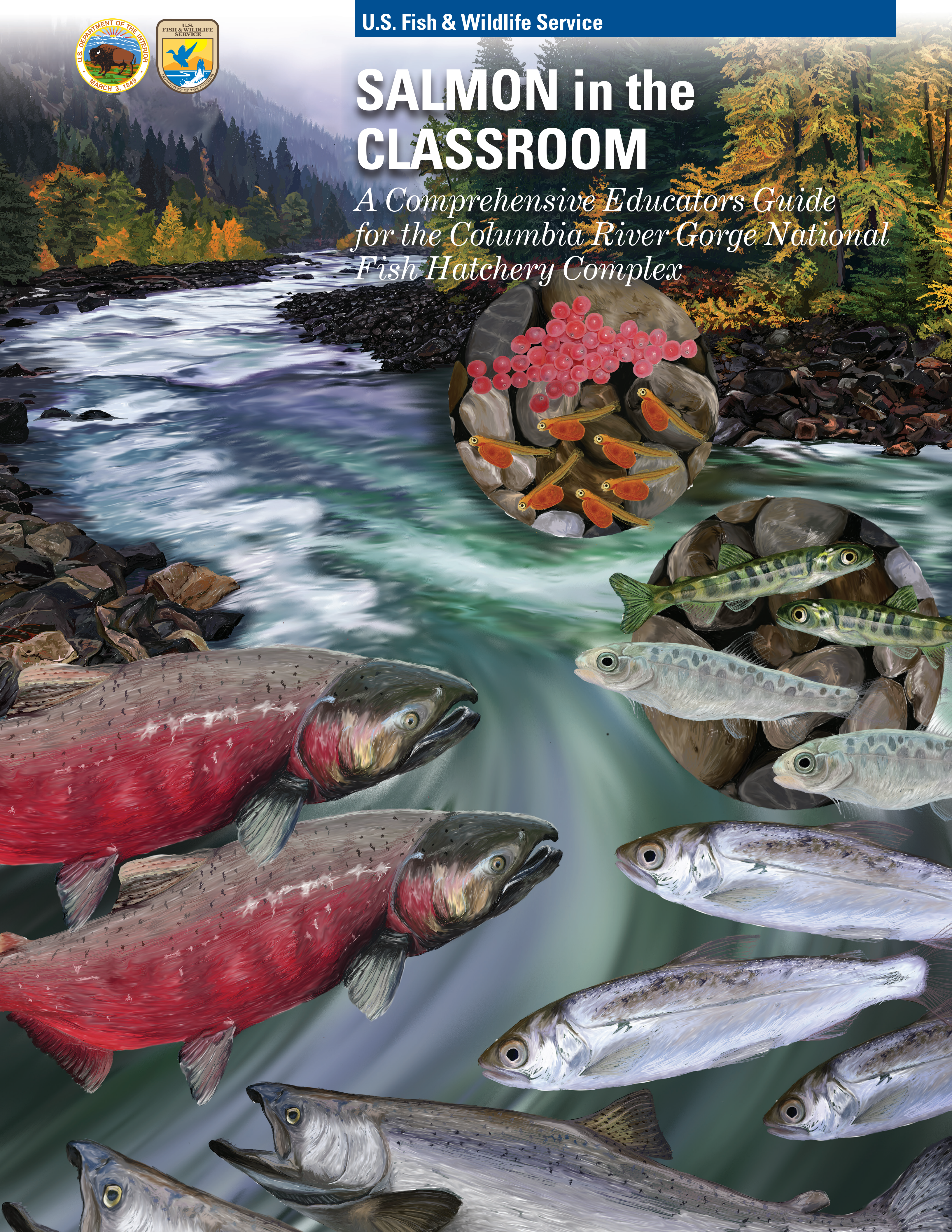
U.S. Fish & Wildlife Service

SALMON in the CLASSROOM

A Comprehensive Educators Guide for the Columbia River Gorge National Fish Hatchery Complex



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A Comprehensive Educators Guide
for the Columbia River Gorge National Fish
Hatchery Complex

U.S. Fish & Wildlife Service
Columbia Gorge Information & Education Office
61552 State Route 14
Underwood, WA 98651

509/493 2934 phone
509/493 1830 fax

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Dear Educator,

Congratulations! You are reading the guide to Columbia Gorge National Fish Hatcheries and Salmon, its development is based on the same framework of goals that distinguish the Columbia Gorge National Fish Hatchery Information and Education Office programs. Its content goes directly to the challenge of meeting the new standards of education of our schools and ties environmental education objectives to the Grade Level Expectations in all subject areas.

Research has now demonstrated learning in all basic subject areas is increased when the students can explore and apply skills in a real world context. With that in mind, the natural and human-made community around the hatchery can be a laboratory for learning and the abundance of excellent environmental education curricula can bring excitement and positive results from the process.

At no time in history has an understanding and maintenance of the environment been of such importance in the lives of everyone. As our region grows and changes, environmental challenges will continue to confront us. As educators, we are playing a critical role in preparing each generation to deal with these challenges thoughtfully and constructively.

We would love for you to call upon the Columbia Gorge Information and Education Office for assistance and information as you plan your instructional programs. We think this educational guide will assist this process and I welcome any thoughts you may have on how we can improve its content.

Sincerely,

Cheri A. Anderson

Cheri A. Anderson
Information and Education Manager
Columbia River Gorge Information and Education Office
61552 State Road 14
Underwood, WA 98651
509.493.2934
509.493.1830 fax
cheri_anderson@fws.gov
http://www.fws.gov/gorgefish

Helping Salmon Through Education and Stewardship

In addition to improving, identifying and carrying out habitat enhancement projects, the U.S. Fish and Wildlife Service (FWS) is committed to communicating with partners and the public to promote involvement and influence attitudes and actions with the goal of improving stewardship of our natural resources.

The Service encourages teachers in the Columbia River Basin to bring their students on tours of hatchery facilities. During these tours, FWS representatives from the Columbia Gorge Information and Education Office (I & E) explain how hatcheries operate and how they fit in the role of salmon enhancement. As a stand-alone piece or as a supplement, the hatchery will provide a 12 minute DVD, which addresses hatchery practices and environmental impacts.

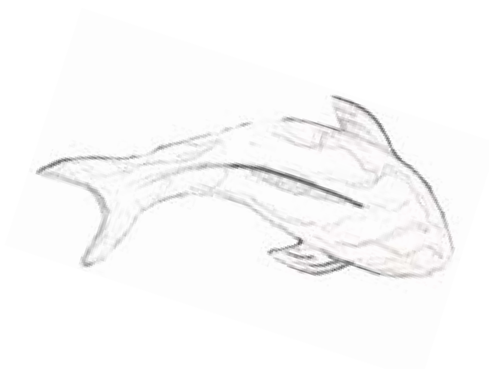
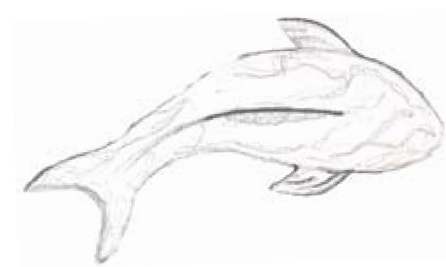
Finally, FWS supports the efforts of other organizations that try to teach people, particularly young people, about how they can help salmon. The FWS provides financial contributions as well as volunteer support.

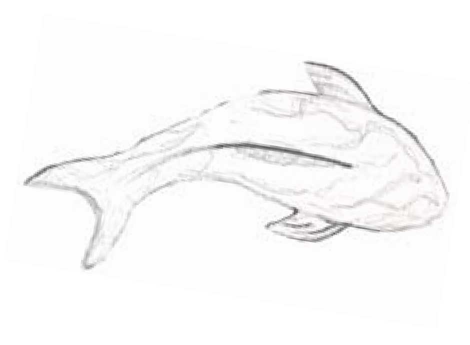
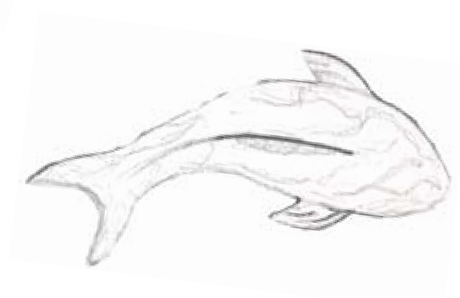
The I & E Office provides support to local schools by providing teachers with this course of instruction called Salmon in the Classroom. This educational curriculum for Columbia Gorge schools encompasses cross-curriculum programming for classrooms, field studies and work experience for all students. The education program gives students a first-hand experience of the natural world particularly the natural world of salmon. Classrooms can participate in a Watershed Assessment which can feature a monthly nature walk, observation of stream conditions, journaling and storytelling. The students can also participate in water quality monitoring, stream surveys and stream mapping. It is a way for students to learn a little bit more about the relationship between humans' activities and their effect on salmon and good stewardship.

Many other resources and teaching aids are also available from the I & E Office. They house an assortment of other curricula, Aquatic Education Bins (fin bins) and a wide array of videos. I & E staff are also available to assist in the classroom in a variety of exercises varying from assisting with a lesson to leading a salmon dissection. If you are interested in us assisting in your classroom, please give us a call at 509-493-2934.

Preparing for a Hatchery Visit

Activities:
- History of the Columbia River Hatcheries
- Columbia River Timeline
- Hatchery Operations

History of Columbia River Hatcheries

To understand the history of Chinook salmon hatcheries in the Columbia River Basin, we need to summarize the history of the rise and fall of Columbia River Basin Chinook salmon fishery. From the first known commercial venture in 1823 to about 1883, the salmon fishery was reaping the benefits of harvesting the lightly exploited populations of Chinook salmon.

In 1877, in response to a perceived decline of the salmon runs, and to avoid proposed restrictions in the fishery, Livingston Stone, a biologist from the U.S. Bureau of Fisheries, was sent to the Columbia River to help the Oregon and Washington Fish Propagating Company (OWFPC) build and operate a hatchery. A site on the Clackamas River was selected and hatchery buildings and racks across the river were constructed. OWFPC leased it to the State of Oregon five years later in 1882. In 1888, it was transferred to the United States Fish Commission. After 1888, there would never be another year in which the reproduction of salmon in the Columbia Basin was entirely natural. By 1928, fifteen hatcheries were operating in the basin and a total of 2 billion artificially propagated fry and fingerlings had been released into the river.

It is important to note that these early hatcheries were not built to save a species, but an industry. People and governments during this time were not focused on the cause of subsequent salmon declines or seeking to correct them, but rather would adopt what seemed a logical and relatively painless solution. If enough fish were not produced naturally, then they would fill the void themselves. Their goal - produce more fish for the commercial harvest. The far reaching impact of this "More is Better" approach to maintaining salmon numbers was not considered, or understood as an issue at the time.

The 1930's witnessed the beginning development of large hydroelectric dams on the main-stem of the Columbia River. The first surge of big river dam building on the Columbia during this period began with operations at the Rock Island Dam in 1933, Bonneville in 1938, and Grand Coulee in 1941. Over fishing was a primary factor in the decline of salmon runs. Additionally, the combination of big river hydroelectric development, timber harvest practices, increased agriculture and continued fishing pressure led to the collapse of the fishing industry on the Columbia River.

Artificial propagation has been an important tool used by salmon managers in the Columbia River Basin for the past 120 years. It was the first management activity undertaken in the basin. In the early years of its development, artificial propagation of salmon was carried out at a small scale in low cost facilities and required little effort. However as early as 1898, 26 million salmon fry were being released from hatcheries into the Columbia Basin each year. These early attempts at large scale propagation were largely ineffective, thus early hatcheries may not have had a significant effect on the number of adult salmon returning to the river. Nevertheless, the program did have a lasting and major influence on fisheries management, philosophy and approach.

Hatcheries are still a major part of the restoration program and make a significant contribution to the remnant runs of salmon into the river. Today, about 80 percent of the adult salmon and steelhead entering the Columbia River were hatched and reared in a hatchery. The National Fish Hatcheries have a unique responsibility in helping to recover species listed under the Endangered Species Act, restoring native aquatic populations, mitigating for fisheries lost as a result of federal water projects, and providing fish to benefit Tribes and national wildlife refuges.

Columbia River Basin Timeline

1792 - Capt. Robert Gray discovers the Columbia River
1800 - Smallpox epidemic decimates Indian populations in the Columbia Basin
1805 - Lewis and Clark explore the Columbia River Basin
1825 - Fort Vancouver established
1827 - First sawmill constructed at Vancouver, Washington
1830 to 1835 - Pestilence kills more than half the 80,000 Indians living in the Columbia River Basin
1848 - Oregon Territory established and gold discovered in California
1853 - Washington Territory established
1866 - First salmon cannery built on the Columbia River
1871 - Congress creates the United States Fish Commission (former U.S. Fish and Wildlife Service)

- *Pre-1877 - Before Europeans arrived in the basin, Native American tribes used salmon primarily for subsistence and trading. Defacto fishery management occurred through tribal cultural practices and harvest techniques.*

1877 - The OR and WA Fish Propagating Company constructs the first salmon hatchery on the Clackamas River.
1878 - First fishwheel erected at the Cascades (present day Cascades Locks)
1880 - Splash dams introduced to timber harvest techniques
1883 - 55 canneries operating on or near the Columbia River
1884 - Columbia River canneries pack 629,400 cases of salmon annually
1885 - Columbia River canneries pack 553,800 salmon cases annually
1887 - Columbia River canneries pack 356,000 salmon cases annually
1889 - Washington obtains statehood
1896 - Little White Salmon Hatchery built
1899 - 76 fishwheels operating on the Columbia River
1900 - Large scale logging begins in the Columbia Basin
1901 - Big White Sub-station in operation. (Spring Creek National Fish Hatchery)

- *1877 to 1910 - <u>Hatchery Program Goal</u>: To supply the fishing industry.*
  <u>Program Development</u>: In 1866 the first cannery opened on the Columbia River, Washington canneries packed about 4,000 cases of canned fish. The canning industry rapidly reaches a high of 629,000 cases in 1883 and declining to 321,000 cases by 1889.

1910 - Only 10 canneries remain in operation
1912 - Trolling for salmon begins off the mouth of the Columbia River
1920 - Population soars to 2.5 million in the Pacific Northwest
1920's - Annual salmon harvest is approximately 34 million pounds
1926/27 - Oregon state outlaw's fishwheels on the Columbia River

- *1910 to 1930 - <u>Hatchery Program Goal</u>: To supply the fishing industry.*
  <u>Program Development</u>: During the early 1900s over harvest of natural runs in the basin continued. Habitat destruction also continued as the building of small dams, logging, irrigation diversions, mining and other activities became more widespread and severe. As a result catches continued to decline despite increased artificial propagation. If an effort to improve adult returns hatchery managers began examining their hatchery rearing practices. To increase the commercial catch managers commonly transferred stocks among hatcheries and around the basin as needed to meet hatchery production objectives. There was not a clear understanding of the donor stock suitability and little if any consideration was given to where they were transferred from. They also planted hatchery fish throughout the basin without regard for potential impact on native fish since there was little concern about the interaction between hatchery stocks and natural or wild stocks at the time. Fishing laws during this period were few and not well enforced.

1930's - Annual harvest decline to 24 million pounds

1933 - Rock Island Dam completed

1933 - Bonneville Dam project begins

1934 - Washington state outlaw's fishwheels on the Columbia River

1938 - Bonneville Dam completed

1940's - Annual harvest declines to 20 million pounds

1941 - Grand Coulee Dam is completed

1950's - Annual harvest drops to 9 million pounds

- *1930 to 1960 - <u>Hatchery Program Goals</u>: To supply fish for sport and commercial fishing and mitigate for lost habitat.*

  <u>Program Development</u>: Several critical changes in the Columbia River watershed during this period dramatically transformed the ecosystem and its ability to support meaningful natural anadromous fish production. These changes resulted in the decline and even extinction of many important salmon runs. Beginning in the 1930s, a series of large, multipurpose dams were constructed on the main-stem Columbia and Snake Rivers. Losses in fish production and habitat during this time were compounded by continued logging, fishing, agricultural, mining and other land-use activities. Following dam development on the Columbia and Snake River, a large number of hatcheries were upgraded or built to mitigate or compensate for habitat losses. Funding for these upgrades or new hatcheries was provided under the Mitchell Act, passed by Congress in 1938.

1960 to 1970 - Fourteen high dams completed on the Columbia River

1970 to 1980 - Commercial catch declines from 12 million pounds to 1.2 million pounds per year

- *1960 to 1980 - <u>Hatchery Program Goals</u>: To supply fish for sport and commercial fishing and mitigate for lost habitat.*

  <u>Program Development</u>: Several major shifts in outlook occurred during this period. The conservation of fishery resources emerged as a necessary public value rather than an amenity, reflecting a growing awareness of ecological values. Also during this period, beginning in 1977, the basin began experiencing what was to become a major drought cycle.

1980 - Northwest Power Act signals a new era to preserve and restore the region's anadromous runs

1985 - U.S. Canada Pacific Salmon Treaty

- *1980 to Present - <u>Hatchery Program Goals</u>: To mitigate for lost fish resulting from habitat destruction and to conserve genetic resources.*

  <u>Program Development</u>: Today, the Columbia River Basin contains over 90 artificial production facilities. Roughly three-quarters of the basin's adult salmon come from these hatcheries (ODFW and WDFW 1995). These facilities are operated by several different entities with separate mitigation obligations.

General Hatchery Operations

The Hatchery Life Cycle

Fish hatcheries are somewhat similar to agriculture in that they acquire their “seed” (eggs) from a chosen source, cultivate their seed and then release the product. There are differing operations depending upon water supplies, species produced, and number of physical, behavioral and physiological objectives.

Most hatcheries in the basin have enclosed areas that provide for inside incubation of eggs and sometimes the rearing of small fish called “fry.” Outside facilities generally consist of ponds and/or cement holding areas for rearing fish to the larger size of smolt.

The preferred water supply for a fish hatchery is a large spring. Because spring-fed water supplies are scarce, most Columbia River hatcheries use tributary water. Water temperatures are critical to the success of a hatchery, as salmon rear best at temperatures in the mid-50°F. Both Spring Creek and Carson National Fish Hatcheries are spring fed.

Traditionally, hatcheries in the Columbia Basin acquire fish eggs directly from adult salmon that come back to the hatchery. To facilitate this return of adults, the hatcheries release their smolts at or near the hatchery. When they return as adults they will be held for a short period and checked periodically to determine if the males and females are mature. When the eggs and milt flow freely, hatchery operators remove or “strip” the eggs from the female and fertilize the eggs with sperm or “milt” from the male.

The eggs are then moved to the incubation building and placed in incubator trays where they are held until they “eye up,” a developmental stage where an eye is clearly visible in the translucent egg. At this time the eggs develop some resistance to shock and can be moved if required or stay until they hatch. Because salmon are cold-blooded, hatching time is directly dependent upon water temperature. For instance, eggs that are placed in the incubation tray with water about 50°F would hatch in about 50 days. The warmer the water the faster the eggs will hatch.

During incubation water flow (to deliver oxygen and carry away waste products) and temperature (40° to 65°F) must be suitable. Salmon are cold water fish and do not tolerate temperatures above 68° F.
Newly hatched fish are called “sac fry” and have their own food supply in the form of an attached protein sac. Once the young have exhausted this self-contained food source, they have become fry and will be moved to outside raceways. One important part of the rearing program is feeding the fish. The fish food is a carefully manufactured diet developed by biologists to ensure maximum growth.

Fish are reared at the hatchery between 90 days and 16 months, depending on the species. Releases are carefully planned to reduce interaction and competition with wild species. Once grown to a decided size or correct physiological stage, they are released directly from the hatchery into the watershed.

The salmon are anadromous, meaning they will spend part of their life in the ocean (the average is two to three years) and part in fresh water. This allows them to take advantage of the abundant resources and habitats offered by both.

Hatchery Fish

The Arguments For and Against

- We have a moral obligation to do something about the fish populations that are dying.
- Hatchery fish compensate for declines in native fish populations.
- Hatcheries help support the economy of the region by supplying fish.
- Hatchery fish help support the angling industry.
- 80% of the salmon caught by the commercial fishing industry are hatchery fish.
- The salmon are of great traditional importance to Native Americans.
- Hatchery fish could be used to supplement natural stocks.
- We have a moral obligation to do something to repair the habitat that we have destroyed.
- Hatcheries create a false sense of abundance, making people less concerned about conserving the habitat that remains.
- Native fish waste precious energy competing against hatchery fish for limited resources.
- Hatchery fish are more prone to disease than native fish.
- When native fish die, their carcasses provide nutrients to the rivers and streams where they spawn.
- Native fish learn to avoid predators, and find food on their own.
- Hatchery fish are hand fed by humans.
- Through a process called natural selection, the native fish that are best suited to their environments are the fish that survive to spawn.
- Genes carry pieces of information that allow fish to inherit traits from their parents. In a population of natural fish with al 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.
- Populations of hatchery fish have less genetic diversity than populations of native fish because hatchery fish have had fewer ancestors than wild fish.
- Raising hatchery fish is very expensive.

Meet the Fish

U.S. Fish & Wildlife Service Take Home Messages

"Salmon issues are extremely complex and include species other than salmon"

The issues involve watershed health, other species and broad scale efforts to increase survival at all stages of the salmon life cycle.

- Twenty -three (23) Pacific salmon and steelhead populations are presently listed under the Endangered Species Act on the west coast. Many more are at significant risk of further decline and require changes in management of Hydro facilities (dams), Habitat protection, Harvest (fishing), and Hatchery operation to recover/restore.

- The salmon issue is more than salmon; it is a watershed health issue that effects many other species, e.g. bull trout, cutthroat trout, snails, sturgeon.

- Salmon issues are international in scope and complexity with significant implications to federal responsibilities to treaties with Native American Tribes and Canada.

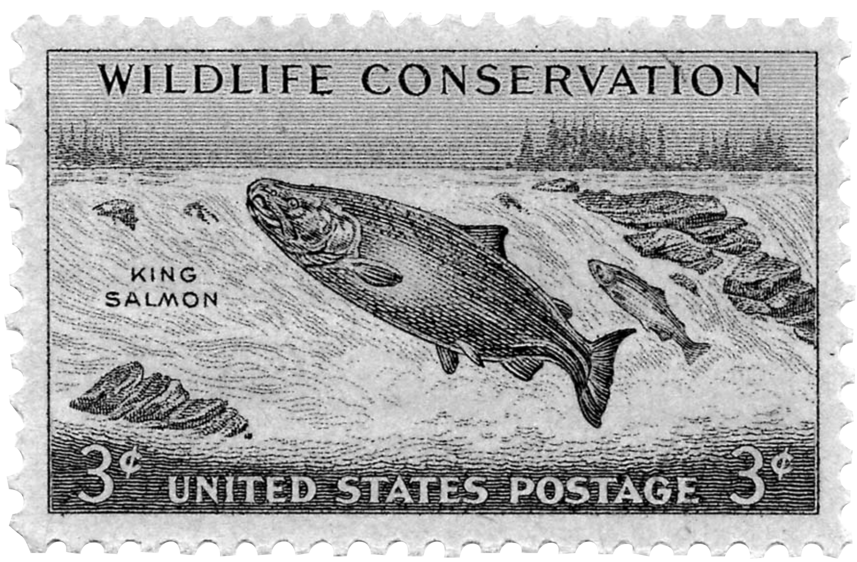
- The problems are large, complex and cut across agency and governmental boundaries, therefore no single agency is in charge or can restore salmon on their own. It will require a coordinated state, tribal, and federal effort.

"The Fish and Wildlife Service is a key <u>action</u> agency for salmon recovery"

- The Service has been active in salmon restoration since the first Commissioner of Fisheries sent an expedition to explore the reasons for decline of Columbia River salmon in the 1880's.

- The Service began the first Federal salmon restoration effort with construction of Federal hatcheries in California and the Columbia River in the 1880's - 1890's.

- From the early efforts in the late 1800's, the Service evolved beyond fish culture into over 40 offices and field stations strategically positioned on major aquatic systems of the west from San Francisco Bay to Puget Sound, to the Columbia River, to Alaska and is actively engaged in all Hydro, Habitat, Harvest and Hatchery (these are referred to as the four H's of Mangement) salmon issues dealing with habitat restoration, harvest management, hydro operations, hatchery management, Endangered Species Act recovery, and more.



Pacific Salmon

There are five species of Pacific salmon: Chinook (king), Chum (dog), Coho (silver), Pink (humpy), and Sockeye (red). All pacific salmon are anadromous, meaning they spend part of their life in the ocean and part in fresh water. That allows them to take advantage of the abundant resources of the ocean and the protection fresh water habitats offer for spawning. In the rich ocean environment salmon can grow rapidly, gaining over a pound a month. These salmon mature and return to freshwater within 2 - 8 years.

As salmon grow in the ocean environment, they are essentially accumulating marine nutrients and storing them in their bodies. Pacific salmon spawn only once in their life cycle and during this event they transport those nutrients back to their stream of origin when they die and decay. Salmon release their eggs and milt back into the freshwater to re-seed the cycle. Eggs that don't get buried in the gravel become immediately available as food for other fish, birds and insects. After spawning the salmon die, and as they decay valuable nutrients are released. These nutrients fertilize the water that feeds the developing salmon, filter feeding insects, and aquatic and terrestrial plant life. This process of salmon accumulating marine nutrients and returning them to freshwater streams has been referred to as "the great nutrient cycle."

One of the most amazing facts about Pacific salmon is their ability to return to their "natal" or home stream or lake. Salmon are thought to use several navigation aids to find their way back to where they were hatched. Scientists believe salmon use a combination of a magnetic orientation, celestial orientation, the memory of their home stream's unique smell, and a circadian calendar to return to their natal stream to spawn. The memory and smell centers' in a salmon's brain grow rapidly just before it leaves its home stream for the sea. A salmon can detect one drop of water from its home stream mixed up in 250 gallons of sea water. Salmon will follow this faint scent trail, with the aid of the other methods mentioned above, back to their home stream to spawn.

Although a single female salmon can lay 1,000 to 7,000 eggs, very few of those eggs actually survive from fertilization to maturity. An average of 3 fish returning from every parent fish that spawns would be considered good production. Many natural and human-related factors cause this high mortality. During spawning, eggs may not be fertilized, or may not get buried in the gravel before they are either eaten by predators (birds and fish) or become damaged as they bounce along the river bottom. Some eggs may not mature and hatch due to freezing, drying out if the water level drops too low, being trapped in the gravel, or silt smothering the eggs.

Those eggs that successfully hatch to the "alevin" stage continue to grow, and then emerge from the gravel as "fry." Fry become subjected to a whole new batch of obstacles (dams, irrigation systems, development, etc.) and predators, since salmon at this stage are near the bottom of the food chain. Pink and chum salmon juveniles head out to sea immediately. The other species may spend as many as two years in freshwater before their seaward journey. During times of these seaward migrations you can find corresponding concentrations of predators, such as arctic terns, gulls and other fish species.

Columbia River Salmon Species

Courtesy of the Northwest Power Planning Council

Along the rim of the Pacific Ocean from Asia to North America, live five species of salmon and steelhead (an ocean-migrating trout) belonging to the genus Oncorhynchus (meaning hooked snout). The six described on these pages Sockeye, Coho, Chinook, Chum, Pink and Steelhead–are native to the Columbia River Basin. A seventh species, the cherry salmon (Oncorhynchus masu), is found only in Japan, Korea and the Soviet Union.

The Columbia River system produces more steelhead than any other river system in the world. Steelhead were once considered a form of trout, more closely related to Atlantic salmon than Pacific and Asian salmon. In 1988, however, after years of debate and study, Pacific steelhead were reclassified as members of the genus Onchorynchus.

Sockeye Salmon *(Oncorhynchus nerka)*
(Known as red in Alaska or blueback in the Columbia Basin)
Sockeye, the most common salmon in the Pacific, spawn in streams that have lakes in their watershed. Historically there were eight lake systems in the Columbia River Basin inhabited by sockeye. Today only Lake Wenatchee in Washington and Osoyoos Lake in British Columbia produce any significant numbers, although a remnant run is still produced in Idaho's Redfish Lake. Landlocked forms of sockeye salmon, called kokanee, or little redfish are found in some lakes and many reservoirs in the Columbia Basin.

After hatching, the young Sockeye spend from one to three years in the lake before migrating to the ocean. Then, between their first and fourth year at sea, the adults weighing an average of 3 to 5 pounds, return to the Northwest streams from July through October to spawn and produce their next generation.

Coho Salmon *(Oncorhynchus kisutch)*
Coho were originally found in many North American streams from the Bering Strait to the Sacramento River. They rarely travel far inland, preferring, in the Columbia system, to spawn in the lower river tributaries below Bonneville Dam. However, in the past, some have migrated as far as the Spokane River. The young fish spend one year in the natal stream, then typically two years in the ocean before returning from early October through late December to the natal stream. Coho at maturity weigh about 7 to 9 lbs.

Chinook Salmon *(Oncorhynchus tschawytscha)*
Chinook are the most important salmon species for West Coast sport and commercial fisheries and are found from the Bering Sea to Monterey Bay. They also have been successfully introduced in the Great Lakes and in New Zealand. Chinook reach maturity when they are between 3 and 7 years old–living the longest of the Pacific salmon. They are also the largest of the salmon, with recorded weights over 100 lbs.

In the Columbia River system, most Chinook return to spawn in the spring or fall, but some can be found in the river almost any months of the year. Before dams blocked off the upper Columbia, Chinook spawning grounds extended from the lower tributaries to the top of the basin in Canada.

The three major divisions in the Chinook species are based on the season of their adult migration to the spawning streams; spring, summer and fall. Each division has two segments based on where they spawn.

The fish of the lower river spring run migrate upriver from January to May, with the peak in late March or early April, and head for the river's tributaries below Bonneville Dam. The upper river spring Chinook run journeys to the Snake and upper Columbia tributaries in late March through May, peaking in late April or early May.

Summer Chinook return to the river system in June through August. One segment heads for the Salmon River drainage in Idaho and the other for tributaries of the Columbia above the confluence with the Snake River. These fish probably were the bulk of the lower river commercial catch in the late 1800s.

From August through December, one segment of the fall Chinook run, called tules, goes to the lower river in early August through December and the other, the upriver brights, continues on to the mid-river tributaries between Bonneville and McNary dams.

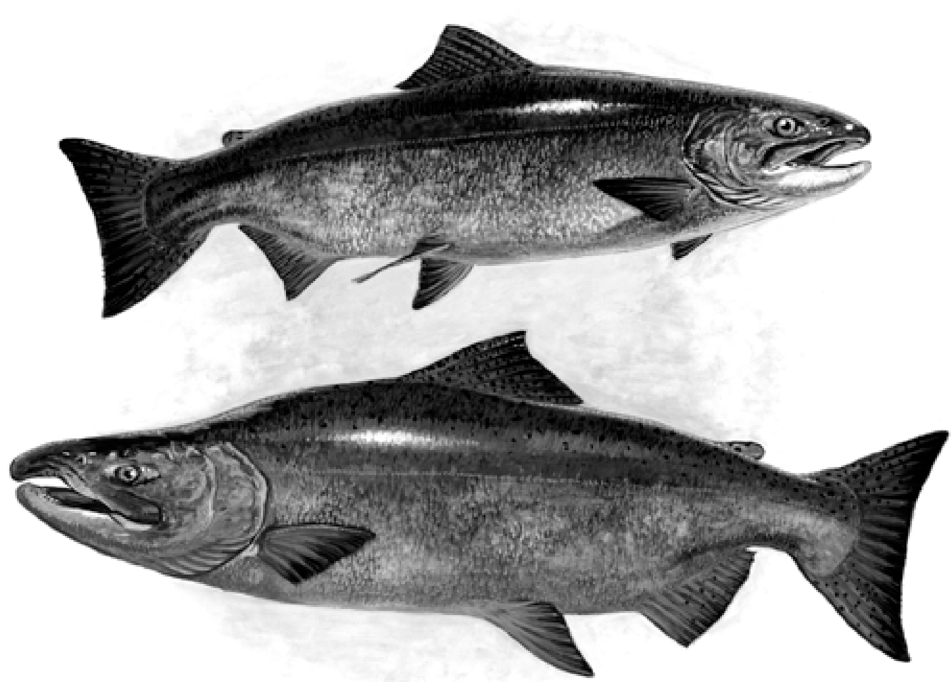
Chum Salmon *(Onchorynchus keta)*
Chum are the second most abundant species along the whole Pacific Rim, although relatively few are found in the Columbia River Basin. Those few enter the Columbia River in mid-October and November heading for the lower tributaries primarily in Washington. Young Chum start for the sea almost as soon as they hatch. Formerly quite abundant in the Columbia Basin, they have declined drastically in numbers this century because of habitat degradation. This degradation primarily is the result of logging activities near spawning streams.

Steelhead Salmon *(Oncorhynchus mykiss)*
Steelhead long were considered ocean-migrating tout and close relatives of Atlantic salmon. In 1988, after years of scientific debate and study, steelhead were reclassified by the Names of Fishes Committee of the American Fisheries Society as members of the family of Pacific salmon.

Like the Atlantic salmon, they do not always die immediately after spawning–some have been known to spawn three times. (In contrast, other Pacific salmon spawn only once before dying.) After hatching, juvenile Steelhead stay in the stream for one to two years. The adults will return to that stream to spawn in their third, fourth or fifth year. At maturity they can weigh up to 40 pounds.

Winter Steelhead migrate in November though June heading to the lower Columbia tributaries to spawn. Summer steelhead migrate from June to October. This migration is divided into two segments: group A–smaller fish returning to the mid- and upper Columbia and Snake River tributaries and group B–larger, later fish that spawn primarily in the Clearwater River drainage in Idaho. Steelhead are rarely caught in the ocean, but are an important sport fish in Idaho, Oregon and Washington.

Pink Salmon *(Oncorhynchus gorbuscha)*
Only a few pink salmon are found in the Columbia River– the southernmost extent of their range. Most are native to Alaska, British Columbia and Puget Sound. Pinks are the smallest of the Pacific salmon, weighing only about 4½ pounds.



Up Close and Personal

With a Hatchery Fish at Spring Creek NFH

Who gets the salmon?
More profoundly than any other species in the Pacific Northwest, salmon are part of our identity. To tribes, salmon are spiritual, cultural and physical nourishment. To sport fishers, they are recreation, time outdoors, and the heart and soul of a fishing trip; to commercial fishers, a livelihood; to the Pacific Northwest, an icon of our environment.

How different are they?
Hatchery fish do differ from wild fish in their early life stages. Hatcheries provide protection from adverse environmental conditions that salmon might experience in the wild. However, streams are more dynamic and prepare young fish for the rigors of surviving in a wild environment. But as adults, both hatchery and wild salmon face the same trials in their journeys to and from their ocean habitat.

Where do hatchery fish come from?
Historically, all salmon reared in hatcheries were derived from wild fish produced in the natural stream environment. As compensation for the losses of wild salmon production, artificial propagation facilities (i.e. Hatcheries) were built throughout the Columbia Basin.

What kind of fish is raised at Spring Creek National Fish Hatchery (NFH)?
Tule Fall Chinook salmon are raised at this hatchery. They are indigenous to the White Salmon River. That means they lived in this part of the Columbia River even before we began raising them and releasing them back into the river. The Spring Creek NFH has been here since 1901, and has reared tules for over 100 years.

How old are the adults when they return?
Most of the adult fish returning to the Spring Creek NFH are 3 to 4 years old.

How big are the fish when they return?
The average weight of the fish when they enter the Spring Creek hatchery is about 23 pounds. The biggest recorded fish that returned to the hatchery was 63 pounds. When Tule Fall Chinook enter fresh water they stop eating and use stored energy to return to their spawning area. By the time they enter the hatchery, they have lost 25% to 30% of their ocean body weight.

How many fish does the hatchery need to get enough eggs?
The Hatchery needs about 10,000 returning adults in order to take the 20 million eggs needed for full production. Each female has an average of 5,000 eggs. The hatchery releases 15.1 million smolts annually.

Did you Know?

- The oldest verified fossil for a freshwater version of the salmon is 50 million years old. Five to six million years ago salmon had fangs, weighed 500 pounds, and were ten feet long. The modern anadromous Pacific salmon emerged about two million years ago in the cold mountain streams of the Pacific Northwest.

- Salmon species have adapted to use virtually every part of every stream here in the northwest. Big rivers are used by pink salmon in the lower reaches, Chinook in the mainstream and larger tributaries, Coho in small tributaries.

- Small streams are used by chum in the lower reaches, and Coho next.

- Humans have given many nicknames to salmon. Chum are often called “dogs” because of large canine teeth they develop during spawning. They are also called “calicos” because of their bright spawning colors. Spawning pink males develop a large humped back and are called “humpies.”

- Salmon do not have ears. Instead they hear low frequency sound waves which vibrate through water to a row of sensory pores, called lateral lines, on the sides of the salmon. Scientists believe lateral lines also may help salmon navigate in the ocean.

- A moving fry is much easier to see than a motionless one. This is why salmon tend to spawn in parts of the stream that their offspring use for rearing; the emerging fry do not have to travel far to find rearing areas.

- The size of a salmon is usually related to its age. Pink salmon are the smallest fall-spawning salmon and are also the youngest, at two years. Chinook can live up to nine years, the longest, which is why some Chinook can grow to over 100 pounds.

- There is a sixth fall-spawning salmon, the masu, or cherry salmon, which is found only in Asia. This fish occupies the same niche that the sea-run cutthroat trout (or steelhead) occupies here in North America.

- Salmon in their saltwater phase travel around 18 miles a day, but are capable of maintaining an average of 34 miles per day over long distances. Salmon often travel much more slowly to feed.

- Coho and sockeye are found in freshwater year round; Coho in small costal streams and sockeye in lakes. They are very susceptible to poor water quality, such as high temperatures and pollution.

- Young salmon moving to sea travel at night to avoid predators. They also drift backwards facing upstream which may allow them to continue feeding and also may provide better control in the downstream current.

- Salmon need cold, clean, well oxygenated water. Even salmon raised in hatcheries spend some portion of their lives in a river or stream. Without healthy watersheds, salmon cannot survive.

- The Chinook salmon is also known as the “King” or “Tyee” (meaning chief) salmon. It is the largest of the salmon species, weighing in at records of 125 pounds.

- Scientists call Pacific salmon Oncorhynchus, the Latin word for “hooked snout” because of the curved jaws which develop during sexual maturation.

- Salmon from many rivers swim together in the same areas through much of their ocean going life.

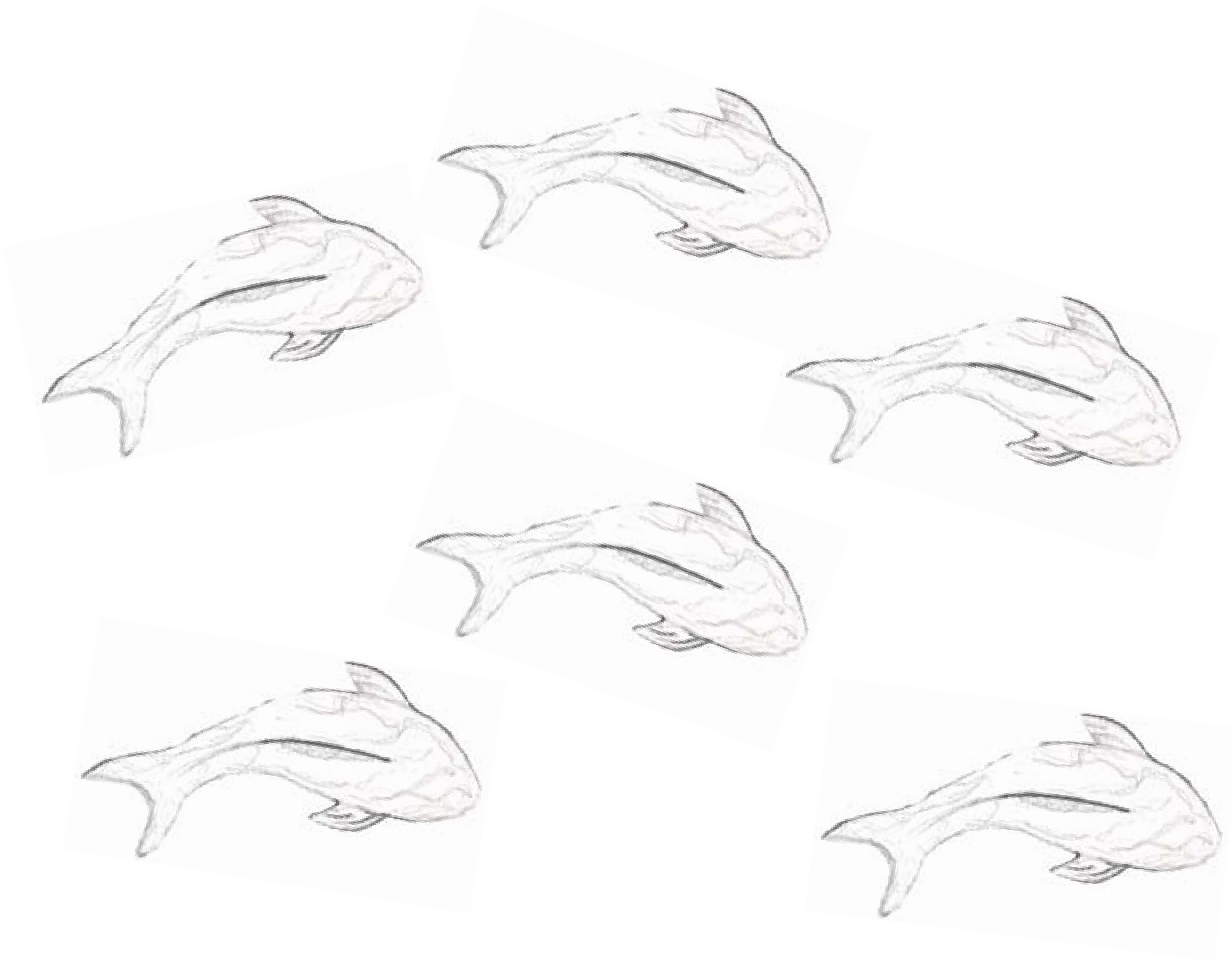
- Salmon in one run may have different weights and sizes; a three year old may weigh 4 pounds, while a seven year old might weigh 50 pounds.

- “Jacks” are small salmon, usually males, which mature after spending only one winter in the ocean before returning.

Lesson 1 – Habitat, Ecosystems and Salmon

Purpose:
This lesson is designed to explore the concepts of habitat, ecosystem and the food chain/web and how these concepts relate to Pacific Salmon. It will also illustrate the effects of removing any one part from an ecosystem to gain an understanding of just how closely related all components of the system are.

Activities:



Habitat

Background Information

All species of animals and plants need a proper combination of food, water, cover, and space in order to live and reproduce. Together, these elements make up their "habitat," an area meeting these needs. Habitat is the key to the survival of any species.

Why Habitat Needs Vary

The specific habitat requirements of many animals and plants differ, although a variety of species may live in the same area. White-tail deer, ruffed grouse, and tree squirrels, for example, prefer woodland, while cotton-tail rabbits and song sparrow favor fields. Waterfowl, fishes, mussels, and pitcher plants are at home in wetlands or rivers, while other species, such as the desert tortoise and most cacti, depend on dry habitat. The common pigeon, starlings, and roof rats can easily adapt to the urban habitats of large cities, towns, and suburbs.

Some animals may require different habitats at various stages of their lives. For example, salmon need clean, cold water in which to live and reproduce. They begin their lives as fertilized eggs in fresh water. Adult salmon lay and fertilize their eggs in clean gravel nests known as a redd. Depending on the species, some salmon may stay in streams or lakes for months or even years after hatching. Others go directly to the ocean to feed and grow in the estuaries or bays. Eventually they all make it to the ocean were they will live from one to eight years depending on the species, with the average being three years.

Habitat and Endangered Species

Conserving habitat is especially critical for the continued survival of endangered plants and animals. Habitat loss or degradation is often the key factor which has led to a species becoming endangered.

Another factor contributing to the imperiled status of many endangered species is a lack of adaptability to different environmental conditions, such as habitat. If a species can only live in a certain type of habitat, such as grassland, and much of that habitat is destroyed, the species may become endangered. The salmon - a fish on the verge of extinction - has declined, in part because of the loss of its habitat. Salmon need large expanses of clean, cold fresh water to reproduce. When salmon lay their eggs, they find gravel bars in the streambed where the eggs can settle, hidden from predators such as crayfish. After the young salmon hatch, they must have aquatic plants, quiet pools, and bottom rubble to provide cover to escape great blue herons, mink, and other predators.

Protecting Habitat Helps People Too

Wildlife and plants, especially those species which are endangered, are often viewed as the "canary in the coal mine," serving as a warning signal that the environment is about to become unhealthy for people, too. For example, many mussel species are endangered because of pollutants in the water supply - the same water supply people often depend on for their drinking water.

Creating, restoring, enhancing, and protecting areas of habitat can prevent the loss of wildlife. Conserving remaining areas of wildlife habitat is a large but very important task. Every concerned citizen can become involved. To learn more about wildlife and its habitat in your area, contact the state or local natural agency, local chapters of conservation organizations, or the U.S. Fish and Wildlife Service.

Ecosystems and Salmon

Ecosystems Depend on Salmon

More than 137 species of fish and wildlife - from Killer Whales to caddis flies - depend on the Northwest Pacific salmon for their survival, and that should make salmon recovery efforts of far greater importance than just producing them artificially. It is well documented that salmon have always played a vital role in a watershed as a food staple for humans, but little has been documented on the role they play on the health of a watershed.

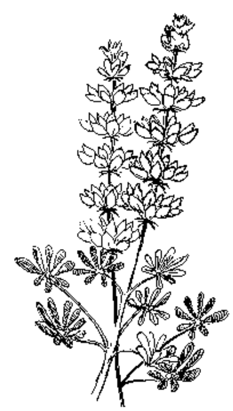
When Pacific salmon return from the ocean, they bring back vital nutrients to their watersheds. The carcasses and eggs contributed by the spawning fish are eaten directly by juvenile salmon, other fish, insects and wildlife. Salmon are not only feeding their own young, they are feeding the whole neighborhood. Many species depend on salmon both directly and indirectly - feeding on salmon as well as preying on species that eat salmon. The insects feed on the carcasses, and then become food for adult and juvenile mammals, birds, and fish.

Putting the Nutrients Back

In recent years, hatchery salmon carcasses have been reintroduced to streams all over the Northwest in an effort to restore some of the lost nutrients. This method of nutrient enhancement is not without concern. The distribution of carcasses into the stream environment is limited because of the possibility of spreading disease and the difficulty of accessing remote areas for distribution. Resource managers also recognize the importance of not introducing fish from other areas or watersheds. *The ideal situation is to use local carcasses from local hatcheries raising local fish.*

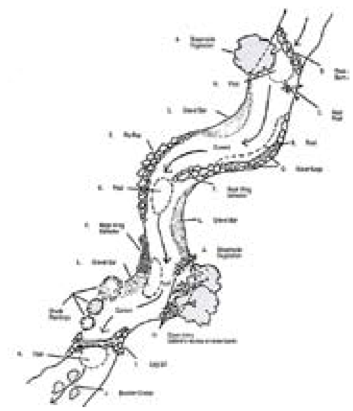
For years, hatchery fish have been used to make organic fertilizer. Now they are being used to develop a whole new product – fish bricks and fish pellets. The fish bricks or fish pellets are not new, but what they are being used for is - nutrient enhancement to watersheds. These new fish bricks and fish pellets are in a limited amount being introduced to watersheds rather then salmon carcasses. The introduction of marine derived nutrients in brick or pellet form addresses some of the concerns, like disease. Another problem is that many spawning grounds that need nutrients are located in places far away from roads and trails. The fish brick or fish pellet would be easier to pack in - with less weight and the mess of using frozen fish. But you have to remember this only helps a portion of a watershed inhabitancy, where the salmon carcasses feed a broader range.

You may also look at the salmon life cycle as a “primitive form of childcare.” By going out into the ocean, feeding and storing nutrients, then returning to their stream of origin to enrich the habitat, salmon evolved to give their young a better chance for survival. Looking closer at this interconnected web of 137 species, including mammals, birds, reptiles and amphibians, you will find that several species depend on salmon both directly and indirectly - feeding on salmon as well as preying on species that eat salmon. Many insects feed on salmon, and then become food for juvenile salmon.



Nutrients from salmon carcasses even find their way into the trees that shade the streams, keeping the waters cool the way young salmon like it. The trees drop organic matter into the streams, which again indirectly feeds young salmon. In recent years both Oregon and Washington have started seeding hatchery salmon carcasses in the rivers to return some nutrients, but a lot more is needed. It will require a major shift in the way we value salmon - from purely commodities to an appreciation of the ecological role in maintaining healthy watersheds.

Home Wet Home – An Activity



This activity was adapted from:
The Stream Scene
Watersheds, Wildlife and People
by Patty (Farthing) Bowers et al
Oregon Department of Fish and Wildlife 1990

Key Concepts:

- Salmonids need certain habitat components to live in a stream.
- Structures in and near streams have benefits for fish.

Teaching Information:

Students should read the background material provided in the activity, analyze the stream diagram and describe how each item noted develops or provides suitable fish habitat. This activity fosters ideal small group work.

Once students have completed the activity, visit an actual stream where they can identify the stream components used in the activity. Since most hatcheries have streams on or next to the hatchery grounds, this could be done during a hatchery visit.

Materials:

- Copies of student sheets (Home Wet Home…)

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

C. Root Wad
Provides shade, cover, and resting areas.

D. Cover Logs
Provides shade, cover, and resting areas.

E. Rip Rap (rocks and vegetation)
Protects banks from erosion

F. Rock Wind 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.

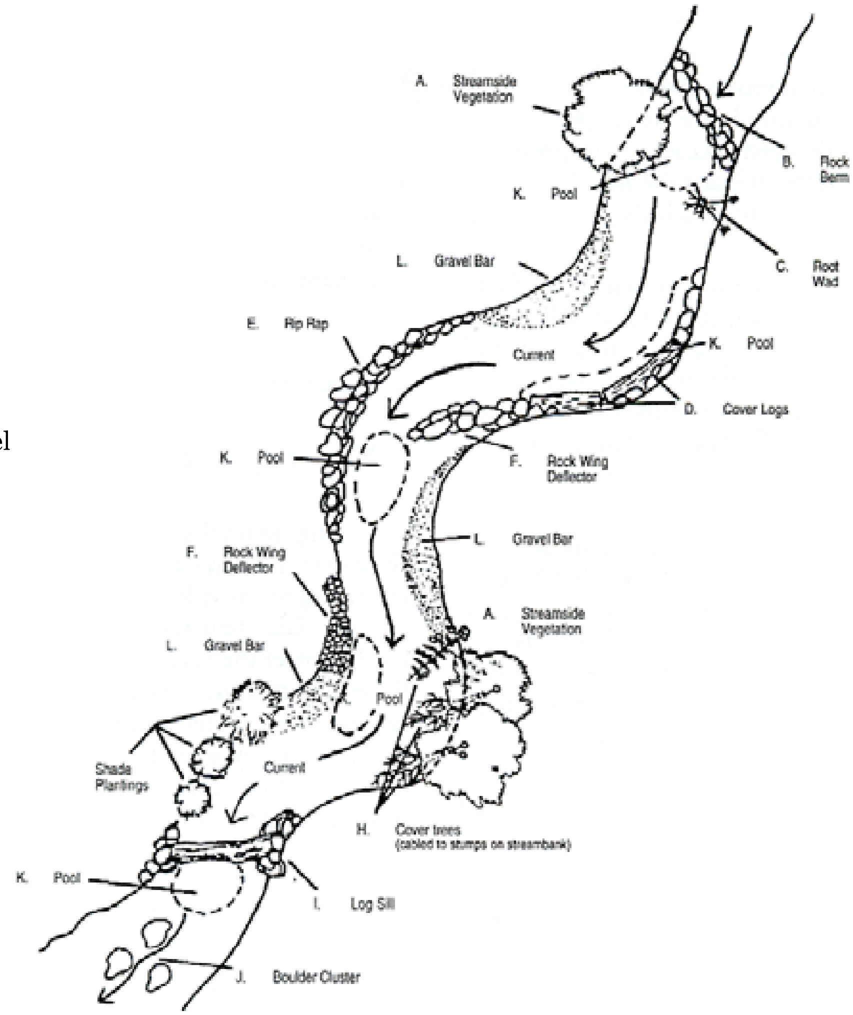
H. Cover Tree
Provides shade, cover, and resting areas, and produces spot scouring.

I. Log Sill
Traps gravel for spawning and creates pools and cover.

J. Boulder Cluster
Changes the flow pattern and provides cover; pocket diversity of habitat.

K. Pool
Provides a resting area.

L. Gravel Bar
Provides spawning habitat.



Home Wet Home

Do you know...
Salmon and trout (salmonids) are important to anglers. Salmon are also important to biologists because their presence helps indicate the health of the stream in which they live.

Salmon 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 salmon as “indicator” species.

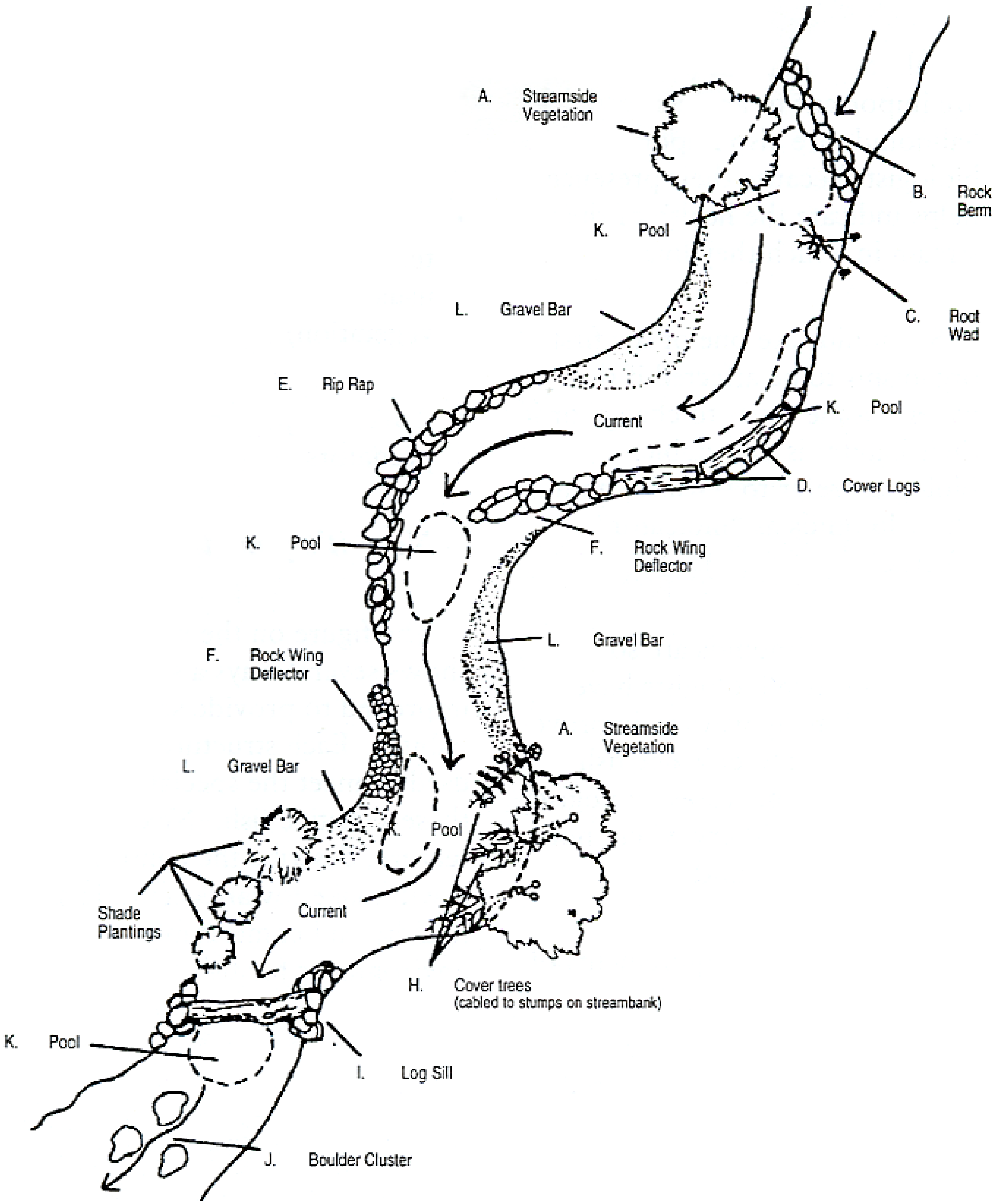
Because salmon are so significant, fish biologists have developed many ways to improve stream habitat to enhance fish survival. In some cases, biologists can produce a fishery where none was previously found.

The ecological requirements of salmon 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 stream-side vegetation)
- Cover for protection from predators

Now it’s your turn…
The figure on the next page shows several ways a stream can be improved to provide salmon habitat. Each structure has been used to meet the special needs of these sensitive fish. Next to each feature, describe the contribution it will make towards creating a healthy and comfortable environment for fish.

Home Wet Home



Riffles and Pools – An Activity

This activity was adapted from:
The Stream Scene
Watersheds, Wildlife and People
by Patty (Farthing) Bowers et al
Oregon Department of Fish and Wildlife 1990

Key Concepts:

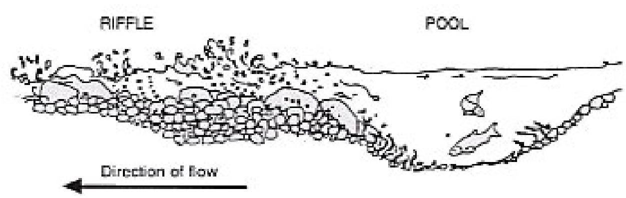
• Riffles and pools are necessary to meet the needs of salmon and trout.

Teaching Information:

Students will apply concepts learned about salmon habitat needs during their life cycle by reading a short informational piece and completing a worksheet analyzing riffles and pools.

Materials:

• Copies of student sheets (Riffles and Pools…)



Answers:

1. Will the dissolved oxygen concentration be higher at the bottom of the pools or 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 salmon 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.*

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 salmon 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 salmon fry use the most energy catching food? Why? *On the riffles. It is harder to maintain position in the faster water of a riffle.*

6. Chum salmon 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 salmon species might it support? Why? *Coho salmon fry could live there because of the availability of rearing habitat.*

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 and Washington'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° to 65°F) water flowing through the gravel itself protects the eggs from predators.

In late winter or spring, the eggs hatch. The young fish, called *sac fry*, 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 sac is used up the fish, now called *fry*, emerge from the gravel in later 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 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 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 mainstem of streams. Weeks or months after they have reached the gravel beds, the female digs a nest, or redd where 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 similar needs during their time in fresh water.

Riffles and Pools

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 salmon spawn in gravel, and gravel is usually found in riffles, riffles are often called "spawning habitat." The amount of gravel and riffles in a stream (if of good quality) determine the number of salmon that can spawn there. The places in a stream that provide a place to eat, a place to rest and a place to hide are called "rearing habitat."
- Stoneflies 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. Salmon 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.

Diagram 1

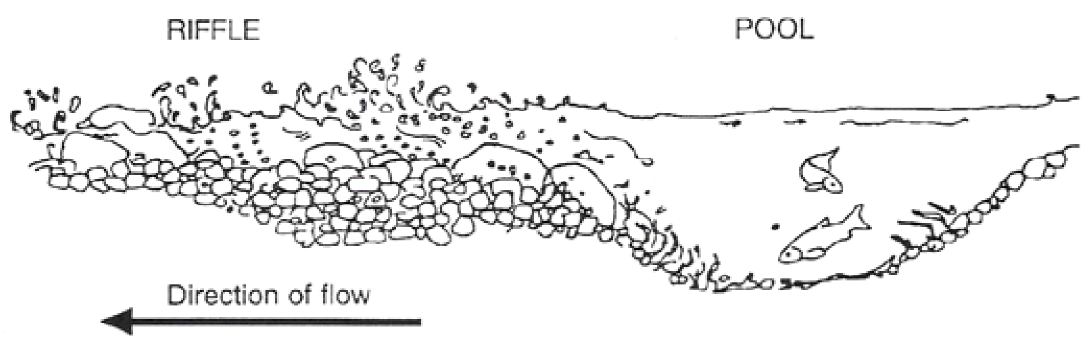
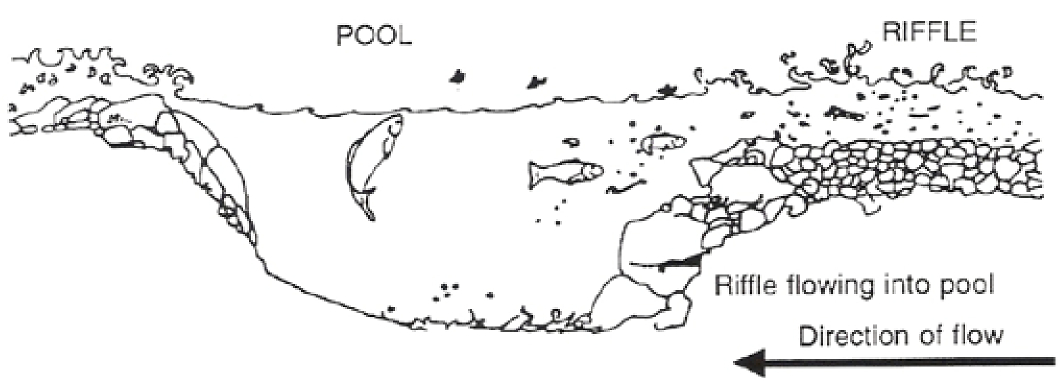
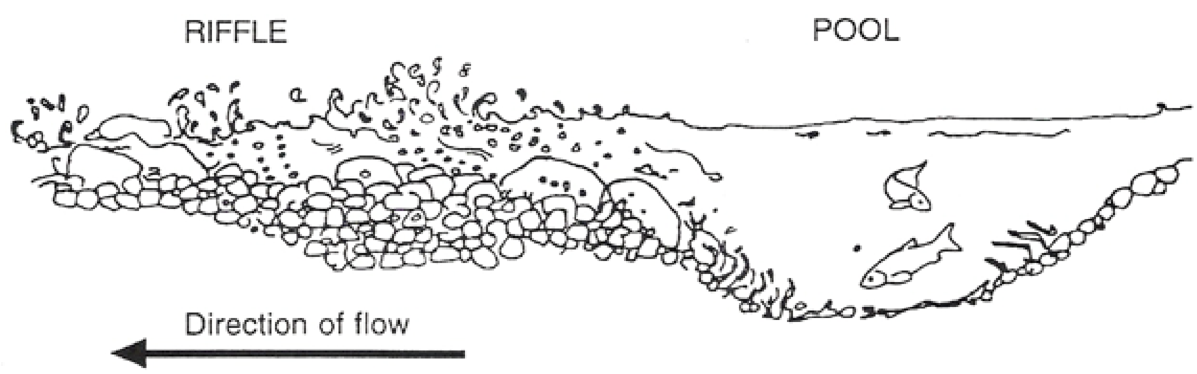


Diagram 2



Questions on Riffles and Pools

Refer to this diagram as you answer questions 1 & 2.

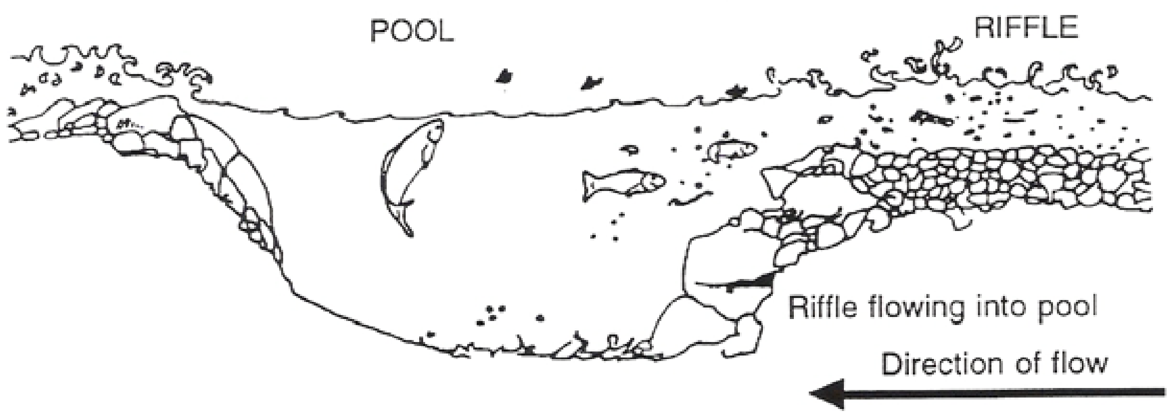


1. Will the dissolved oxygen concentration be higher at the bottom of the pools or the riffles? Why?

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

Questions on Riffles and Pools

Refer to this diagram as you answer questions 3 - 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 salmon fry to wait for lunch? Why?

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

Questions on Riffles and Pools

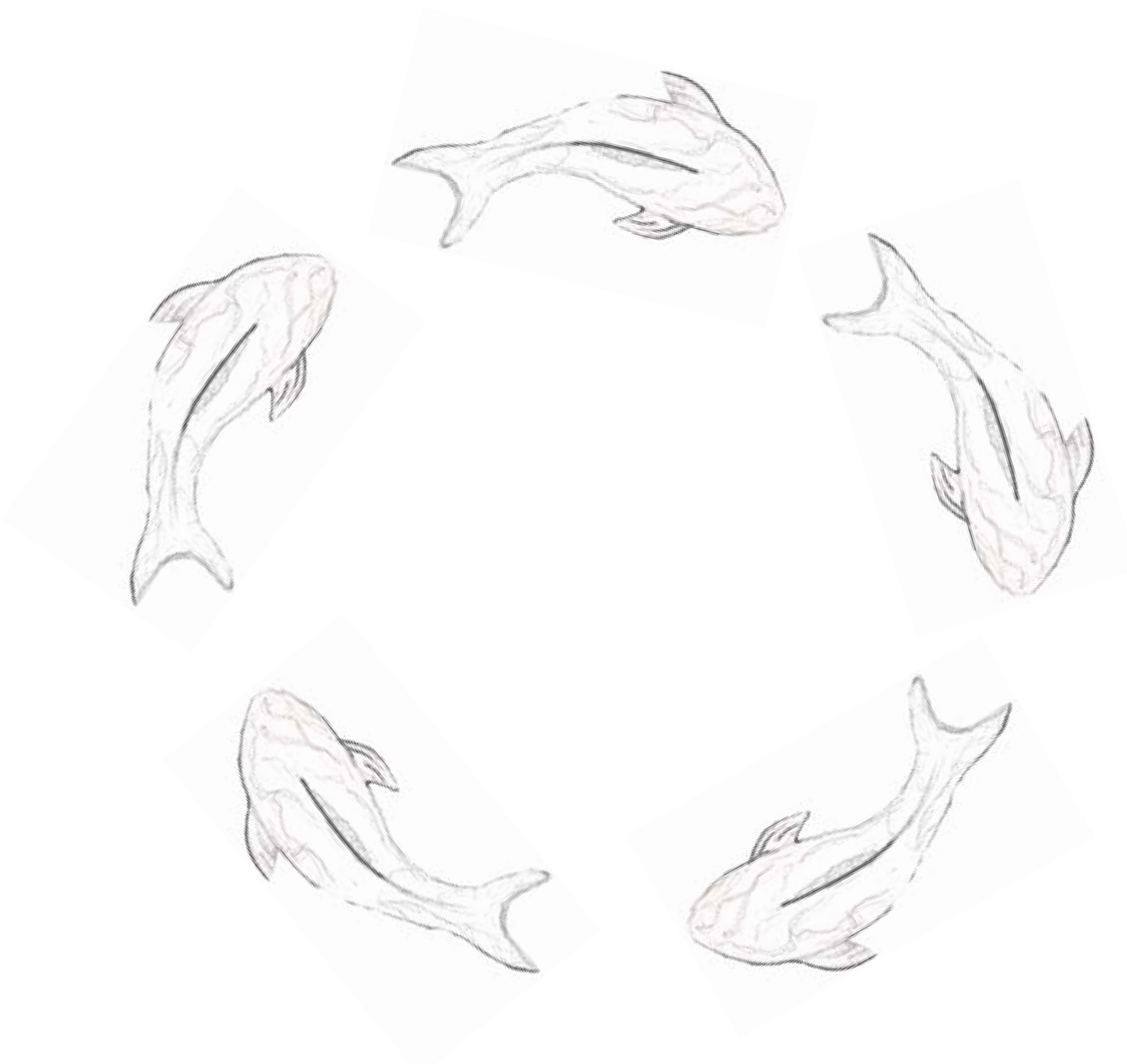
6. Chum salmon fry only spend as much time in the stream as it takes to get to the ocean (one day to three weeks). Coho salmon juveniles live for a year in the stream before heading to the ocean. Steelhead juveniles live up to three years in the stream before heading to the ocean. If a stream has good 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 salmon species might it support? Why?

Lesson 2 – The Salmon Life Cycle

Purpose:
This lesson is designed to explore the life cycle of Pacific Salmon, comparing hatchery and wild.

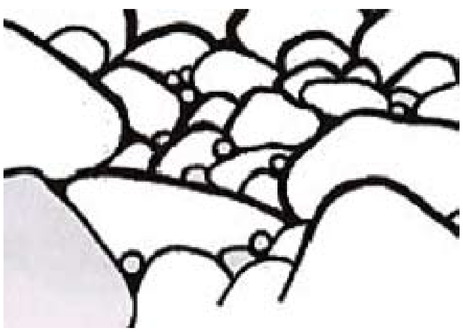
Activities:



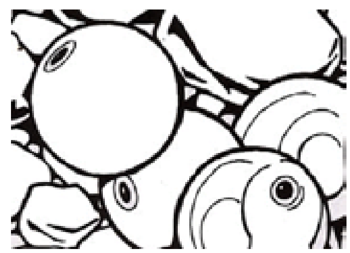
A Salmon's Incredible Life Cycle

It begins with a downstream journey from the fresh water where they are born, to the ocean where they will live for most of their adult life, and then back upstream again, to the exact location where they began three to seven years earlier.

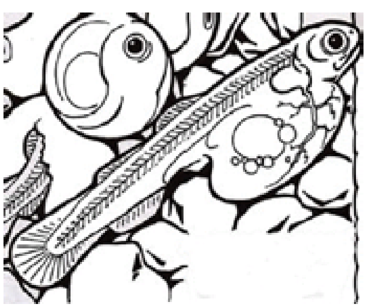
Female salmon lay their eggs in many of the streams and rivers connected to the Columbia Basin. Depending on the species, the female can lay anywhere from 1,500 to 7,000 eggs in a nest (redd) she has created by fanning a shallow depression in the stream bottom with her body. The male fertilizes the eggs and then both will brush gravel over them for protection.



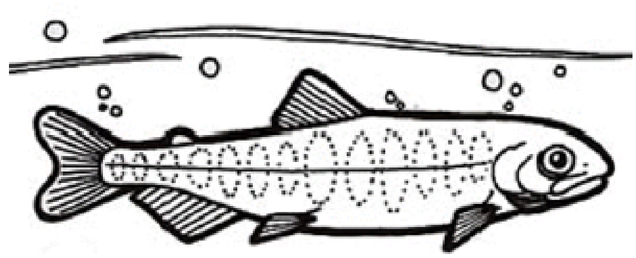
Now the eggs are protected from sunlight, strong currents and hungry animals and insects. For the next four weeks or so, the eggs remain hidden in the gravel.



Near the end of four weeks, the eggs begin to change. Inside each living egg, a head, eyes, and a body begin to take shape.



It will be another four weeks or so before the little fish hatch and become alevins or sac fry -- looking more like a worm than a fish. These tiny fish depend on a yolk sac that will provide them with nourishment until they are mobile enough to emerge into the stream and find their own food. They will first feed on tiny plants and insects. This phase of their lives they are known as fry.



A Salmon's Incredible Life Cycle

At this stage they are ready to migrate to the ocean. They also start to undergo a physiological transition which will allow them to move from freshwater fish to saltwater fish. Only about 10 percent of the fry make it to this stage and are called smolts. Smolts are especially vulnerable. Living in shallow pools near the edge of the stream where the current is slow. They are already quick at this stage - a good thing because as they feed, they can also be easy food for trout and other fish, ducks and herons.

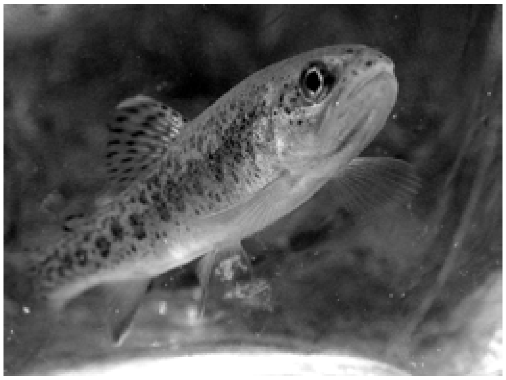
The smolts that complete the journey downstream spend several weeks in estuaries where the river meets the ocean, feeding on small fish and shrimp. Eventually, they disappear into the ocean where they grow to adulthood.

After two to five years, the adult salmon are ready to migrate upriver to spawn. Starting the cycle all over again.......

The journey upriver is a difficult one. Salmon do not eat during this time, but live on fat stored in their body.

Obstacles encountered upstream are many and varied. Dams, waterfalls, anglers, bears, uncertain stream conditions, and habitat degradation are among the most common challenges for the salmon in the Columbia River Basin ecosystem.

Ocean Migration



In general, juvenile fish migrate downstream during spring and early summer. Throughout the freshwater rearing stage, which varies from species to species, the juvenile fish receive a succession of cues which may assist them in returning to the natal spawning grounds. During their journey to the ocean all young salmon face the same biological hazards: starvation, predation and disease. They also have the same requirements or needs: food and shelter. For this requirement they will spend time in the estuary where nutrients from the ocean are brought to the river mouth area. Estuaries are the zone where fresh water and saltwater mix. The length of time spent in the estuary is very species - specific.

The pacific migration is a route taken by migratory salmon during their arduous ocean journey before returning to breed in the Northwest. How far a salmon travels in the ocean and the direction it goes can vary. The extent and direction of the salmon's travels depends on time and size when they enter the ocean and the marine conditions they encounter. The growth rate in the ocean is very rapid. Many salmon travel along with the ocean currents in circular routes. Some wander as far as 2,000 miles from their stream. Others stay closer to home. The salmon grow to adults on rich seafood diets including small fish like herring and anchovies. The Chinook salmon, for example, can grow up to five feet long and weigh from 22 to 100 pounds.

Migration makes it possible for salmon to benefit most from favorable weather conditions; they feed in the northern waters of the Alaskan coast. This pattern is called return migration - the most common type of migration by salmon.

The migration of salmon usually refers to their movement between fresh water and saltwater homes. Some salmon migrate thousands of miles, while others may travel less than a hundred miles. This movement has long been a mystery to humans. Through natural selection, migration evolved as an advantageous behavior. Salmon of the Columbia and Snake Rivers migrate north to feed where space is substantial. Food supply is considerably better in many northern areas and migrant species are usually assured of adequate space and ample food upon arrival. It begins when the salmon enter the ocean by turning toward their hereditary feeding grounds. For some it is north of Alaska. Others will feed in the deeper waters off California.

Salmon can be food for bigger animals like tuna, seals, dolphins and whales. But even in the ocean a salmon has ways to help it escape these predators. They feed mostly at night when they are harder to see. Their color also helps to hide them. Seen from above they look dark like the deep ocean. Since the water looks white or silvery from below, they have silver, shimmering bellies.

Time spent at sea is variable according to species, ranging from one or two years for Coho to four or five years for a Chinook. When the time comes, a little understood combination of genetic memory and sense of smell bring them back to their natal streams or hatcheries to spawn.

The Return

As the salmon approach maturity they begin a movement to coastal waters. At first, they may find their way across the oceans using currents, stars and the earth's magnetic forces. As they leave the ocean pastures and head closer to land, they leave the company of other salmon and begin their solitary journey home. Each salmon is seeking its home or natal stream. Distinctive home stream odors assume great importance. Studies show that the sense of smell is the significant factor in homing. Every stream is unique. The young salmon is able to detect immeasurable traces of element present in their environment. Odors from the rocks, plant life and other aquatic organisms all have an everlasting influence on the young salmon. The young fry absorb the key elements of its stream. They retain this sense of having-been-there-before. Visual cues are of secondary importance.

The adult runs, or migrations of salmon populations, occur from April to November. Chinook migrate in spring, summer and fall.

Salmon returning to their place of birth will generally not spawn in alternate locations. The long journey to their ancestral spawning grounds is a remarkable feat. The trip upstream can present many obstacles. Both natural and man-made hazards face the fish. Swimming against the current, the salmon may encounter waterfalls, dams, fallen trees, low water flows due to drought, adverse water conditions and predators. If the salmon encounters an insurmountable obstruction along the journey to their home stream, they will die attempting to overcome it. If their path is clear, they travel back to the exact place where they were hatched, no matter how small the stream may be. Salmon have been programmed to return to the same tributary of the river and even the same stream and gravel in which their parents spawned.

Estimating Fish Populations – An Activity

Key Concepts:

Students make math calculations with different colors of beads to learn a technique biologists use to estimate the total size of a population of fish.

Objective:

Students will be able to:
1. Describe the mark/recapture method used to estimate fish populations.
2. Explain why it is important to be able to accurately predict population numbers.

Materials:

- Two colors of beads that are roughly the same size and shape.
- One large jar for each team of students.
- Calculator

Background:

Biologists and wildlife managers can make better management decisions if they know the total population size of a group of fish. Determining the number of fish spawning in a small clear-water tributary is relatively easy. Biologists can set up weirs or counting towers and simply count the fish as they pass by. Determining the total number of salmon traveling through the vast, muddy waters of the Columbia River drainage is a much more difficult task. In these situations, biologists sometimes use a method to calculate population called mark/recapture.

Biologists use nets, fish wheels, or some other method to capture salmonid. They insert a numbered plastic tag in the fish's back near the dorsal fin, then release it back into the river. At a point farther upriver, biologists use the same method to recapture fish. Here, they keep track of the total number of marked and unmarked fish caught. With this information, they can do the following calculation.

$$\text{Estimated Population} = \frac{MC}{R}$$

M = Fish caught and tagged in the marking event.
C = Total fish recaptured.
R = Total recaptured fish that were also tagged.

Method:

For example, in the marking event, you catch and tag 100 salmon. In the recapture event, you catch a total of 100 salmon. Of these, 10 have the plastic tags. Using this formation you do the following calculation:

$$\frac{\text{100 Fish Caught and Tagged} \quad \text{X} \quad \text{100 Total Recaptured Fish}}{\text{10 Recaptured Fish that had Tags}}$$

$$\frac{100 \quad \text{X} \quad 100}{10} = \frac{10{,}000}{10}$$

Or, there are approximately 1000 fish in the total population.

Procedure:

Count out 1000 red beads and place them in a large jar before the activity. (Less than 1,000 will be too small for accurate calculations) Have the students count out 100 blue beads to represent the fish tagged in the capture event. Add these to the jar and shake it well.

Pour the mixed beads out onto a tray and have the students count out 100 beads without looking at them. This will represent the total fish caught in the recapture event. Then, have the students count out the number of tagged fish caught in this sample (the blue beads). Plug these numbers into the equation to determine the total population of fish. Have the students count the actual number of beads to see how close their calculations came. Discuss the possible causes for any discrepancies.

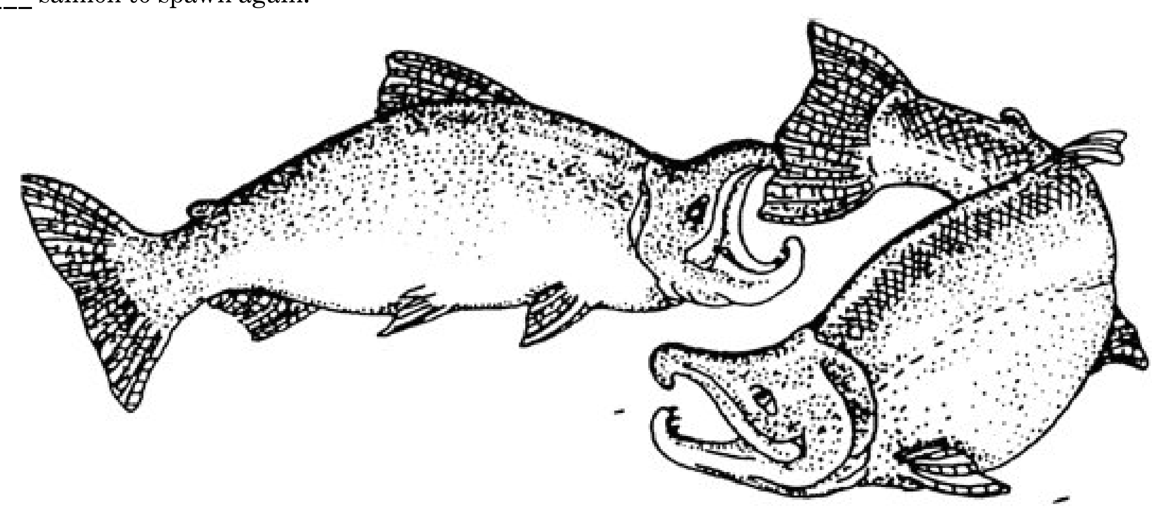
Form the students into teams. Have each group retry this experiment with an unknown number of beads in each jar. Have teams experiment with larger and smaller samples sizes to see who can make the most accurate prediction of the sample size. Discuss the results.

Marking Techniques

MARKING TECHNIQUE	ADVANTAGES	DISADVANTAGES
Fin Clipping	inexpensive; easy to see; applicable to many sizes of fish; can identify groups, easy to apply	may negatively effect fish; no information for individual fish; requires handling each fish; few combinations of markings
Jaw Tag	inexpensive; easy to see; durable tag; can carry individual code number	can negatively effect fish's growth; can only be used on medium & large fish
Coded Wire Tag	can use on small to large fish; doesn't effect fish's swimming; many codes available	fish must be killed to recover tag; relatively expensive; each fish must be handled
Radio Tag	can follow movement of individual fish; no other technique can provide the same information	special equipment needed to hear signals; tags are expensive; only used on large fish
Visual Implant Tag	can be coded for individual fish; information recovered without killing the fish	need trained people to notice it; may cause negative skin reaction and eventually become difficult to read
Passive Integrated Transponder (PIT) Tag	unique 10 digit code read while inside the fish with a detector-decoding system; tags last ~ 10 yrs	tag area may not heal properly; needle injection required for insertion; expensive to use
Disk Tag	easy to see; can code for groups or individuals; lasts the lifetime of the fish	difficult to apply correctly; time-consuming application
Paint	can be highly visible; quick and easy to apply; can color-code groups	makes fish more visible to predators, which effects survival; cannot distinguish letters or numbers
Freeze Brand	can identify groups; little injury to fish; does not effect fish's swimming; relatively simply application	group information only; limited available codes; becomes difficult to read over the fish's lifetime
Otolith Patterns	fish not exposed to chemicals, injury, or stress of handling; potentially limitless number of coded patterns	fish must be killed to retrieve information; commonly used only on hatchery fish; requires special equipment

Salmon Story Problem – An Activity

Using the math you've learned in school, fill in the correct numbers in the missing spaces. If 10 salmon lay 5,000 eggs each in a stream, there are _____ eggs. One-half of these eggs do not get fertilized. This leaves _____ developing eggs. A new road is built alongside the stream leaving lots of loose soil. A rain storm carries some of the soil into the stream. It falls on and kills 2,000 of the eggs. Now there are _____ eggs. These eggs hatch into small salmon and begin their journey to the ocean. People spray lawn and garden chemicals in their yards. These are carried into the steam and kill 5,000 salmon. Now there are _____ fish. Predators such as larger fish, sea gulls and seals catch 10,000 more salmon. There are now _____ fish. Another 5,000 are caught by people fishing. This leaves _____ fish. Some of the remaining salmon swim close to an oil spill in the ocean and 2,000 die. There are now _____ fish. Some hungry bears catch 500 fish as they return to spawn. Now there are _____. A careless person pours old anti-freeze from his car into this stream. It kills a 3 mile stretch of the stream and 450 fish die. This leaves _____ salmon to spawn again.



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Home Sweet Home – An Activity

Key Concepts:

Prior to this activity, students could learn about the life cycle of the anadromous salmon and the importance of flowing water to their migration patterns.

Objectives:

1. Develop an awareness of fish life cycles and migration.
2. Appreciate the necessity for clean, flowing water in our streams and rivers.

Materials:

- 6 film canisters filled with cotton saturated in 6 different essential oils, such as: cinnamon, cloves, eucalyptus, apple, orange, anise (you may want more canisters depending on the size of your class). One canister can even be scentless. The lid and bottom of each canister is coded with a number that matches the essential oil on a separate, written key. For each canister code, write the corresponding code numbers on several 3x5 cards – the number of cards depends on the class size. (For variety, write local river names on the cards).
- Blindfolds for the "salmon" students.

Background:

After maturing, salmon return to fresh water in order to reproduce. Although it is not fully understood how they manage to navigate the many bodies of water, it is believed that they have a built-in homing device that enables them to smell their home water address. As juveniles, they imprint this smell. And as adults, they are able to find this smell once again.

Methods:

Warm Up Exercise
Discuss with the class the life cycle of salmon and how important water is to their habitat. Have them compare how their home habitat and life cycle compare to that of salmon. Ask them to list some river and stream water addresses near their school or home. How far is it to the ocean? Would they need to get past any barriers such as dams to reach home? Discover with the students some possible journeys salmon species may make to other places in the Pacific Northwest.

Home Sweet Home

The Activity

1. Tell the students they are going to play a salmon migration game. They are going to pretend to be adult salmon and try to find the smell of their water address in which to spawn. Ask them what they think is the purpose of this activity.

2. Assign six students to be the "water address," or "rivers." (You can do this by counting off or having them pick numbers). Give each of them a (closed) film container with the corresponding coded 3x5 cards and have them stand together in the activity area. (They must keep their water address identity a secret).

3. Have the remaining students, or "salmon" move to the opposite side of the area. Stand them in a row facing the "water address" and blindfold them. Tell the salmon students that they are now going to get a whiff of their home water address from their river.

4. Send each river/water address student (one at a time) over to the fish and let a fish smell their opened canister keeping their scent a secret. After the fish has smelled their scent, have the river student place a corresponding 3x5 card in the blindfolded student's hand. The rivers should do this until all of their cards are used up, picking their fish at random. All the rivers will then return back to their side of the activity area and form a row, again facing the salmon.

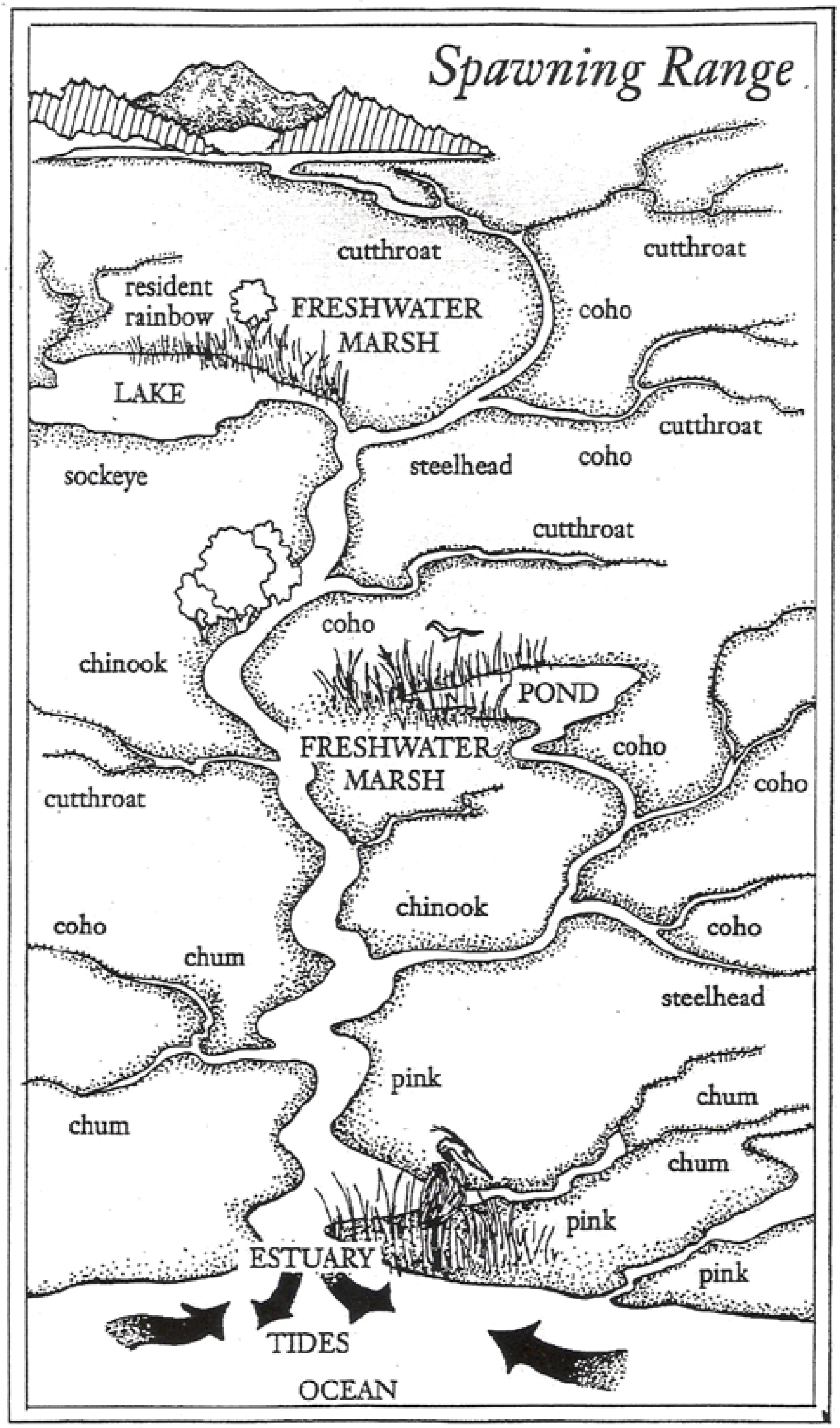
5. After all the salmon have smelled their water address they can take off their blindfolds and form a line. Now, they can walk (one at a time, single file) past the row of rivers while smelling each opened canister. If the fish students think they have smelled and found their water address they line up behind the proper river student.

6. When all the salmon have found their home address, have them compare the coded 3x5 cards with the coded numbers on the film canister. Are they the same?

Evaluation:

- Design a story or mural of the fish life cycle.
- Pretend they are a salmon migrating back to a nearby river or stream and write a descriptive story of everything they smell, taste, see and hear.
- Create a skit about being a migrating salmon.

Home Sweet Home



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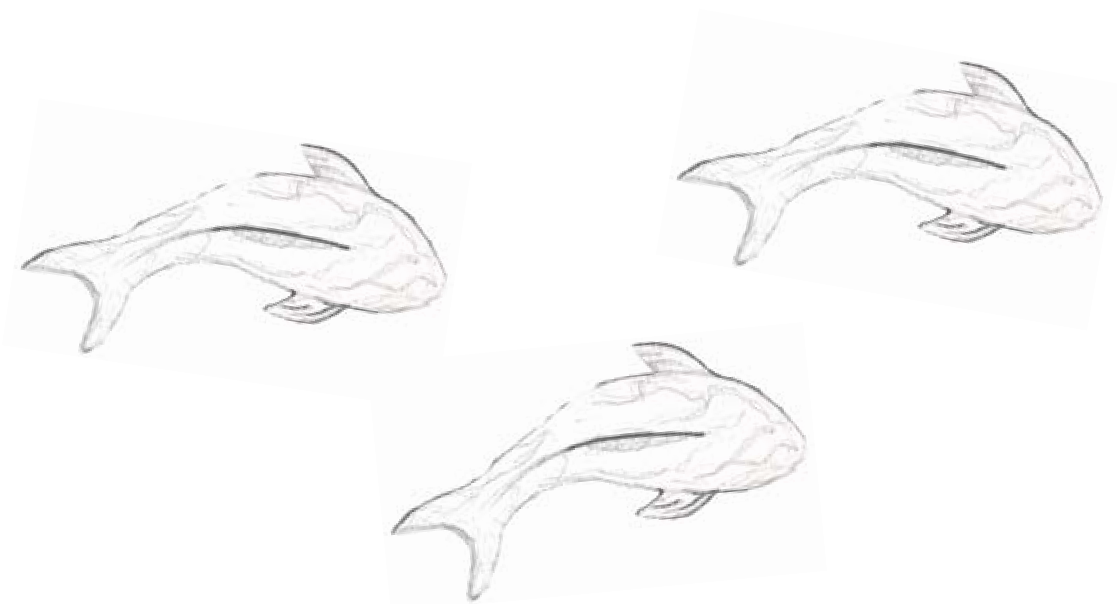
Lesson 3 – Anatomy of a Fish

Purpose:
This lesson is designed to introduce students to salmon, an endangered species of the Pacific Northwest, to encourage a sense of connection between the students and salmon and more specifically to introduce the students to the salmon anatomy.

Activities:



Classroom Salmon Dissection

Background Information:

Many of the schools which are involved in our Salmon in the Classroom program have been able to expand their studies in many ways. One activity that has been well received by teacher and student is the dissection of a salmon.

This is a lesson in comparative physiology/anatomy.

Before beginning:

Before the dissection begins, prepare all the materials in a convenient area, and pass out the drawing of a salmon. This drawing includes the fins, gill covers, lateral line and other details.

Take time to consider the physical arrangement of the room. Keep in mind that some children may find this activity somewhat stressful, so try to make everyone comfortable with their participation and their involvement in the activity. Try to arrange the room in such a way as to allow students to be close if they wish, yet be able to move in and out according to their curiosity. If the children feel fixed in one location, the possibility exists that they may also feel unable to escape from the situation if it disturbs them, and this may have unfortunate results. A touch of humor is very appropriate in order to take the edge off the activity.

It may be inappropriate to pass the parts around from student to student. Imagine what might occur if the part doesn't make it all the way, and it ends up in someone's pocket! Instead, it may be better to get a volunteer to help ensure that parts stay with the fish. This method could also be a relief for those kids who want to participate, but don't wish to get to close to the action. Try to use parents when ever possible.

Much of the dissection is done with the hands. It will be quite messy and hands will need a good washing afterward to rid them of blood and slime, rubber gloves may be a desirable item.

Materials required for a fish dissection:

- Kitchen knives (sharp and flexible)
- Paper towels
- Paper plates
- Newspapers
- Magnifying glass (optional)
- Plastic bags (for waste)
- Tweezers
- Dissecting picks
- Scissors (small)
- Soap and water (for washing up)

Parts of the Fish

Head
The head contains the eyes, nostrils, mouth, gills. The area in front of the eyes above the mouth is called the snout. The position of the mouth varies among species. Fish absorb oxygen from the water. The water is taken in through the mouth, flows over the gills and then passes out through the gill openings. The gills are protected by a cover, called the opercle or gill plate. Fish can have teeth in the jaws, mouth and pharynx.

Body
The area just behind the opercle is called the pectoral or chest region. The humeral area, or shoulder lies above the base of the pectoral fin. The belly extends from the pectoral fins to the anus.

Tail
The tail is that part of the fish behind the anus. The slender section between the base of the tail fin and the anal or dorsal fin is called the caudal peduncle, or commonly, the wrist.

Structures and Their Functions

Eyes
As in humans, fish eyes serve a variety of purposes - to seek out food, to avoid predators and other dangers and perhaps even to navigate in the ocean. Fish do not have eyelids. They are constantly bathed in water and do not need tears.

Nostrils
Salmon have a well developed sense of smell and use this ability to seek out their home streams for spawning. In some cases this scent is also helpful in avoiding predators. Fish breathe through their gills, not their nostrils.

Lateral Line
Fish do not have ears, as such. In part, low frequency sounds are detected in the water through a system of small holes along each side of a fish called the lateral line, which is connected to a delicate system of nerves.

Mouth
Fish use their mouth to catch and hold food of various types, but their food is not chewed before swallowing. In addition, the mouth is a very important part of the breathing process. Water is constantly taken in through the mouth and forced out over the gills.

Gills
Fish gills are composed of two basic parts, the gill covers and the gill filaments. The gill covers protect delicate filaments and together with the mouth force water containing oxygen over the gills. The gills are probably one of the most important organs of the body of the fish. They are delicate but very effective breathing mechanisms. Gills are far more efficient than human lungs, because they extract 80% of the oxygen dissolved in water, while human lungs only extract 25% of the oxygen in the air.

Gills are thin walled structures, filled with blood vessels. Their structure is arranged so that they are constantly bathed in water. The fish takes in the water through its mouth. The oxygen dissolved in the water is absorbed through the thin membranes into the fish's blood. Carbon dioxide is simultaneously released from the blood into the water across the same membranes.

Fins
Salmon have two sets of paired fins (pelvic and pectoral) and four single fins (dorsal, caudal, anal, and adipose). Except for the adipose and caudal fin, all the others are basically used to balance the fish in the water. The adipose is a small, fleshy fin which serves no known purpose. The most important fin is the caudal. It acts like a rudder, and combined with the very strong body muscles the fish, is their only means of propulsion. The caudal fin is used by female salmon to dig the redd where they deposit their eggs.

Scales
The bodies of salmon are protected by scales which grow in regular concentric patterns and can be used to determine the age and life history of the fish. Over the scales is a layer of mucous (slime) which further protects the fish from disease organisms and helps it slide through the water more easily.

Air Bladder
A membranous sac filled with gas, situated in the body cavity of fish, ventral to the vertebral column, used to control buoyancy.

Esophagus
The gullet, or esophagus, carries food from the mouth to the stomach.

Gall Bladder
The gall bladder is a sac in which bile is stored. Found in the lower part of the alimentary canal extending from the pyloric end of the stomach to the anus.

Kidney
These organs remove waste from the blood and produce urine.

Liver
A digestive, storage and excretory organ.

Ovaries
The female reproductive organs which produce eggs.

Pyloric Caeca
An appendage in the form of a blind sac, connected with the alimentary canal, in which digestion takes place.

Spleen
The organ in which white blood cells are produced and red blood cells are destroyed, in vertebrates.

Stomach
Sac-like digestive organ receiving food from the esophagus and opening into the intestine.

Heart
A hollow, muscular organ, the heart circulates blood through the body.

Testes
The male reproductive organ in which milt is produced.

Vent
The external opening of the alimentary canal. Urine, feces, eggs and milt exit here.

External Anatomy

Slime-why is a fish slimy?
- To slip away from predators such as bears.
- As an anti-abrasive to slip over rocks.
- Lubricant to enable easy swimming through the water.
- An “envelope” or “living plastic bag” as a protection from fungus, parasites and disease.

Identify the external anatomy.
- Mouth, Eyes, Gills, Nostrils, Vent, Lateral Line

Identify both single and paired fins:
- Caudal fin, anal fin, pelvic fin, pectoral fins, dorsal fin, adipose fin (unless it is a hatchery fish, in which case the adipose fin may have been clipped to identify it). Clipped hatchery fish will also have a tiny steel pin, or coded-wire tag, about the dimension of a day’s growth of a man’s whisker, embedded in the nose cartilage.

What are the fins for?
- For swimming and steering. The muscles of the entire body of the fish are used for propulsion, and even if the fish had no fins at all it could still make progress through the water; however it would not be able to right itself well.

How are the fins attached?
- To muscle tissue, not to the skeleton.

What are the scales for?
- As “armor plating”. Remove a scale for later observation under a microscope or hand lens.

Did the fish always have as many scales? Are there more now than when it was little.
- Fish have the same number of scales all their lives. The fish stacks up “plates” in order to grow the scale. This can be seen under magnification as rings. It is similar to a tree ring, with the difference being that the rings develop as food is available, and the groups of rings coincide with the seasons. An experienced biologist can determine the age of a fish by looking at the rings.

What do you think happens when a scale is shed?
- Scales are regenerated to fit into the missing space, and so these scales will have a clear center, since it does not have the “plates” of previous growth stacked above.

Do all fish have the same scale arrangement?
- The arrangement and placement of rows or scales is a positive species identification. Each type of fish has a different arrangement.

What is the lateral line for?
- It emits low level vibrations, somewhat like sonar. It functions something like an organ of touch, something like an organ of hearing, and something like an organ of seeing. It helps fish find their way when they cannot see, such as at night, or when the water is muddy.

How does a fish breathe?

- The gulping action demonstrates how water is drawn in through the open mouth, the mouth and the throat closes, and the water is forced out past the gills. Gills extract oxygen from the water. Cold water, if saturated with oxygen and holding as much as it can, may have 13 parts of oxygen for every million parts of water.
- To demonstrate what 13 parts per million (ppm) is, imagine that you have a million marbles, of which 13 are white oxygen marbles, and the rest are plain water marbles. If you were to drop one marble per second into your pocket, how long would it take you to reach a million? 12 days! Imagine how large your pocket must be.
- At the end of 12 days of marble dropping, you would then drop in the 13 oxygen marbles: that shows how efficient gills must be, and how sensitive they are to material in the water. In fact some pollutants cause problems at levels of parts per billion. Using the same analogy, it would take 38 years of marble dropping to get a billion! Fish, and all living things must live within an environment, which is why it must be clean.

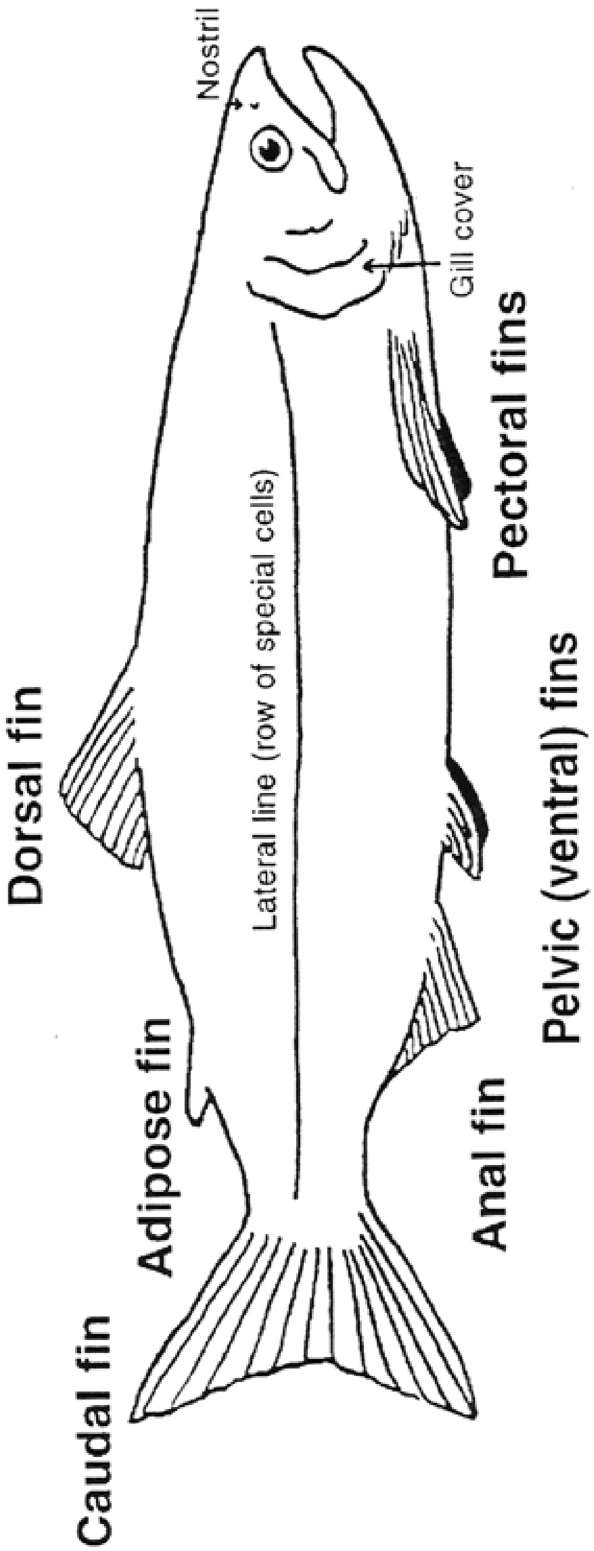
What do the gills look like? How are they used?

- The gills have an extensive blood supply, which accounts for their color. The laminae, or branches of the gills, perform the same function as the small sacs or alveoli within your lungs, in that they act to transfer the carbon dioxide from the body of the fish and absorb the oxygen from the water. The laminae are only two cells thick and present maximum surface area to permit the most efficient transmission of gases. Under a lens, the laminae look like a Christmas tree.

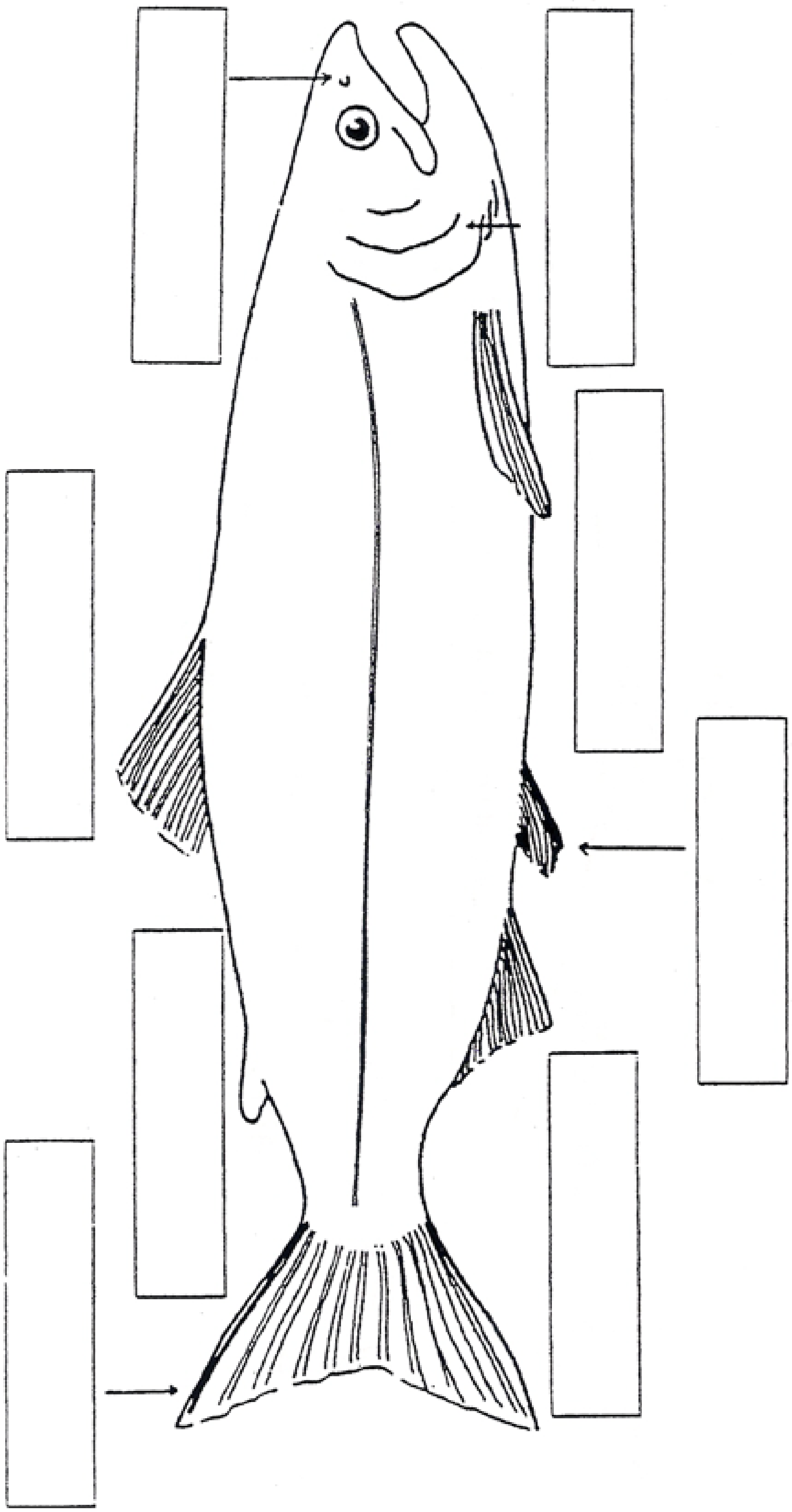
Look at the gill rakers (the spines that guard the opening of the throat).

- The gill rakers prevent food from entering the gill passages, and instead guide it into the throat.

External Anatomy of a Salmon



Label the Parts of a Salmon



Internal Anatomy

When cutting open the fish, what do you expect to see?
- Place the fish on its side, belly away from you, on newspaper. If right-handed, hold the tail firmly with the left hand. It may help to use paper towels to improve the grip. Insert the tip of the knife or dissection shears into the vent and cut forward only as far as the pectoral fins, passing between the pelvic fins.
- <u>A safe cut is away from the body with a truly sharp knife. A knife that is thin and flexible is best.</u>

What is the first thing that you will see?
- If the fish is a mature female, a large portion of the body cavity is filled with eggs. If the fish is ripe and ready to spawn, the eggs will be loose within the body cavity; more likely the eggs are contained within a membrane. Pull out one of the roe sacs by hand and observe the blood vessels contained within the membrane. What are these for?
- A mature Chinook has 3,000-5,000 eggs. The egg provides one half of the genetic information needed in order for fertilization to occur.
- If the fish a mature male, a large portion of the body cavity is filled with the testes. A white bladder of milt will be easily observed. The milt provides the other half of the genetic information needed.

Why are so many eggs needed?
- On the average, and in rough proportions, Chinook salmon lay about 5,000 eggs. Of these, only 15 percent live to hatch in the wild. Of those remaining, only 30 percent will last the first year. Of those, only 4 make it to adult, and only 2 live long enough to spawn.

Looking into the body cavity, you will see a large dark red organ. What is this organ? Remove it with your fingers.
- The liver stores, synthesizes and secretes the essential nutrients that were contained in the food. It plays a part of maintaining the proper levels of blood chemicals and sugars. The gall bladder, which is attached to the liver, contains green bile which in part is used to help digest fats.

Remove the stomach and upper gut. Use your fingers.
- It is attached at the throat and, which you cut when you remove the gills, and attached again at the vent. It will come away with the "spaghetti" of the pyloric caeca and the dark spleen attached. It will strip out to the vent.
- The pyloric caeca act like a small intestine, in that they exude the digestive juices needed to break down the food, and absorb the components into the blood stream which passes it on to the liver.
- The spleen acts as a storehouse of blood, to be used if there is an emergency, and to recycle worn-out blood cells.

If the fish has been taken from a river, it is unlikely that there is any food anywhere in the digestive system. Salmon do not eat once they enter freshwater, and it may be as much a 16 weeks from the time that they take their last meal in the ocean and the time that they spawn and die.
- The digestive tract is surprisingly short and simple, and does not have the extensive intestine that mammals have. This is because fish are cold-blooded, and do not require a large amount of energy to be extracted from their food since they do not heat their body by their metabolism.

We have not seen the heart yet-is it where you thought? Carefully continue to belly cut forward to the throat, but only deep enough to cut through the skin. Find the heart and remove it. What does it look like?
- The heart is located where the gill covers come together high up in the throat, and it may be removed with the fingers. It is triangular in shape, and consists of 2 chambers. The white tube is the venal aorta, and it leads the short distance to the gills. Why is it located so close to the gills?

Remove the swim bladder that is attached to the esophagus by stripping it out from the front with your fingers. Would anyone care to demonstrate how the swim bladder can be inflated?

- Most fish are able to adjust the amount of air in their swim bladder so that they are able to stabilize their movement within the pressures of the water. Notice that the swim bladder is just below the spine, which is just below the center line, or the center of balance of a fish. This is why fish float upside down when they die.
- When a fish, such as a salmon, is deep in the ocean, it adjusts the amount of air in its swim bladder so that it can hover comfortably without sinking or rising in the water. If it wants to go deeper in the water, it must release some of this air, something like a burp, in order to hover at lower depth. Some bottom fish, such as a rockfish, are unable to adjust their swim bladders by burping, and this is why when a bottom fish is caught and brought to the surface its stomach protrudes into its mouth: the swim bladder has expanded due to decreased pressure and is forced the internal organs out through their throat.

The dark red line along the back bone is the kidney. Where are your kidneys and what are are they for?

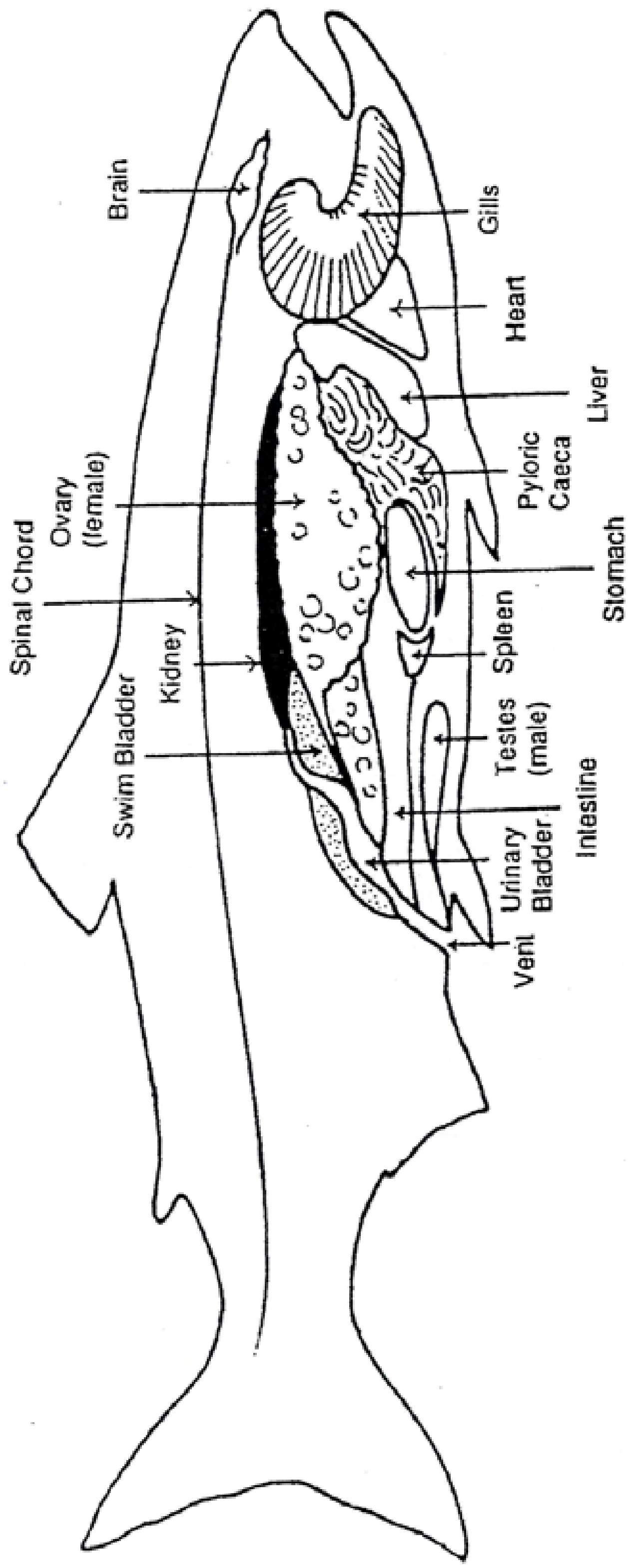
- The forward part of the fish kidney functions to replace red blood cells, and the rearward part filters waste out of the blood. The kidney can be removed by slicing through the membrane along each side, and them scraping with the spoon.

What is left is a fish that is well cleaned!

How Does a Fish Compare to a Human?

Fish	Human
Respiratory System	
Water enters the mouth. It is forced between the gills. Thin membranes absorb the oxygen from the water and carbon dioxide is released.	Air enters the nose. The respiratory system includes the larynx, trachea and lungs. This system provides oxygen for the body cells and removes the waste products (carbon dioxide).
Circulatory System	
The circulatory system carries blood throughout the body. The heart is like a pump. Arteries carry oxygen rich blood from the heart to the body. Veins carry oxygen poor blood from the body back to the heart.	The human circulatory system includes the heart, veins, arteries and capillaries. The blood carries oxygen plus nutrients to the cells and removes waste products. The heart is like a pump which circulates blood throughout the body.
Reproductive System	
Female salmon deposit between 500 - 10,000 eggs in redds and the male fertilizes them with milt. The eggs incubate for about one to four months and hatch as alevins.	The ovaries of the female produce eggs cells. The testis of the male produces sperm cells. The two cells unite and the embryo develops in the uterus of the female.
Nervous System	
The brain and spinal cord of all vertebrates are similar in structure and function. The central nervous system controls all conscious body functions. It includes the brain, spinal chord and peripheral nerves.	
Digestive System	
The alimentary or digestive canals are similar. They prepare food for use, absorb nutrients and eliminate waste.	

Internal Anatomy of a Salmon



Adaptation

What is an adaptation?
An adaptation is a genetically-controlled characteristic that may help organisms survive and reproduce in their environment. Species often evolve similar adaptation to survive in the abiotic and biotic conditions of the ecosystem.

Adaptations may occur to an organism's:
- Behavior
- Body Structure
- Body Processes
- Coloration

For example, if an ecosystem has long cold winters, a species may hibernate (a behavioral adaptation), have thick fur (a body structure adaptation), or have the ability to live in fresh water and salt water (a body process adaptation). Animals that live in a snow environment, like the snowshoe hare, become white in the winter, to give them **camouflage** from predators (a coloration adaptation). *The characteristics of plants and animals offer great insight to the physical and biological conditions of the ecosystem.*

Examples of Species Adaptation:
PLANTS that experience drought (water or heat stress), like cacti, usually have some or all of the following characteristics:
- Thick, leathery evergreen leaves
- Reduced leaf area
- Deep root systems
- Thick white hair or wax on their leaves

These adaptations help reduce water loss, increase heat loss or reduce the amount of light absorbed by the leaf.

Some aquatic INSECTS, like Mayflies, have adapted to live in fast-moving water. They have:
- Flat bodies
- Claws with hooks

These adaptations allow water to flow over the insects and help them to cling to rocks in a swift current.

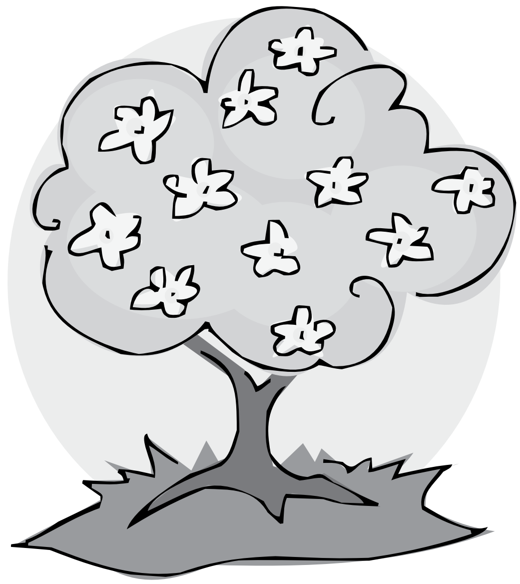
Pacific Salmon – Species Adaptations

- Salmon have good hearing. Using their lateral line they can distinguish notes that are far too fast for humans to separate.
- Salmon are "armor plated." They have scales which regenerate to fit into the missing space.
- The "tail fin or caudal fin" is used for movement. Salmon can swim at an estimated 14 miles per hour. Chinook can leap as high as 10 feet.
- Their tongues have teeth that are used to catch and hold their prey.
- The salmon's sense of vision is highly developed to pursue food and avoid predators.
- Salmon do not chew their food. The digestive system has to break down all the food.
- Salmon have to work within strict weight limits if they are to be able to swim. They do this with a lightweight skeleton of cartilage.
- The salmon has a line of pores running along each side of its body; this "lateral line" detects low frequencies close to the fish.

Aging Trees and Fish – An Activity

Key Concepts:

FOR YOUNGER STUDENTS and OLDER STUDENTS
• By examining a drawing of a salmon scale, students will be able to determine their age.



Objectives:

1. Students will learn about tree growth patterns.
2. Students will be able to age a tree by counting its growth rings.
3. Students will relate growth information to the aging of fish through their scales.

Materials:

• Tree cross-sections (if available)
• Enlarged fish scale drawing
• Copy master (following page)

Background:

Cross-sections of tree trunks reveal the different layers of a tree. Each ring in the trunk of a tree represents one year of tree growth; they are called annual rings. Each year the cambium (cambium is the area just under the bark) forms a layer of light-colored cells in summer. You can 'read' the age of a tree by counting the rings in a cross-section of the trunk. The annual rings in a tree cross-section vary depending on the weather and growing conditions.

Method for Aging Trees:

1. Explain how tree rings are made and what constitutes one ring. Pass out tree "cookies" from the kit to students. Have them decide how old the tree was when it was cut.

2. Each group finds the rings that correspond to the years their classmates were born. Use pins to mark the ring(s), first placing a paper "flag" on the pin to label the date.

3. Use pins to mark other significant dates. For example, how large was the tree when:
    a. Students were in the first grade?
    b. The school was built?
    c. Washington or Oregon became a state?

4. Examine the cross-section for differences in growing conditions during the years the trees lived.

Method for Aging Fish:

This is where we relate tree rings to the aging of fish through their scales.

1. Split the class into groups of two. (If you have a small class the students could work individually).

2. Give each group one scale to work with, can be xeroxed from the following page. They may need a magnifying glass to see the details of the rings. A photocopy of the scales could be used so the students can write directly on the scale.

3. Students should look for the heavy or dark rings in-between the lighter rings. The heavy lines are called annual rings (the mark of 1 year of life). Just like the cross-section of a tree trunk, the oval scales of the salmon show annually growth rings. Annual rings can be used to learn the age of a tree or fish. During the summer or other times when growing conditions are good, the fish grows quickly and the rings are far apart. In winter when living conditions are not as good, the fish grows slowly so the rings are close together.

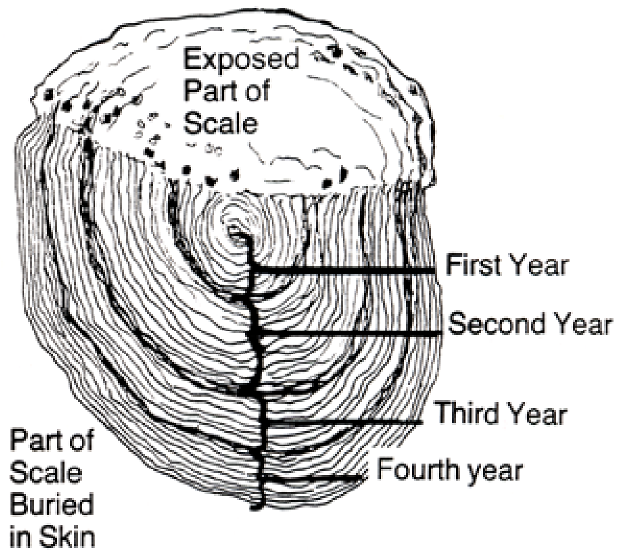
4. Ask students to tell about their fish. How old is it? Did this fish have a lot of space between the annual rings or very little? What des that mean? Which part of the scales shows where it was attached to the fish? What part was exposed?

5. Students could create their own scale, drawing the light and dark lines indicating differing growth patterns. Have them explain the reasoning behind what they created addressing some of the same questions in #4 above.

Evaluation:
Students observe the cross-section of a tree and list events which might cause differences in the width of tree rings. They describe how each event might influence the size of the ring.

How is a Salmon Like a Tree?

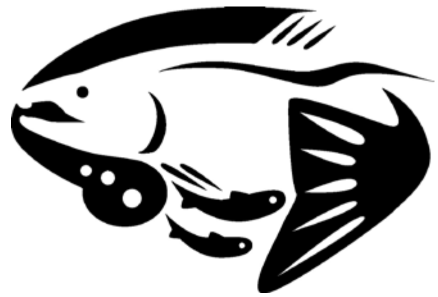
Cross Section of Tree



Salmon Scale

Just like the cross section of a tree trunk, the oval scales of the salmon show annual growth rings. Annual rings can be used to learn the age of a tree or fish. During the summer or other times when growing conditions are good, the fish grows quickly and the rings are far apart. In winter when living conditions are not as good, the fish grows slowly so the rings are close together. How old is the fish below?

Fashion A Fish – An Activity



Key Concepts:

For younger students:
• Fish can be classified according to body shape and coloration.

For older students:
• Fish have adaptations that enable them to survive in their habitats.

Objectives:

1. Students will identify and describe the advantages of fish adaptations.
2. Students will evaluate the importance of adaptations to fish.

Materials:

• Art supplies (crayons, paint, chalk, colored pencils
• Pencil and paper
• Outdoor items for creating habitat (leaves, rocks, seeds, sticks etc.)
• Adaptation cards (following page)

Background:

Fish have a variety of adaptations, including characteristics of fins, senses, scales, shape and color. These adaptations have evolved so that the fish is better suited to its environment and lifestyle. The purpose of this activity is for students to realize 1) there are advantages for the fishes appearance and 2) recognizing some of the ways in which fish are physically adapted to their environment.

Methods:

Discuss with the students the meaning of habitat and adaptation. You may use the various adaptations listed at the end of this activity. Or, brainstorm a list of fish characteristics, then describe the advantage of the adaptation represented by the characteristic. Tell the students they will each have a chance to design their own original fish - one well adapted to its habitat. Divide the class into 4 or 5 groups. Assign each group one adaptation from the following four categories (you may want to reproduce pages 66 & 67 and have the groups draw their adaptation cards from the categories):

• Coloration
• Reproduction
• Shape
• Mouth/feeding

Based on the adaptations assignments (each group will have a type of coloration, a style of reproduction, a body shape and a mouth/feeding style), the students will decide what adaptations are necessary for their fish and write them down before proceeding further. Using their list of adaptations, each group will create their own original fish; for example, by drawing or sculpting it. After creating their individual fish, the group will then create a larger habitat where they will attach their fish. The habitat must be appropriate for the fish they have created. In conjunction with each drawing or sculpture, each student should write a short report which includes the name of the fish and its food source, habitat, and life cycle. Students should also include their lists of adaptations, the reasons for the adaptations, and the advantages provided by the adaptations. Completed project may be submitted to the teacher, presented to the class or displayed in the classroom.

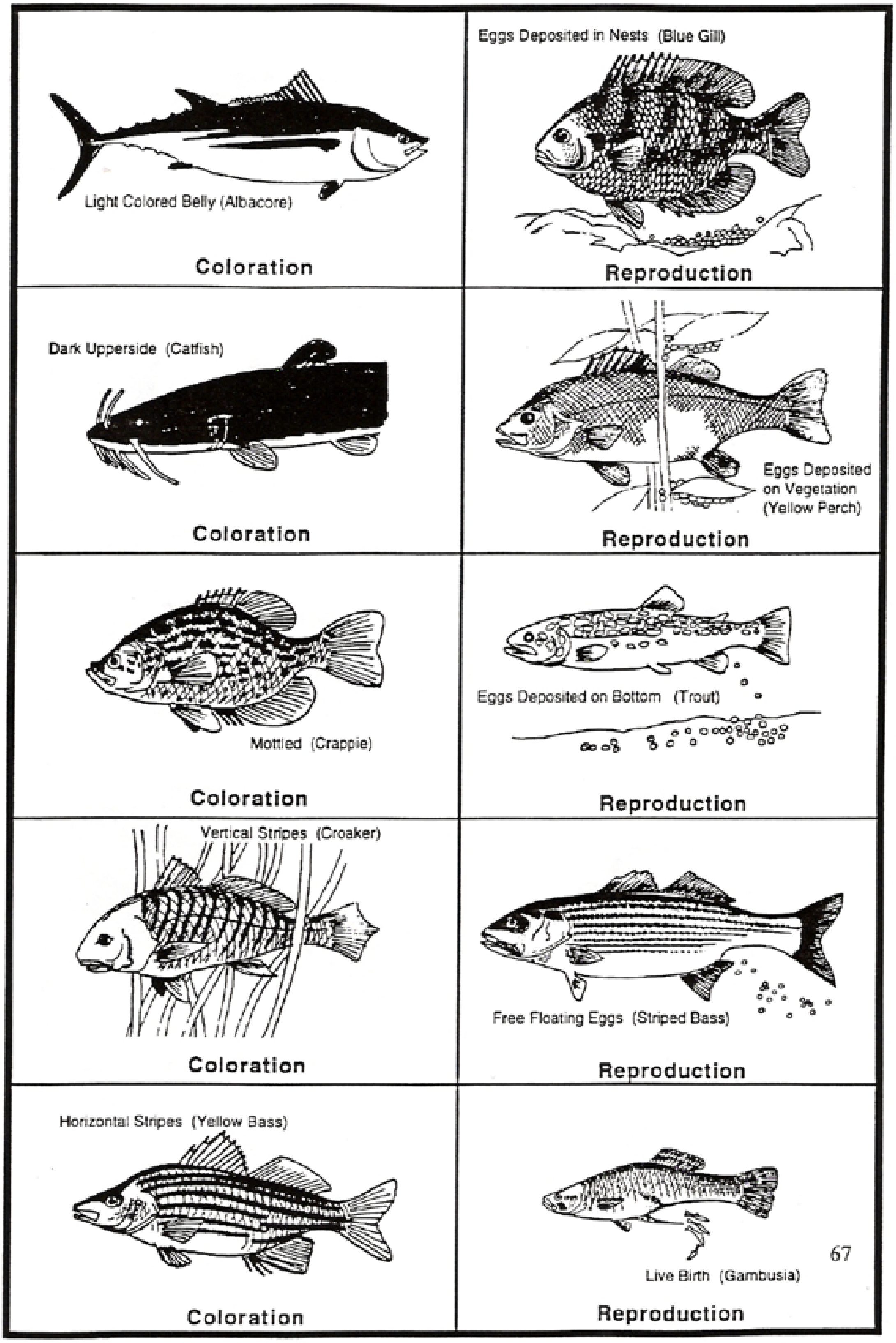
Evaluation:

Name two fish adaptations for each of the following body parts, listing their advantages: mouth, shape, coloration, reproduction. Then describe the advantages of each of these adaptations to the survival of the fish in their habitats.

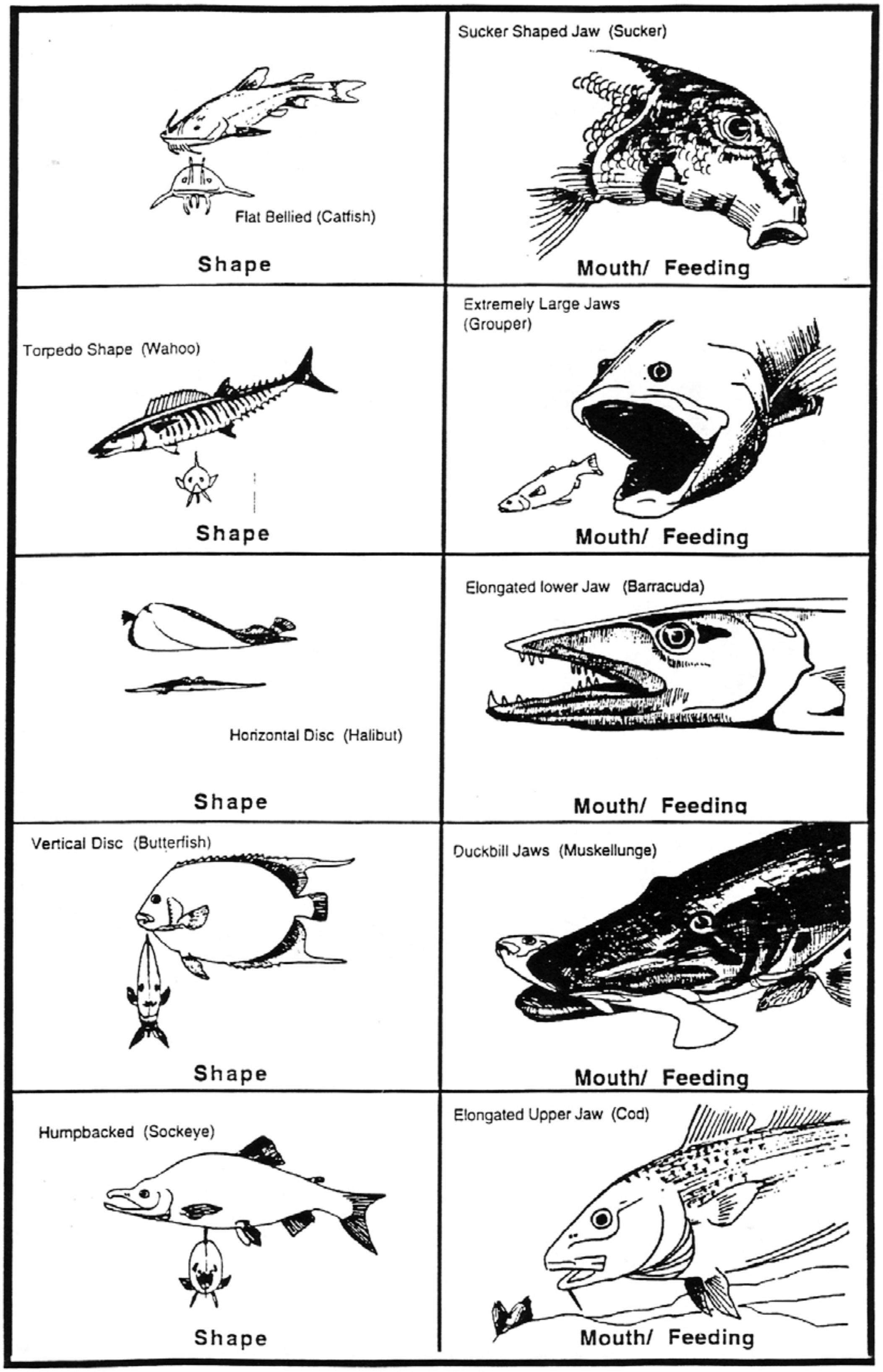
Fish Adaptations for Different Body Parts

Adaptation	*Advantage*	*Examples*
Mouth		
Sucker shaped mouth	Feeds on small plants and animals	Sucker, carp
Elongate upper jaw	Feeds on prey it looks down on	Spoonbill, sturgeon
Elongate lower jaw	Feeds on prey it sees above	barracuda, snook
Duck Bill jaws	Grasps prey	Muskellunge, pike
Extremely large jaws	Surrounds prey	Bass, grouper
Body Shape		
Torpedo shape	Fast moving	Trout, salmon, tuna
Flat Bellied	Bottom feeder	Catfish, sucker
Vertical disk	Feeds above or below	Butterfish, bluegill
Horizontal disk	Bottom dweller	Flounder, halibut
Hump backed	Stable in fast moving water	Sockeye salmon, chub razorback
Coloration		
Light colored belly	Predators have difficulty seeing	Most minnow, perch, tuna
Dark upper side	Predators have difficulty seeing	Bluegill, crappie, barracuda
Vertical stripes	Can hide in vegetation	Muskellunge, pickerel, bluegill
Horizontal stripes	Can hide in vegetation	Yellow and white bass, snook
Mottled coloration	Can hide in rocks and on bottom	Trout, grouper, rockbass
Reproduction		
Eggs deposited in bottom	Hidden from predators	Trout, salmon, most minnows
Eggs deposited in nests	Protected by adults	Bass, stickelback
Floating eggs	Dispersed in high numbers	Striped bass
Eggs attached to vegetation	Stable until hatching	Perch, northern pike, carp
Live bearers	High survival rates	Guppies

Fashion a Fish



Fashion a Fish



Gyotaku – Fish Printing! – An Activity

Key Concepts:

Fish are fun to catch. Fish are good to eat. Fish are fun to print.....Waaaaaait a minute! Print a fish? That's right - you can actually make colorful prints of the fish you catch! And now that the fish are biting, it's a great time to try your hand at fish printing. This process allows you to record your catch in an artistic way. You can make a print with most any fish, but those with larger scales and bodies such as salmon, carp, bass, bluegill, rock fish or flounder, will give the best results.

Objectives:

1. Students will be able to classify animals as fish or non-fish.
2. Students will name the external features of a fish.
3. Students will describe functions and adaptations of the external features of a fish.

Materials:

- Fresh, frozen or rubber fish
- Newspaper
- Modeling clay, straight pins
- ½" stuff bristle brush, small paint brush
- Water based ink (linoleum block ink is best; liquid tempera paint also can be used)
- Rice paper, newsprint or other moisture-tolerant paper (since rice paper is expensive, you might prefer to start with newsprint. After you gain experience you might want to try making a print on a tee-shirt.)

Background:

The art of fish printing is called gyotaku (pronounced ghio-ta'-koo) has been used in Japan for more than a century to record catches of sport fish. The Japanese technique is also used by scientists.

Methods:

1. Use soap and water to clean the outside of the fish as completely as possible. The cleaner the fish, the better the print. Dry the fish well.

2. Place the fish on a table covered with newspapers. Spread the fins out over some clay and pin them in this position. Allow the fish to dry further.

3. Brush a thin, even coat of ink or paint over the body and fins. Leave the eye blank.

4. Carefully place a piece of rice paper or newsprint over the inked fish. Use your fingers to *gently* press the paper over the surface of the fish. Be careful not to change the position of the paper or a double impression will result. Also, do not press too hard, or it will all blur together. *You will get better detail if you press lightly!*

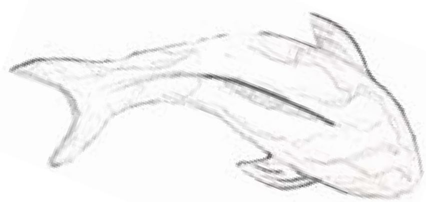
5. Remove the paper from the fish quickly, lifting up one end and peeling it off. Often the second or third print from one inking or painting comes out the best.

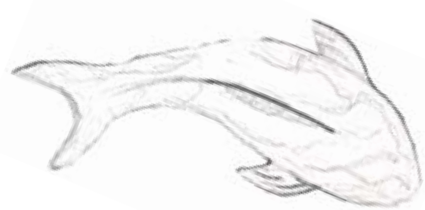
6. Use a small brush to paint the eye on the finished print.

Lesson 4 – People & Salmon Through Time

Purpose:
This lesson is designed to review human impacts and explore connections between people and salmon both past and present.

Activities:





People and Salmon Through Time

The earliest archaeological evidence of human habitation in the Columbia River Basin dates to 10,000 B.P. (Before Present Time). The earliest groups lived by fishing, hunting large mammals and gathering plant foods. Cultures in the proto-historic and historic periods varied greatly along the river. On the lower Columbia groups lived in large multi-family long houses, while on the middle and upper river sections, people moved seasonally and lived in smaller groups. Native fishers took salmon at Willamette Falls on the Willamette River and at Kettle Falls on the upper Columbia. Celilo Falls on the middle river was the most important native fishery. Thousands gathered there during the spring and summer fish runs to harvest Chinook salmon and trade. In the early 19th century, Pacific Fur Company trader Alexander Ross called Celilo "the great emporium or mart of the Columbia."

The Columbia River first appeared on European maps in the early 17th century as "River of the West," when a Spanish maritime explorer Martin de Auguilar located a major river near the 42nd parallel. Cartographers often labeled the "River of the West" as an estuary to the mythical Straits of Anian, or the Northwest Passage and located it anywhere from the 42nd to the 50th parallel. The first confirmation of its location came in 1775 when Bruno do Hezeta described a river estuary at the Columbia's correct latitude. In May 1792, American trader Captain Robert Gray sailed across the bar in the first documented Euro-American visit to the river. British explorer George Vancouver sent Lt. William Broughton up the river more than 100 miles in October 1792, and Broughton produced the first detailed map of the lower river. Meriwether Lewis and William Clark explored the river in 1805 - 1806 for the United States. Northwest Company fur trader David Thompson made the first map of the full river in 1811 - 1812. After the War of 1812, England and the United States jointly occupied the Columbia River Basin territory.

Britain's Hudson's Bay Company established a fur-trading authority in the region and built a headquarters post at Fort Vancouver in 1825. Britain's Hudson Bay Company trappers and traders spread throughout the Columbia River Basin and beyond, bringing furs back to Fort Vancouver for shipment to England. Americans returned to the region as settlers during the 1840's, when over land migrants came to the Columbia and Willamette River valleys on the Oregon Trail. In 1846, the Oregon Country south of the 49th Parallel became United States territory by treaty with Great Britain. Oregon achieved statehood in 1859, Washington and Montana in 1889, and Idaho in 1890.

During the late nineteenth century, capitalists developed natural resource and transportation industries on the Columbia. From 1860 to 1883, Portland's Oregon Steam Navigation Company dominated steamboat transportation on the lower and middle river. R. D. Hume established the first salmon cannery on the Columbia in 1866, and by 1883 forty canneries operated on the river, packing 634,000 48-pound cases for export. During the period 1880-1900, orchardists established operations at Hood River and Wenatchee on the Columbia and along the Yakima and Okanogan Rivers. Engineering projects on the river began with navigation canals at Cascade Locks in 1896 and at the Dalles-Celilo in 1915.

Twentieth-century alterations on the Columbia River dwarfed the early dredging and canal building. In 1932, private power companies completed Rock Island Dam on the middle river. In 1933, the federal government began work on the Bonneville Dam on the lower river and Grand Coulee Dam on the upper river. By 1975, eleven dams stood on the main stem, with many additional dams on major tributaries. The hydroelectric resources contributed directly to waging World War II. Electricity from the Columbia River powered aluminum plants, shipyards, and the development of the plutonium atomic bomb at Hanford Engineering Works near Richland, Washington. The hydroelectricity generated on the Columbia has stimulated significant industrial growth in the Pacific Northwest since World War II.

Native American Teachings

Based on Cedar Tree Teachings of elders of the Pacific Northwest Tribes and the text
Look to the Mountain by Dr. Gregory Cajete of Santa Clara Pueblo

The following is a brief outline of deep principals upheld by many traditional cultures that are transferable to contemporary society. The terms used by contemporary ecologists are also indicated.

Seventh Generation Teachings
Considers our responsibilities in terms of both our future and our past. We honor our ancestors back at least seven generations when we make an important decision that affects our society. This means we take their way which worked well for so long into account when we plan a new road or teaching process. It doesn't mean we can't change but that we change carefully.

We honor our descendants not only because they carry the future but because we will be their ancestors and we are responsible for how they will live. This means we leave wetlands and regenerate deforested slopes so our great-great-great-great-great grandchildren thank us for our decisions. This is called "intergenerational equity" by ecologists.

Listening is Participating
Paying attention is considered the beginning of all knowledge. Traditional teachers will point out to children that the Creator gave us two ears but only one mouth, so we listen at least twice as much as we talk. Children are taught to consider that everything has wisdom and that if we learn the skills of listening we can hear the voices of the animals and plants and mountains. Listening is not what happens when we tell children to shut up. Rather it is what happens when we give them the capabilities to open up. Ecologists call this sensory integration.

We Are a Gift to Each Other
In a consumer society the goal is to acquire more than is used so there is a surplus that creates wealth. In a society based on sharing the individual is aware of her or his responsibility, giving in equal value to what is received. This can be as simple as keeping toxic chemicals out of local waters or as difficult as asking the basic questions of mutual interdependence.

We Are All on a Journey Together
We grow and change in much the same way other living beings do. This "Link of Life" both supports us and challenges us. If we learn where we are meant to go from other living beings we also learn how to behave in this interspecies adaptation.

With Careful Work We Can Restore Ourselves to Balance
Much of Native American environmental activity is ceremonial. This is conscious community action that acknowledges the basic harmony of the natural world and the unique ability human beings have to get out of balance with that existence. The two steps are to recognize when we are not connected and then restore ourselves to stability.

The Importance of Storytelling

Adapted from:
Pacific Northwest Salmon & Watersheds

People have always tried to understand the world around them and the way that it came to be. People in all cultures try to explain their surroundings based on the information available to them.

Stories are one way that we can answer these questions about ourselves and our environment. They could explain the origins of the people, the animals and their environment, or they could contain messages about how people should behave as a part of the world. These stories could then be used to pass ideas from one generation to the next. Storytelling is therefore an integral part of traditional Native American culture.

Storytelling is a communal experience, requiring both tellers and listeners. To make sure that the audience is paying attention to the story, a storyteller may use any number of tactics to include the audience in the story. They may expect response words or answers to questions. For example, whenever a storyteller says, “Ho?” the audience is expected to respond with, “Hey!” Also, songs known by the people might be incorporated into story.

Another common storytelling technique is the Story Circle. Use of the Story Circle varies from everyone in the circle telling a long traditional story to passing a story stick in silence from one person to the next. The circle is important because it serves as a symbol for the cycle of life. A circle is similarly important when telling stories.

Stories are considered to be living things, capable of evolving as necessary. Native American Indian people consider them to be one of the greatest gifts that humans have been given. For this reason, they were and are treated with a great deal of respect. Some stories could be only told by certain people and at certain times of the year.

Because stories are so important, people who were particularly good storytellers were very well respected by others. Stories could be shared as dramatic performances. The teller might use tone of voice or gestures to indicate certain characters. The teller, often an elder, might travel around sharing the stories with people in more than one lodge during the storytelling seasons.

The Secret of Flowing Waters – A Story

Adapted from:
A Salmon Homecoming Story-based Curriculum for Primary Environmental Education
Tribal Communities of the Pacific NW, the NW Indian Fisheries Commission and the Seattle Aquarium

The journey we salmon make down the river where we are hatched is full of risks and adventures. We are lucky to travel with all our brother and sister fingerling salmon. The journey we make circling the ocean is something of a mystery. We keep it that way. This is our salmon secret. To learn about it your must put on your salmon eyes.

The elders tell stories about our ancient village, far over the western horizon. If we go there during our time in the ocean, it is an important part of our journey. Sometimes it seems, from our home creek to our legendary island, we never stop traveling. We must love moving more than almost anything.

We salmon learn how to move from water. It teaches us how to flow downstream. It also gives us the strength to swim against the current, when we need to. Testing our energy against the rush of a river is how salmon dance. When we don't have a stream to swim through, we become lazy.

So salmon know a great deal about flowing. We know that when a lot of water falls, in rain, we are in for flooding. Then, the rivers rise up and fill their lowlands. After such a heavy rain, we may need help restoring our stream banks and waterways. Particularly important to us is the restoration of our gravel redds, or nests.

When our nests are disturbed, we can't live there. It is as if somebody went into your bedroom and turned your bed upside down, forcing you to sleep on the ceiling. If our cold, shaded pool is rebuilt, replanted, or restored it is like falling into a deep, comfortable quilt is for you. We are not so different, except you don't care as much about flowing.

We also love how water drops down a mountain. You call that a 'cascade.' When a fast downhill flow connects us with our redd, we love thrashing up the rushing water. Going upstream, going to our nest, is our great challenge. There is nothing like zipping through fast water, for a homebound fish.

One more thing about flowing; the river goes through many places. It starts up in the melting snow and rocky slopes and ends in low valleys, swamps and finally its mouth, where it enters the salt water. Imagine flowing water as a giant circle, with evaporation rising from streams and lakes. Then the rain falling is how the circle comes back to Earth and closes. Imagine our salmon journey as a great circle, like the water. We go from the watershed to the ocean and back again, over a period of three to five years.

On the way we learn many things. The river tells us stories about others who also need its water. This helps us feel we are part of the whole land the river covers. We learn about the bears and water beetles who share the flow with us. We enjoy the endless movement we flow with.

This is the secret of flowing water. When we go with it we are carried to the sea. But when we go against the flow, we help keep the great circle alive.

Eye of the Beholder – An Activity

Key Concepts:

A salmon, by any other name, would still smell as sweet! Well, at least it would still smell like a salmon.

Objectives:

1. Students will become aware of and appreciate various attitudes towards salmon by comparing descriptions of salmon from scientific and cultural points of view.
2. Students will recognize several types of relationships people have with fish through further investigation and role playing.

Materials:

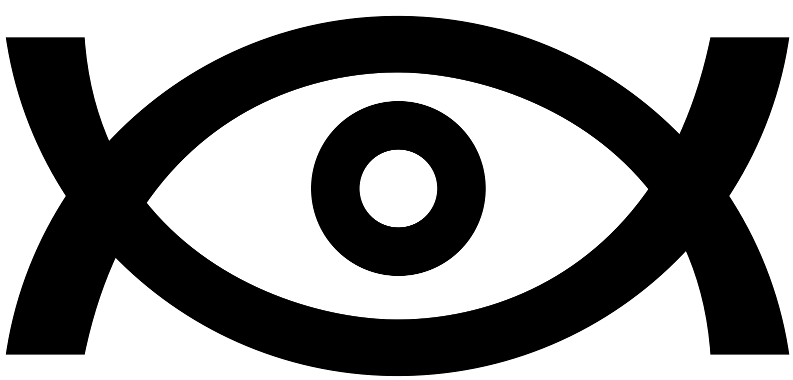
- “The Natural Order of the Chinook” (page 75)
- “Supernatural History of Chinook” (page 76)

Methods:

1. Divide the class into groups of 4-6 students.
2. Distribute “Supernatural History of Salmon” to half of the group, and “The Natural Order of Chinook” to the other half of the group.
3. Students read handouts and then discuss what they read within the group.
4. Each group should then compile a list of salmon characteristics based on the handout they received. (Half of the lists will contain “supernatural” or cultural traits, while the other list will relate to “natural” or historic observation.)
5. As a class, develop two lists of salmon characteristics: “natural” and “supernatural.” Compare and contrast these lists.

Evaluation:

Have students describe three different points of view people have towards salmon.



Eye of the Beholder

The Natural Order of the Chinook Salmon

This is a story of decline, and one of resilience. Neither the salmon nor the men and women whose way of life is shaped by its complex life-cycle, will expire without a fight. The Pacific Salmon represents a miraculous evolutionary adaptation to fresh and salt water environments, commencing when the females deposit their eggs for male fertilization in the gravel beds of coastal streams and rivers. After the eggs hatch, the Chinook salmon travel down river to estuaries where they feed and gain strength prior to entering the sea. The cycle continues when millions of salmon return to spawn.

It all sounds simple, but this reproductive cycle is a risky proposition. Natural predators take a toll, and streams must be sufficiently clear of obstruction to permit migration. If the salmon succeed in their arduous upstream journey, they require a narrow range of water temperature and quality conditions in addition to clean river beds.

For centuries, the abundance of aquatic resources enabled the Native Americans of the north Pacific coast to enjoy a high level of economic prosperity. Salmon had a central place in the trading and cultural practices of Indians who trolled from canoes, employed nets and harpoons and built sophisticated weirs to harvest the annual runs. Drying and smoking techniques were used to preserve the catch, and a complex system of rights was developed to regulate access to the resource.

Eye of the Beholder

Supernatural History of Chinook Salmon

Chinook salmon; spring salmon; tyee; king salmon; blackmouth; springer; quinnat.

Many Pacific Northwest Native American stories share the theme of the Salmon People. Salmon People live in villages under the sea, where they walk and talk just like ordinary humans. Once a year, Salmon People put on their silvery scaled robes and transform themselves into the fish seen swimming upriver. After the migration and spawning, Salmon People return to their undersea home until the next year.

Many stories warn that migrating Salmon People follow a leader, who must be treated with respect. For some tribes, this leader is Fog Woman, who hovers over the water. Others suggest that the leader is the first salmon caught by a tribal member. Traditionally, tribes held special ceremonies to honor this first salmon. Although the details vary from tribe to tribe, the ceremony usually included returning this first salmon, or its bones, to the river. The first salmon was returned to the water to tell other Salmon People how much the tribe respected them. It was believed that Salmon People would not travel upstream to provide food if they were not shown proper respect.

The Path of the Salmon People – An Activity

Adapted from:
A Salmon Homecoming Story-based Curriculum for Primary Environmental Education
Tribal Communities of the Pacific NW, The NW Indian Fisheries Commission and the Seattle Aquarium

How the Rain Moves Through the Watershed
The salmon nations made the return journey from their village far out to sea because a promise was made by the human beings by the elder and the children. What was the promise? To allow the continual movement of the five helpers through the watershed so the salmon could come home.

Let us imagine what it is like when everything flows freely. Brother Rain Helper knows how to teach this but everything in the world flows. Gravity causes things to flow downward. We don't sit up in a chair. We sit down in a chair. When the salmon move through the flow it is because they know they can keep going to reach their goal.

Generations of Salmon People are certain of their progress up a particular corridor of the watershed. Each of the six nations of salmon likes a different kind of water flowing. For example:

Chinook salmon which are very large choose big rivers. They like long journeys against the flow leaping up amazing waterfalls and taking as long as six months to reach their spawning grounds. Of all the Salmon People, Chinook most enjoy everything to be full of energy. Females lay up to 5000 eggs in fast-flowing water. Probably their choice of powerful flowing water has been why they have grown so strong themselves.

Coho salmon like all kinds of water. Unlike the Chinook they choose quiet side streams, calm channels and the most insignificant of winter creeks. What might seem a tiny waterway can still be a marvelous place for Coho nests. If they have a choice the Coho will always take the middle flow looking for water that is neither too fast nor too slow.

Chum and **Pink** salmon don't travel far from the sea. Chum are the opposite of the adventurous Chinook. They choose coastal channels with low flows and if there are any local springs to bring oxygen to their eggs they will just make their nest in the lowest of flows. Pink salmon go a little further upstream and like slightly faster water, but both Chum and Pink fry (baby fish) spend their early schooling in the estuaries and beach swamps before they go out to sea. This is where they learn to adjust to salty water.

Sockeye salmon ride any river as long as it ends in a lake. They spawn in flow that comes from inlets or even near gravelly shorelines of lakes so their young can grow up in the lake. Sockeye like to swim around and around in circles before they take off on their journey to the ocean, maybe so they can create their own flow.

Steelhead another salmonid fish, make the longest journey of all. They can enter a great river like the Columbia any time of year. They spawn from late winter almost to summer. Some Steelhead travel as far as the Snake River, sharing their nests with mountain trout, way up in the Idaho wilderness.

Now that we know a little about how each salmon enjoys the fast or slow flow of water, what are some things that stop the movement of Brother Water Helper through the watershed? Remember this also keeps the six nations from reaching their nests and completing their circle of life. All of these are problems human beings can help the salmon people solve.

These are a few examples of what keeps the water from flowing as the salmon want it to flow. There are far too many blockages to put in this short story.

Dams are how we control flooding and get electricity. The lakes that build up behind dams can be used to store water or send it to farms. Unfortunately, dams slow the flow. The great migrations of the salmon from their nests to the sea or back upriver can be stopped by dams. Sometimes we can build fish ladders and help the fish make their run. Sometimes we can control the flow in a way that makes it easier for salmon to migrate. Always, we can conserve water and electricity so there is more water for fish to swim in, and always we should be sure that dam turbines are screened so they don't kill baby fish swimming down river. Sometimes dams can even be removed to free the flow.

Cities and towns are built for people to live in. This is very comfortable for us but we pave over the watersheds and instead of flow we have storm water runoff. This means that the rain that falls on a city does not go into the soil or the roots of trees and the branches of bushes. Instead the rain goes into sewers and reaches the sea full of poisons and garbage. Sometimes we can restore the watershed like in a city park. The best thing is for us to be very careful of any new construction or conversion of forest land, wetlands or green belts into developed property. Then we will always remember how to keep the water flowing as it wants to.

Farms divert the flow to fields and animals such as cows and sheep. The water goes through irrigated land picking up fertilizer and pesticides before running back to the main river. Sometimes we channelize (or straighten) streams and rivers to make more land available for farming or ranching, and sometimes we dike river banks to keep them from overflowing in times of flood. This can destroy salmon habitat, too. We can help by fencing streams so cattle don't break down the banks when they go to the creek for a drink. We can help by controlling herbicides and pesticides we put on the crops so we don't accidently poison the flow. We can also help by keeping streams and rivers in their natural condition, so the water flows the way it was meant to. Then when rain and rivers go through the crops we eat they will be part of the flow and keep us fed and deep us healthy.

Forests are not something we think of as stopping the flow because we have seen with our salmon eyes how the trees drink the rain and then send it slowly downhill with gravity to join the stream. But log jams can stop the flow, keeping salmon from going upstream or down. Clear cutting, taking out every tree from a particular place in the forest, can hurt the soil, eroding it and sending water full of mud into the salmon channels.

Life along the stream banks can be ruined when we log right up to the edge of the river. Trees and brush are needed along streams to slow the flow of rain. They also help keep the water cool, the way fish like it. They provide protective cover for fish, and other wildlife, and provide natural nutrients to the water. They also provide habitat for insects, an important food source for the salmon. We can help the flow by logging selectively; taking out only the trees we need from one part of the woods and then going to another place. We can leave at least 200 yards of trees on either bank of the river to keep the salmon nests and nurseries pure. We can replant many more trees than we cut down. We can remember how important the trees are to keeping the water flowing clean.

Can you think of other ways to keep water flowing clean and fresh through forests, farming and cities?

From the mountainside to the sea, the pull of gravity and the pressure of the river corridor keeps the water moving as it should. Different salmon like different currents but there is not a bit of the flowing water that does not help the circle of life as long as we remember our responsibility to keep the way open so the journey of the salmon keeps moving as it has for so many generations.

Lesson 5 – Impact

Purpose:
This lesson introduces students to the factors that change or impact salmon and their habitat.

Activities:

History of Fishing on the Columbia River

Paul Kane was born in Ireland in 1810, but moved with his family to Canada when he was eight years old. He studied painting at Upper Canada College and after working in Detroit, Michigan and Mobile, Alabama he went to Europe for two years to study art.

Having developed an interest in western Indians, Kane arranged to visit their territories, leaving Toronto in May 1846. He went as far west as Fort Vancouver on the Columbia and over to Victoria and returned in October 1848.

First Fishers of the Columbia

His field sketches and watercolors are an important record of a period before photography. Returning to Toronto, he spent six years making a series of 100 large oil paintings from his work.

This trunk full of sketches and paintings gives us a glimpse into the past of the Columbia River and its people. They showed the many ways the Native Americans fished for salmon and other species of fish. Spears were used to catch fish from canoes, river banks, and platforms built out over the river. In his paintings the fishermen stood on rocks beside the river, poised to thrust their spears when they saw a fish swim by. If you look very closely, you can see that the spears have three points, or prongs. There were many types of spears and harpoons. A good fisherman knew just what type of weapon to use in different conditions such as deep swift water, shallow water with a rocky bottom, or deep ocean water, for example.

What's the difference between a spear and a harpoon? Hilary Stewart, author of the book *Indian Fishing*, provides this explanation:

> *"While a large, struggling fish impaled on a fixed spear point could break the shaft or point, or free itself by thrashing about, the detachable harpoon head allowed the fish to move in the water without putting direct strain on the gear, while its struggles imbedded the barbs well into the flesh."* (p. 65)

Traps or weirs documented by Kane were just one of the methods the Indians of the Northwest used to catch fish. Sturgeon, trout, echelon (a tiny, anchovy-like fish) and especially salmon, was the staple food of their diet. There were so many fish in the river that a fisherman might catch as many as 100 fish in a day! At this rate he soon caught enough fish in a month or two to feed his family through the winter. Some of his catch could also be traded to people who did not live near the rivers where the fish swam. Although Paul Kane observed the weir in his painting, archaeologists still sometimes find the remains of these structures in streams and rivers throughout the Northwest.

The method which attracted the most attention between early explorers and trappers was the dip net, a device that was fished in fast waters. The net was hung on a four-foot diameter hoop attached to a thirty-foot pole. The net was made to slide on the hoop so as to close into a bag with the weight of a salmon. It was usually fished blind, which means the fisherman could not see the fish. Dipping platforms were built over eddies. The swirling water caused the bag of net to flare. When the fisherman felt something, strike his net, he rapidly pulled the net straight up out of the water.

Just as there were many ways to catch fish. There were also many ways to prepare them for eating. Kane showed the fish cut into fillets and hanging from racks to dry in the sun. Large quantities of fish were dried in this way and smoked by hanging from the rafters over the hearth of a plank house or smoke house. When completely dried, the fish could be pounded into a powder and hen packed into woven baskets. Sometimes holding up to 100 pounds of powdered fish, these baskets were traded to inland people or stored away to be eaten during the winter. Other methods included roasting, boiling, or steaming in an earthen pit lined with leaves.

A Native American population of 50,000 caught an estimated 18 million pounds of Columbia River salmon each year. This figure is based on an average daily consumption of one pound of salmon per person.

The Inexhaustible

The treaties of 1855 allowed both Native American and settler to fish in common for salmon. In the early 1860's, the Columbia Rivers' resources seemed inexhaustible and capable of serving the needs of both groups. It wasn't long before some settlers saw more than subsistence in the salmon; they envisioned riches that could be gained from trade and commerce. The early efforts at marketing salmon - shipments of barrels of salted salmon to Hawaii, the Atlantic Coast and Europe-were not particularly successful, because salmon did not keep well on long journeys' and spoiled before reaching their destinations. Salmon harvests boomed with new and improved canning processes which enabled long distance transport and long term storage of salmon.

Hapgood, Hume and Company introduced salmon canning on the Pacific Coast in 1864 on the Sacramento River, but moved to the Columbia River in 1866 because of over fishing, hydraulic mining and stream obstructions which depleted the salmon runs. Their new canning operation began with 4,000 cases packed and sold at an average of $16 per case. As early as 1872 the total pack reached 250,000 cases, the price per case having declined to $9. Success, however, does not go unrecognized, and many more canners came to share in the profits. By 1883, there were 55 salmon canneries operating on or near the Columbia River.

It is important to note that the drop in price per case was due to the success of canned salmon. Canning salmon and locating markets for the product increased the pressure on the Columbia River's salmon resource. The success also attracted cannery men and fisherman from around the world to the Columbia. Soon canners and fishermen were competing for a portion of the pack available which was on a decline. Cannery men knew in 1883 - 1884 that they had saturated the market. They tried, but failed in attempts to limit production and establish agreements between canners. The problem was no one wanted to be limited on production based on their current capacity. The key to success in this market was innovation and anyone with the inventiveness to expand determined whether or not they stayed in business.

So how did they do it? When the early settlers began to fish for salmon, they introduced many methods already in use around the world. Gill nets, fishwheels and hand or horse drawn seines had been used with a great deal of success on the East coast to catch Atlantic salmon. Fishwheels were water-powered machines which scooped salmon out of the river and dumped them into a box. They were placed in swift water in the path of migrating salmon. Samuel Wilson built the first fishwheel on the Columbia in 1879. By 1899, there were 76 fish wheels in operation. The Seuferts' No. 5 wheel on the Columbia River caught 4,625,776 pounds of salmon in 31 years of operation, averaging 149,218 pounds per season, or about 75 tons. 1n 1913, one fish wheel caught 70,000 pounds of salmon in one day. Fishwheels were outlawed in Oregon in 1926 and later the citizens of Washington were next to make gear changes. Initiative 77, passed in 1934, eliminated all fixed gear, fishwheels, traps, seines and set nets.

Horse and hand seining was another way used to catch salmon. Fishermen put seines, special types of nets, in the river. Horses were used to pull the seines closed, trapping salmon inside. The horses pulled the seines to shore where the salmon were taken from the nets. Ernest Woodfield was the Sand Island Foreman for the Columbia River Packers Association. On July 31, 1912, his Sand Island seine took 20,000 pounds in one haul. A record day was August 22, 1921, when 60,000 pounds were caught in one haul. You can see this method worked very well. Horse drawn seines were outlawed in the 1950's.

Hatcheries and Fish Culture

By the early 1870's, farsighted canners began experimenting with artificial propagation and establishing hatcheries. In response to a request from a group of Columbia River canners, Congress asked Livingston Stone of the U.S. Bureau of Fisheries to travel to the Columbia Basin in 1877 to locate a site for a hatchery station on that river system. In 1877 he established the region's first artificial propagation operation on the Clackamas River.

Early fish culture development on the Columbia was erratic. The U.S. government operated the Clackamas River hatchery until 1880 when it left the site, only to return in 1889 when it took over operations from the Oregon State Board of Fish Commissioners, which had run the site for two years. Between 1880 and 1887, the only hatchery in Oregon was run by canning operator R. D. Hume on the Rogue River.

Many of the early efforts to establish fish stations failed, owing to a lack of knowledge concerning the life cycle of the salmon. The State of Oregon, for example, opened several stations in the early 1900's only to close them a few years later because state officials had built in the wrong locations. After several initial failures, however, Oregon took the lead in developing artificial propagation in that state and funded the operations with state money.

Fish culture activity intensified between 1887 and 1894, and salmon populations increased by 1890. However, this success was difficult to duplicate and fish populations did not increase significantly until 1915. Fish canners, demanding to know why the runs continued to decrease, eventually blamed the early release of the salmon fry by hatcheries. In response, the Oregon Fish and Game Commission in 1915 developed "the improved hatchery system," which included the use of feeding ponds to hold the young fish until they were large enough to survive the rivers. This new system was more expensive to operate, but led to an increase in the fish runs between 1917 and 1918.

Degradation of Habitat

Over harvesting of anadromous fish populations in the late 19th and early 20th centuries was an immediate, highly visible reason for the decline in the resource. A less obvious cause involved the destruction of habitat in the Columbia River Basin. As early as 1894, the U.S. Fish Commission reported that placer mining near Caldwell, Idaho had significantly reduced salmon runs on the Upper Boise River. In 1933, the Oregon State Game Commission claimed that "there is no question but that the pollution of the tributaries of the Columbia is a menace to the salmon industry." For decades, farming, grazing, mining, and lumber operations had contaminated the Columbia and Snake Rivers. These activities sometimes resulted in the construction of barriers that blocked spawning grounds. They also eroded the soil, which settled on the gravel of streambeds, hindering the reproduction of anadromous fish.

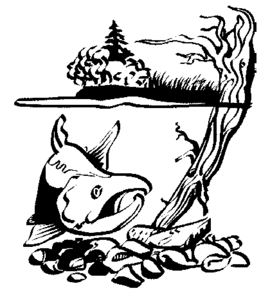
Irrigation also contributed to the loss of habitat in the Columbia Basin. Owing to the diversion of the rivers, many tributary streams dried up during low-water periods. The building of unscreened diversion canals and small dams for agricultural production further hindered the migration of anadromous fish. Canals drew fish on to fields, where they lay stranded.

When construction began on large-scale multipurpose dams in the 1930's, salmon populations had already diminished. Decades of intensive harvesting and destruction of habitat had taken their toll. Many Americans of the early 20th century had inherited a perception that natural resources in the Pacific Northwest remained unlimited. - even scientists had little understanding of the consequences of intensive use of the Columbia River and its fish. During the 1930's, the dams came to represent the hopes and high expectations that the arrival of the transcontinental railroad inspired a half a century earlier. In the midst of the depression, hydroelectric projects brought jobs to a region suffering from economic collapse and extensive unemployment. For farmers attempting to cultivate the arid lands east of the mountains, dams meant irrigation on a scale that remained beyond the funding capabilities of individuals or small companies. The construction of dams also brought improvements in navigation and flood control.

Most important, it was the promise of cheap electricity that would attract the aluminum industry to the shores of the Columbia. During the 1940s, the Boeing Company, initially dependent on spruce, looked to the new aluminum industry for raw materials for the construction of aircraft. By 1944, Boeing had employed nearly 50,000 workers in the Seattle area. Cheap electricity also encouraged the development of the Hanford Complex in central Washington. Historically, Pacific Northwest residents had remained dependent on logging, farming, mining, and fishing. Hydroelectric projects stimulated economic and population growth. Without the dams along the Columbia and Snake rivers, the region would be a very different place today.

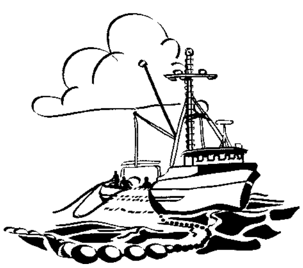
What Has Caused the Declines?

Background
Declines in Northwest salmon and steelhead populations have led to several listings under the federal Endangered Species Act (ESA). There are a lot of opinions as to whom or what might be the cause of salmon decline in the Northwest. Some of the things that people agree on as factors responsible for these declines: habitat, harvest, hatcheries and hydro. Once called the Four H's are now referred to as the contributors.



Habitat Destruction
Agriculture, urban development, mining and forest practices can generate large amounts of sediment that cover spawning gravels necessary for juvenile salmon survival. The fresh water habitat used by salmon has been severely altered by the increasing human presence in the Northwest. Logging and related road building can increase erosion and cause streams to become filled with too much silt. Logging can also result in the removal of stream side trees which reduces stream cover and can increase summer water temperatures and decrease winter temperatures to critical levels. This can also reduce the amount of wood available to streams. Large woody debris (logs, trees and root wads) help create pools and accumulate gravel needed for spawning.

Fish Harvest



As adults, salmon are caught in both salt and fresh water. Over harvesting of adults salmon by sport and commercial fishers for food and sport, have been a major factor in the decline of some stocks such as the Columbia River Coho. Hatchery stocks typically can sustain a harvest rate of about 90 percent. However, in a mixed-stock fishery of wild and hatchery salmon like the Columbia River, wild stocks are harvested at a rate beyond their ability to sustain themselves over time. Recent changes in harvest management, however, are focusing on reducing the catch of weak populations of salmon by targeting commercial and sport fishing on more abundant runs, and reducing illegal harvest.

Hatcheries
Most salmon produced in the Northwest are reared in hatcheries. These hatcheries are operated by state and federal agencies and other cooperative partnerships to supplement natural stocks and provide salmon for sport and commercial harvest. A hatchery can increase the survival rate of eggs to juvenile salmon and, at least for a time; result in additional adult fish for harvest. However, hatcheries have contributed to problems faced by the wild salmon. Hatchery fish have had demographic, ecological and genetic impacts on wild salmon populations and may have caused problems related to the behavior and health of wild salmon. When hatchery fish stray into other watersheds they make contact with wild salmon and sometimes cause the following problems: **Competition** between hatchery and naturally produced fish for food or space at mainstem dam fish passage facilities, in mainstem reservoirs, in the estuary, and in the ocean. Although still unproven, **disease** may be transferred from hatchery fish to wild fish and visa-versa. Through years of adaptation, wild fish have developed greater resistance to local diseases and the ability to time their migration and spawning to take advantage of optimal river conditions. **Predation** caused by hatchery fish or non-salmonids on naturally produced fish. Straying of hatchery fish into natural spawning grounds and **harvest** of naturally produced and hatchery fish in mixed-stock ocean and river fisheries.

Hydro Operations

Hydro projects and other dams have blocked access to about half of the historical salmon habitat in the Columbia River basin. The Northwest dams range in size and number from major dams on the Columbia and Snake rivers to countless small irrigation dams on tributaries. Used for hydro power, flood control, irrigation or domestic water supplies, dams can cutoff entire basins to fish migration. They can also change runoff patterns, water quality and loss of habitat where rivers become lakes favoring different kinds of fish. They can make salmon more susceptible to predators that gather at the base of the dams. A number of solutions have been used or proposed, including fish ladders, barging salmon around dams, and drawing down water levels behind dams to increase river flows and bypass hydroelectric turbines.

Human Impacts on a Watershed

Water development projects on the Columbia River have altered the temperature conditions, which may at certain times or localities, create unfavorable situations to particular life stages of Chinook and Coho salmon. Migration and survival of adult fish have been linked to critical temperature limits. Exposure of ripe adults and eggs to water temperatures in excess of 56°F is commonly assumed to incur greater than normal losses and abnormalities of young salmonids.

The activities of fish are controlled by temperatures in the aquatic environment. Extremes in temperature, whether hot or cold, produce adverse effects in fish. The tolerance of fish to temperature extremes varies with the life stage; whether, egg, fry, fingerling, smolt or adult. In addition to direct effects of temperature on fish, indirect effects due to temperature also occur that can limit fish populations. Such effects include altered food abundance, increased predation, temperature-mediated disease, dissolved oxygen and increase toxicity of various compounds.

Thermal Pollution occurs when the temperature of a surface water body (e.g., river, stream, pond) is raised or lowered beyond its normal range in temperature. A drastic change in the water temperature can be due to either the addition of heated or cooled water to the surface water body, or a change in the amount of solar radiation reaching the water surface. The following are ways we cause thermal pollution:

- <u>Electrical Power Plants</u> - many industries use water to cool the machinery in their plants. This water is taken from a river, stream or lake. It usually returns to the surface water body at a higher temperature than when it withdrawn.

- <u>Heated water holds less oxygen</u> - this leads, indirectly, to an increased oxygen demand in organisms living in the area of the outfall (where the water is returned to the stream). In other words, there is less oxygen in the water (lower Dissolved Oxygen), so organisms have to work harder to get enough oxygen to live (higher oxygen demand) and therefore, have less energy for things like reproduction and avoiding predation.

- <u>Altered solar radiation</u> reaching surface water bodies. Surface water bodies absorb heat from the sun rays that reach the water surface. The cutting down of trees along a river bank is one way to change the amount of solar radiation reaching water surfaces.

- <u>Construction Sites</u> - these big projects include things like dams or altering stream channels. Since a dam blocks a river or stream and only lets some of the water flow downstream, there is a backup of water behind a dam. This backed up water floods a lot of land behind the dam and creates a lake or reservoir. These large slow-moving bodies of water then act as solar collectors raising the surface water temperature higher then normal. For some fish species, aquatic insects and plants this could spell the end. On the flip side of warmer surface water temperatures these conditions may favor a different kind of fish species, insect or plant. Making salmon more susceptible to larger predators' populations, diseases and a larger abundance of oxygen absorbing plant life.

Slow Motion to the Ocean – An Activity

Columbia River fall Chinook salmon swim all the way from the Spring Creek National Fish Hatchery (NFH) in Washington where they're born down to the Pacific Ocean–a distance of nearly 167 of miles. In spring, young Chinook "smolt up." Their bodies turn silvery in color, and they become restless. Once they are released from Spring Creek NFH where they've lived since hatching and enter the Columbia River it's all downhill. From here to there, it's a float trip.

Doing the Backstroke
If you could look underwater and watch them pass by, you'd see something surprising: The salmon smolts migrate backwards! Instinct tells them to face into the river current and travel downstream tail-first.

Spring Creek NFH times its releases with natures timed migrations, which occurs in the spring, because that is when snow in the mountains begins to melt and swell the rivers. At four inches long, the young Chinook aren't big or strong enough to swim all the way to the ocean. For much of the time they ride the river currents. Chinook smolts used to get to the ocean in a hurry. In spring, the river currents flowed at about seven miles per hour and swept them downstream to the Pacific Ocean in about 10 days.

Today, large dams have turned the Columbia River into a series of lakes. The water flows at only one mile per hour. Now it takes the smolts weeks or more to reach the Pacific. Most of them die before they get there from stress, predation, disease, pollution and other causes.

The Need For Speed
Chinook salmon begin life in fresh water. When they enter the ocean, they're suddenly exposed to salt water. To survive in the new environment, their bodies must go through physiological changes. These changes start to happen when the young fish "smolt up." Nature scheduled the process to take place during the 10 day journey to the ocean. But now, with all the dams slowing down the river current, Chinook cannot reach salt water as quickly and this disrupts the changes. If the trip takes too long, the Chinook will be unable to live in the ocean and will die without ever returning to Spring Creek NFH to spawn.

Words to Know

Chinook salmon
The largest of the salmon that live along the Pacific Ocean. An average adult measures thirty-six inches on and weighs about thirty pounds. They stay in the ocean three to four years.

Smolt
A young salmon that has turned silvery in color and is migrating to the ocean.

Northern pike minnow (*squawfish*)
A predatory fish species that lives in the Columbia River Basin.

Dam turbine
A large propeller mounted in a dam that turns with the flow of water to generates electricity.

Study Questions (answer on the back, or a separate page)

1. Young Chinook salmon swim from Spring Creek NFH to the Pacific Ocean. What is the distance they travel?
2. True of false: Chinook salmon smolts travel downstream tail first?
3. When a young Chinook becomes a smolt, it turns bright silvery in color. Does any other change occur?
4. Nature timed the smolt migration to happen in spring. Why?
5. Why is it important for Chinook salmon to reach the Pacific Ocean quickly?

Glossary

adaptation: Adjustment or modification of an organism to changes in the environment.

adipose fin: A small fatty fin found on the top back of salmon and trout between the dorsal fin and the tail (caudal fin). This fin is a key identification feature of salmon or trout.

aerate: Supplying the oxygen; with water it is a process of exposing water to the air usually by churning or breaking the surface of the water, such a waterfalls, riffles, etc..

alevin: Newly hatched fish with yolk sac attached. See sac fry.

algae: Simple plants that grow in water. They range from microscopic size to plants hundreds of feet long.

anadromous: Migratory. A fish that spawns in fresh water and the young migrate to the ocean to grow and again return to fresh water as adults to spawn. (From the Greek words for "up river")

anal fin: Fin located on the bottom and near the back of the fish.

anglers: People who fish. Usually refers to recreational (sport) fishers using a rod and reel.

anthropologist: A person who studies human beings and human cultures.

aquatic: Water-related. Anything that lives in the water.

bar: The area at the mouth of a river where sediments are deposited.
barrier: Barricade; separator; blockage of a route.

benthic: Bottom-dwelling.

brood fish/brood stock: Fish held in the hatchery to produce eggs like one would raise chickens for eggs.

buck: A male fish.

carbon dioxide: A gas (like oxygen is a gas) which is exhaled from animals and absorbed by plants.

carcass: Body of a dead animal; corpse; carrion.

carrying capacity: The number of fish or wildlife that can be supported by a given area of land or water.

cascades: A steep series of small waterfalls. It is the name given to the mountain range that runs through the center of Oregon.

catastrophe: A sudden and tragic event; disaster.

caudal fin: Another name for the tail of a fish.

char: A genus of small-scaled trout (Salvelinus).

commercial fishing: Fishing to sell the catch of fish for the market.

counter-shaded: Offset coloration allowing an animal to be hidden in its environment. Fish usually have darker tops and lighter bottoms, making it difficult to see from above or below.

cycle: A series of events that happen regularly and repeatedly.

debris: Left over material from something breaking down or being broken.

decay: To decompose or rot.

decompose: To break down into smaller parts / elements. Living things that die are decomposed (broken-down) by microscopic organisms.

domestication: To adapt an animal to life in association with humans.

dorsal fin: Dorsal means top. This is the large fin on the top of the back of a fish's back.

ecological: How plants, animals and other living creatures interrelate to their environment.

ecology: The relationship or study of the relationship of a fish or animal to its environment.

eddy: A current of water (also could be air) which runs against the main current.

electromagnetic signals: Small electrical charges based on magnetic properties.

Endangered Species Act: A law that requires special protection for plant and animal populations that are in danger of becoming extinct.

estuary: The area where the tides of the ocean meet a river current.

environment: The total of all the things around you, both physical and biological.

erosion: The natural process of moving soil and rock material from any part of the earth's surface.

evaporate: Change from a liquid or solid to gas.

exploitation: Take for personal use without providing a benefit in return.

extinction: Gone forever.

eyed egg: A fish egg that has developed to the point where the dark eyes of the embryo can be seen through the shell.

fertile: An egg that has the potential to develop and hatch or an animal or fish that can produce young.

fertilize: Mix sperm and eggs. One sperm unites (fertilizes) one egg to create a complete set of genetic instructions (genes).

fingerling: A small fish, up to one year of age. A small fish about the size of your little finger. A stage or size measurement in the growth of a fish.

fishing regulations: Laws that are made to protect fish, and govern how many fish can be caught and under what conditions.

foliage: Plants

food chain: A chain or series of plants and animals where some feed on certain ones and are in turn eaten by others.

forb: An herbaceous plant other than grass growing in a field or meadow.

freshets: A stream created by overflow or runoff.

fry: Recently hatched fish, after yolk sac has been absorbed, and prior to the fingerling stage.

fungus: A type of lower plant (such as mold) that helps decompose organic matter.

gene: The unit of genetic information passed along from generation to generation through mating.

gills: The feathery organs of fish and other aquatic creatures that extract oxygen from the water.

gillnet: Nets that capture fish as they try to swim through the holes in the net. Used mostly by commercial fishers

gradient: Gradual change in coloration, slope, or pressure.

grading: The process of sorting fish by size.

ground water: What that is contained in the soil or ground and is pumped out of wells.

habitat: The place where a fish or animal lives. It must include the necessary food, water, and shelter.

habitation: Occupancy; residence; moving in.

hatchery: Location for raising fish.

heath tray: Tray used in hatcheries to raise eggs to the fry stage.

hen: Female fish.

homing: Ability to return or relocate "home", or a desired location.

hydroelectric facility: A dam; a place where electricity is made by falling water.

ice age: A period in geologic time, over 10,000 years ago, when nearly 1/4 of the earth was covered with ice.

immortal: Unable to die.

imprinting: Behavior in which the first response to a particular stimulus, early in life, becomes a fixed response to the same stimulus thereafter.

incubator: A human-made environment where eggs are placed to hatch.

incubation: The entire process of hatching an egg.

inorganic: Made from material that is not from an animal or plant.

interspace: The area on a fish between the parr marks.

invertebrate: Does not have a back-bone.

juvenile: A young fish or animal that is not mature.

larvae: An immature stage of development in many kinds of organisms.

lateral habitat: The calm water areas along the edges of a stream.

lateral line: A sensitive line along the side of a fish which senses changes in pressure.

leaf litter: Old fallen decaying leaves.

lethal: Deadly; able to kill.

liberation truck: The specially equipped tanker truck that hauls fish to the place they will be stocked.

life cycle: The stages of development from egg to adult.

limiting factor: Factors that reduce the populations of living organisms.

marked fish: A fish that has had a fin clipped off, a dye sprayed on, a tag attached, or a wire implanted so it can be identified at a later date.

mash: Food pellets fed to young fish at the hatchery.

maxillary: The upper jaw bone of vertebrates, including fish.

midge: The larval form of any two-winged fly.

migration: Traveling between seasonal habitats.

milt: A milky liquid from the male fish that contains sperm.

Miocene: The geologic time period between twelve and twenty-five million years ago.

mortality: Death.

navigate: To find one's way on a journey between one place and another.

niche: The role that a fish or animal plays in the plant and animal community. The type of habitat it uses.

nutrients: Natural particles which are used by living organisms.

organic: Of plant or animal origin.

oxygen: A gas essential for life.

parasite: A plant or animal living in or off of another plant or animal, in a harmful way.

parr marks: Vertical lines on young fish which make them harder to see.

pectoral fin: Front steering fins on either side of a fish; corresponds to front leg.

pelvic fin: Lower fin on either side of a fish; corresponds to hind legs.

percolation: To trickle/flow through something.

pesticide: A substance that is poisonous to certain animals considered by humans to be pests.

physiological: Having to do with what goes on inside of a body.

plankton: A tiny animal or plant which floats in water.

pool: A still/clean place of water.

porous: Full of holes and allows liquid to pass through.

predator: An animal that eats another animal.

prey: An animal which is food to another animal.

pristine: Original, pure, uncorrupted.
lethal: Deadly; able to kill.

raceway: A rectangular hatchery pond where water enters at one end and leaves at the other.

rapid: Fast moving churning water.

ray: The main supporting structures for fins of a fish, usually easy to see and count.

rearing: To raise young.

redd: The nest made by salmonids for their eggs.

reservoir: Storage place for water.

respiration: The process of getting oxygen into the blood, either from the air or water. Another word for breathing.

riffle: Fast, shallow waters of a stream.

riparian zone: The vegetated area next to a stream/river.

run: A population of fish that returns from the ocean at about the same time headed for the same place.

run-off: Excess water beyond the normal flow of a stream.

salmonid: Any fish of the salmon or trout group.

sediment: Fine particles of rock and sand that collects along a river bottom.

seine: A net weight at the bottom that hangs vertically in the water and catches fish when its ends are drawn together.

shelter: Cover. A place to hide, raise the young, or get protection from weather or predators.

silt: Tiny, fine particles, such as soil or sand, suspended in and deposited by water.

slime layer: The layer of mucous covering fish that protects it from fungi, parasites, and disease.

smolt: A young salmon or trout that has turned a silvery color and is ready to migrate to the ocean.

solar radiation: Sun's energy with which plants use to grow and produce food.

spawn: The act of egg laying by the female and fertilization by the male.

species: A specific type of animal or plant that can breed and produce offspring only with its own kind.

sperm or milt: Milky substance produced by the male fish to fertilize eggs.

sport fishing: Fishing done for sport or for personal use.

stocking: The process of releasing fish into a lake or stream.

storm drain: Drains from streets and parking lots that channel rain water directly into streams.

stream velocity: The speed and volume with which a stream flows.

streamline: A torpedo like shape that moves easily through the water.

substrate: Bottom material.

terrestrial: Belonging to the earth.

transpiration: An animal or plant giving off a watery vapor.

tributary: A side stream which joins a larger river.

turbulence: Uneven rough flow.

vegetation: Variety of plants growing in an area.

vent: The tube with which the female deposits her eggs.

watershed: The land area where water collects and flows.

weir: A fence or enclosure set in a waterway for capturing fish. Also, a dam or obstruction in a stream to raise the water level or divert its flow.

wildlife: All living animals, including birds, fish, insects, mammals, etc.

yolk sac: Sack attached to a newly-hatched fish containing a balanced diet for its early growth.

zooplankton: Microscopic and other very small animals in water, many of which are larval form.

U.S. Department of the Interior
U.S. Fish & Wildlife Service
Columbia Gorge Information and Education Office
61552 State Highway 14
Underwood, WA 98651

509/493 2934 (ph)
509/493 1830 (fax)

http://www.fws.gov/gorgefish

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