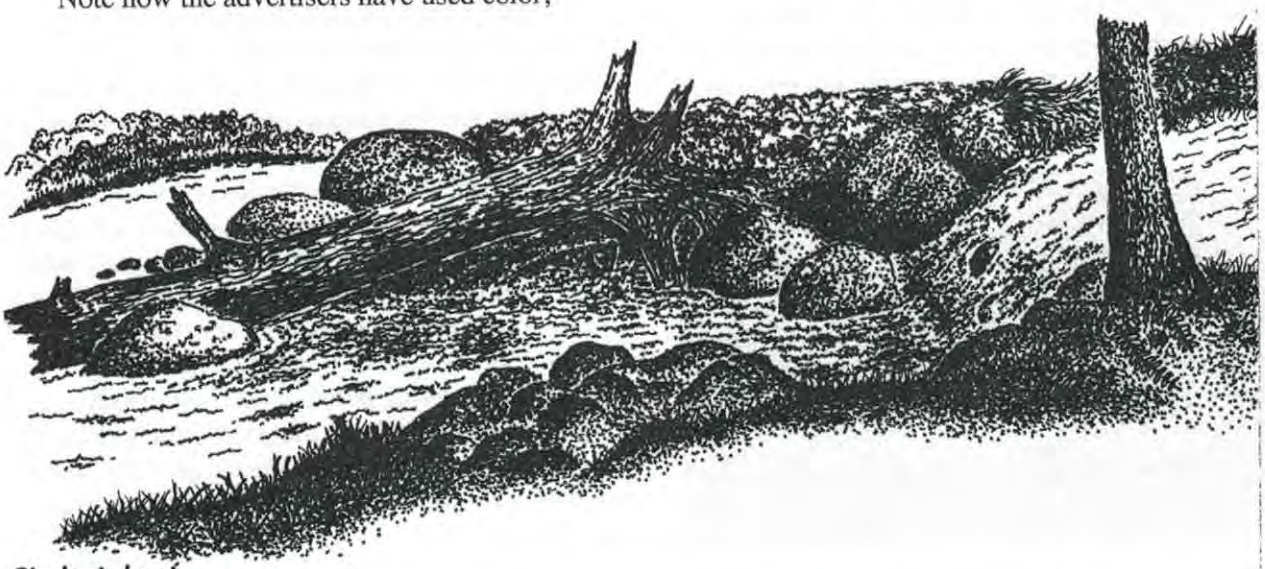
Once young fish hatch they also need barrier-free access as they distribute themselves both upstream and downstream where food and cover is available.

Now it's your turn . . .

You are an employee of an advertising firm that has been hired by the local watershed council. A local client has approached the watershed council for help in getting salmon to come back to the stream on his property. The stream begins in a wilderness headwater area, flows through farmland and finally through urban areas on its way to the Pacific Ocean. This stream needs salmon! You are going to break with tradition and see if you can get salmon to come back to this stream even though they did not originally grow up there. Your job is to create an advertisement that will attract salmon to this stream! The advertisement will tell salmon how great the stream is and why it is suitable place for salmon to live.

The ultimate goal of the advertisement is to communicate what salmon need to live and reproduce, impacts human activities have had on watersheds in the past, and how we can improve streams to attract salmon in the future.

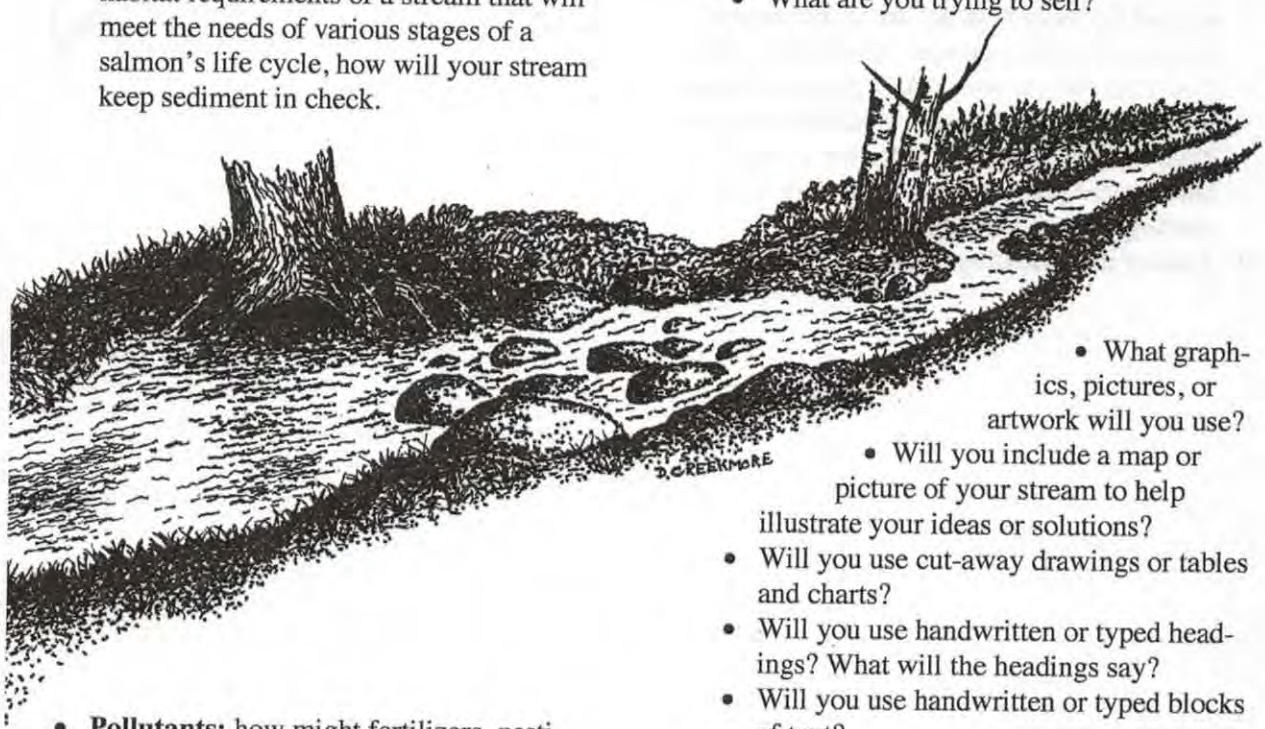
1. Work in groups of three students.
2. As a group, look at examples of advertising campaigns in newspapers, a variety of magazines, and junk mail. Look for the common themes in all of the advertisements. Note how the advertisers have used color, headlines, text, pictures, charts, art work, and other features to convey the message.
3. Name your stream. Use this name to distinguish your stream from that of other groups.
4. Create a map of the stream and its watershed based on the description above. Determine where in the watershed the client wants salmon to spawn? Center your work in that area.
5. Organize your thoughts around the question "Why should salmon come and live in this stream?"
6. Create a planning guide around the main topics noted below. Use the questions following each topic to prepare for the advertising campaign and guide your research. Then, choose the points you want to emphasize in the advertisement.
   - **pH:** what is it, why is it important, how have humans altered the pH of streams, what range do salmon like best, how can humans keep pH within acceptable ranges.
   - **Temperature:** why are cool temperatures important to fish, how have human actions changed water temperatures in rivers and streams, what is the best temperature range for salmon, how can you protect a stream against drastic changes in temperature.
   - **Dissolved oxygen:** what is dissolved oxygen, why is it important to fish and



Student sheet

other organisms, how do dissolved oxygen concentrations change naturally, how do human activities change dissolved oxygen concentrations (for worse or better) in streams, how is dissolved oxygen related to temperature, what are the best levels for salmon, and do salmon need different amounts of dissolved oxygen during different parts of their life cycle.

- **Sediment:** what is sediment, what is it source, what is its effect on a stream (good and bad), how are excessive sediment accumulations controlled.
- **Food:** what are the food needs for salmonids, how does the stream provide for these needs.
- **Stream habitat:** what are the physical habitat requirements of a stream that will meet the needs of various stages of a salmon's life cycle, how will your stream keep sediment in check.

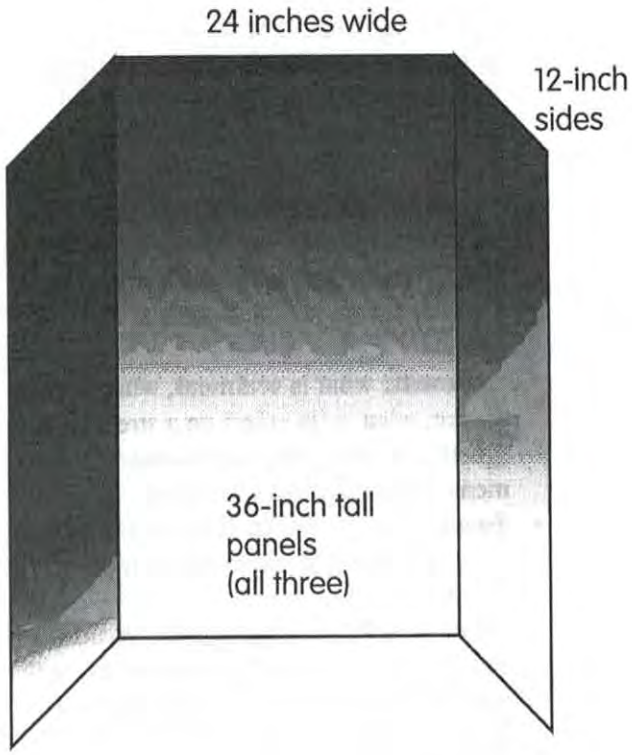


- **Pollutants:** how might fertilizers, pesticides, or other pollutants get into a stream and how might they harm a river or stream, how are pollutant problems solved.
- **Watershed land use activities:** how might watershed activities like mining, forestry, ranching, and farming practices, commercial and recreational fishing, dams, and urban development affect rivers and streams and salmon (good and bad), what are some alternatives, how can watershed management activities be designed to be salmon-friendly
- **What does a healthy stream look like:** in the forest, passing through a farm, passing through a city?

7. Use butcher paper or other large pieces of paper to prepare a rough draft of the advertisement. Consider the following as you plan the display.
   - What key information will you include?
   - Where will you place the key inforamtion on the poster?
   - What colors will you use?
   - Who is your audience?
   - What are you trying to sell?
   - What graphics, pictures, or artwork will you use?
   - Will you include a map or picture of your stream to help illustrate your ideas or solutions?
   - Will you use cut-away drawings or tables and charts?
   - Will you use handwritten or typed headings? What will the headings say?
   - Will you use handwritten or typed blocks of text?
   - Will you add 3-D models? Hanging or attached?
   - Will you use interactive parts (flip cards with answers or facts) on the display?
8. Prepare the final advertisement as a tri-fold poster made from two pieces of 24"×36" poster board or ¼" foam core board. See diagram.

Student sheet

9. A successful project will include:
   - The stream name in a prominent location.
   - Appropriate stream, fish and watershed words.
   - Effective layout and promotional features, (quotes from visitors, headlines, etc.).
   - Pictures, diagrams, artwork, and photographs to help tell the story.
   - Well-organized information so that the message and the effect is clear and attractive.
   - Specific methods used to improve past stream habitat problems.
10. Set up your advertisement for display. Obtain a copy of the grading sheet. Write the name of your stream in the box provided. List group member's names on the back of the grading sheet. Place the grading sheet in a location close to your advertisement. Move around the room viewing the advertisements produced by other groups. Choose two, other than your own, to score. As a group complete the grading sheet for each advertisement you have chosen. When four different groups have scored your advertisement, turn in the grading sheet to the teacher.
11. Answer the following questions.



Questions

1. What did you like most about this activity? What did you like least? Why?

2. How did this activity help you complete your study of watersheds and fish habitat?

3. What would you change if you were to do this activity again? Why?

4. What were the main sources of information used to complete your research?

5. What was the most interesting thing you learned about advertising as a means of persuasion?