Photo by John Durand

American River Salmon

Educator Activity Guide

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Introduction

The theme of the American River Salmon Festival is; "Celebrate the Importance and Conservation of Chinook Salmon." The Festival Schools Day committee is responsible for providing educators with professional development opportunities and educational materials for classroom use. Until 2003, educators attending the American River Salmon Festival Teacher Workshop were provided a copy of *Some Things Fishy, A Teacher's Guide for the Feather River Fish Hatchery,* developed by California Department of Water Resources for the Feather River Hatchery program. It was the goal of the Schools Day Committee to produce materials specific to the salmon of the American River watershed. Materials distributed for grades K-8 focus on increasing the student understanding of salmon ecology and resource conservation. In 2003, a special Sports Fish Restoration Grant provided the funding to accomplish this goal.

This guide provides background materials specific to the American River watershed. The activity guide targets grades Kindergarten through 8th grade, is correlated to the California Educational Content Standards, and contains assessment tools. The guide was developed using materials and adaptations from a variety of sources, each source is noted at the conclusion of the activity. Activities are arranged in units and are placed in order of complexity. Each activity provides the educator with background information and requires minimal preparation. There is an assessment with each activity as well as an overall assessment at the end of the guide. Refer to the

Acknowledgements

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What Are Salmon?

Salmon are fish. What is a fish, exactly?

Fish are aquatic animals adapted to life in fresh or salt water. Fish come in many sizes, shapes, and colors. There are tiny fish, giant fish, flat fish, skinny fish, flying fish, electric fish, and fish that live in schools. Although there are about as many kinds (species) of fish as mammals, birds, reptiles and amphibians put together, the habitat and behavior of fish make them difficult for people to observe in nature.

Because of the variety of conditions within each habitat, many different fish can live together and flourish. Fish can be found wherever there is water, such as salt water (like the ocean), freshwater (like lakes, ponds, streams, and rivers), and places where salt and fresh water meet (these are called estuaries).

Fish are cold-blooded vertebrates with gills, fins, and a body that is usually covered with scales. Fish breathe oxygen with gills, which are covered by *opercula* (gill covers). Fish can sense their environment in a variety of ways. Along what is called the lateral line, fish have sensors that detect motion, vibration, and sound. Salmon also have an excellent sense of smell. If you look at a salmon, you won't see an obvious nose. Instead, look for two comma-shaped holes on either side of its head below the eyes. Water flows in one hole, over the olfactory receptors that absorb molecules from water, and out the other. These receptors convey information to the fish about its environment. Consequetly, salmon can detect minute amounts of dissolved substances.

The Salmonoids

Scientists classify all plants and animals into identification groups. The many varieties of salmon and trout are in a group known as *salmonoids.* The American River Watershed is home to Chinook salmon and steelhead trout.

Salmonids date back to the Miocene geologic era, and evolved in the cold, oxygen-rich waters of the northern hemisphere. Their unique migratory behavior is believed to have originated over 10,000 years ago as a result of the advancement and receding of the continental ice sheets. About this time period the Pacific salmon became separated from the parent salmon stocks in the Altantic, and as the great glaciers of the Ice Age melted, safe places for spawning and rearing were revealed.

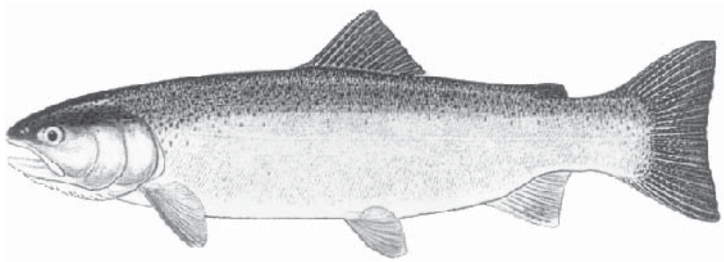
Most fish live in either salt water or freshwater. But, some fish are diadromous (dye-AD-ruh-mus), which means they can live in fresh and salt water at different times in their lives. Diadromous fish are divided into the following two groups:

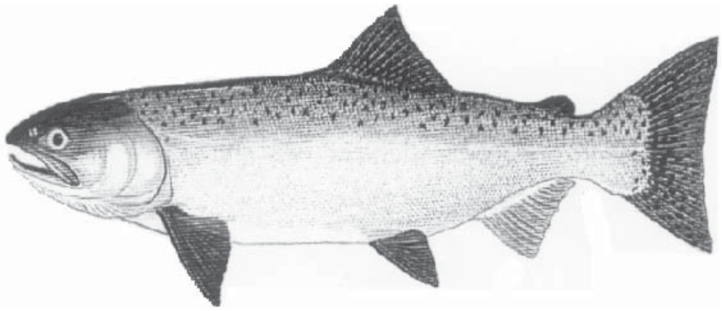
1) Anadromous (ah-NAD-ruh-mus) fish begin their lives in freshwater, move to salt water to feed, and return to fresh water to spawn.
2) Catadromous (ca-TAD-ruh-mus) fish are born in salt water, move to freshwater to feed, and return to salt water to spawn (lay their eggs).

Salmon and their relatives, steelhead, are anadromous fish. They begin their lives as eggs in cold mountain streams, grow to adults in the Pacific Ocean, and return to their natal streams to spawn.

It seems difficult to understand how a way of life involving dangerous journeys and high risks could be beneficial. However, consider where salmon live. On a yearly basis, the Pacific Northwest endures floods, landslides, droughts, and fires. Periodically, catastrophic events occur such as volcanic eruptions or ocean disruptions such as El Niño. Salmon, as a species, survive these upheavals because of their adaptability and strength, and because they have a large population divided into hundreds of small populations throughout their range.

Picture the many populations of salmon as a tree. That's how the National Research Council illustrates the salmon population in the book, *Upstream: Salmon and Society in the Pacific Northwest.* The trunk consists of all the salmon that migrate up their home watershed from the Pacific. At each large river, big groups of salmon branch off. Smaller and smaller groups of salmon continue on up the smaller rivers, the streams, and the headwaters. If a landslide destroys one of those uppermost branches, hundreds more remain intact. If ash from a volcano coats a dozen spawning areas, dozens more remain viable areas. In the ocean, if El Niño changes the food supply for one year, some





salmon might die, but more will be coming in the following year.

Scientists estimate that a small salmon population can recover from a natural disturbance in about ten years.

Chinook Salmon

Records exist of Alaskan Chinook weighing 126 pounds. The record for a California River Chinook is 88 pounds. This is why people call Chinook the “king” salmon. Other nicknames include Columbia River salmon, black salmon, chub salmon, winter salmon, and blackmouth.

If you’ve ever seen spawning Chinook and noticed their dark bodies undulating with the river current, then you know why some people call them black salmon. Their mouths are also black, hence the nickname “blackmouth.” Black spots are on a Chinook’s fins and back and are most visible when they sport their mature metalic silver coloration.

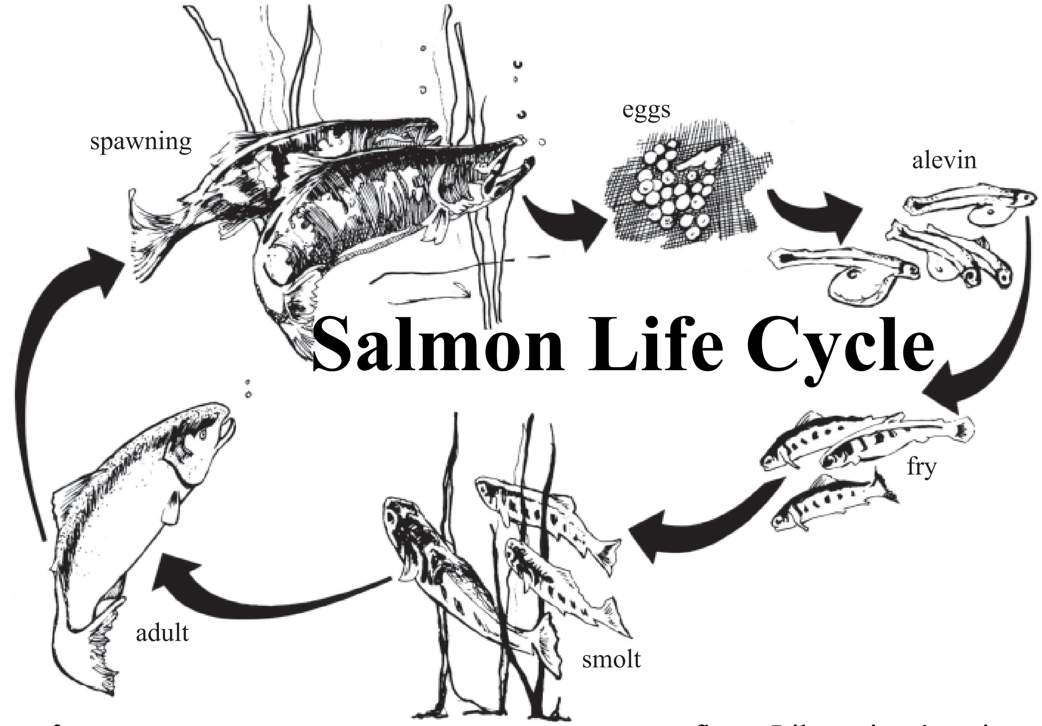
Biologists recognize four types of Chinook salmon depending upon the time they enter the fresh water: spring, fall, late-fall and winter. This behavior is genetically determined. The Sacramento River Watershed is unique among all salmon rivers because it has all four types.

Spring Chinook migrate in the spring and summer, and spawn in the late summer and early fall. Fall Chinook migrate and spawn in—you guessed it!—the fall. In California, they usually spawn in the lowest sections of rivers.

Steelhead Trout

When is a salmon not a salmon? When it’s a steelhead. Formerly classified as a member of a trout

Visitors to the Nimbus Hatchery learn about salmon anatomy. The Hatchery Visitor Center Interpretive Display provides information about salmon, steelhead, the American River watershed, and the role of a hatchery. For more hatchery information call (916)358-2884.



We begin to trace the life of Chinook salmon from its freshwater start. A bed of gravel chilled by flowing water doesn't sound appealing to us, but it's the perfect place for salmon eggs. Female salmon leave thousands of soft, pea-sized orange eggs to settle into the spaces between gravel, where they will cover the eggs with more gravel. There, they are protected from most predators. Water flows easily through the gravel, keeping the eggs cool, moist, and suffused with oxygen. The gravel nests where salmon lay their eggs are called "redds."

After a few months (depending on species and water temperature), tiny alevin (or sac-fry) hatch from the eggs. These inch-long fish still carry a yolk sac on their bellies. They remain in the gravel for several more weeks absorbing their nutritious yolk. Meanwhile, they begin to feed on bits of food that float through the gravel.

The fry swim out of the gravel and begin feeding on microscopic water animals called zooplankton. They are now considered salmon fry.

Fry-hood

Salmon fry develop some spiffy skin marks that look like vertical black bars, called parr marks. (That's why salmon fry are also called "parr" salmon. When they grow to one and one quarter inches in length, they may also be called "fingerlings.") For tiny fish living among underwater vegetation, parr marks are great camouflage. Like a tiger's stripes, parr marks make the fish look like lots of light and dark shapes, not one tasty fish. So they may help the tiny fish blend in with stream-bottom vegetation instead of catching the eye of bigger fish and diving ducks.

Most salmon fry stay close to home for at least several months, but some stay in their natal streams for a year or two. Some Chinook spend up to two years in their birth streams; however, they might move downstream in the fall to find better winter habitat. Other Chinook head downstream right away.

About the time that salmon fry become as long as your hand, they begin to lose their spiffy stripes and take on a sleeker appearance. They are becoming fingerling/fry, or teenagers of the salmon world.

We all know teenagers go through dramatic changes in their behavior and in their physiology. Teenage salmon have an irresistible urge to leave home and begin traveling. The signal to leave is in their genes and may be triggered by the length of day and regulated by water temperature and flow. Fingerlings/fry often begin their travels in spring or early summer when streams and rivers are running high and fast because of snow melt. The young salmon head into the current and begin their long journey to the ocean.

Some scientists think that river currents carry fingerlings/fry backwards all the way to the ocean; drifting instead of swimming would save energy.

Other scientists say they actively swim, which would use more energy but help them avoid predators. When American River salmon migrate to the Sacramento/San Joaquin Delta, they are going through some major changes. They are going through smoltification, a process by which their bodies are changing so that they can live in salt water.

Freshwater fish maintain their complex body chemistry by excreting water and taking in ions. Saltwater fish must do the opposite by taking in water and excreting ions. The changes that occur during smoltification—which involves the gills, kidneys, and other organs—allow the young salmon to begin maintaining their body chemistry in saltier water.

Ocean Life

Salmon teenagers swim out of their smolt status and into adult life when they enter into the Pacific Ocean. If they survive their first few weeks in the coastal waters, where seals and other predators seek them, the young adult salmon will swim thousands of miles for the next one to three years. (Length of time depends on the species)

As they exit their home stream and enter into the ocean, many young salmon catch rides on the strong coastal currents that flow north and south along the Pacific coast. Chinook coming from the San Joaquin/ Sacramento River Watershed of California tend to be found between Monterey and the Oregon border on the shallow Continental Shelf that extends as much as 70 miles from the coastline.

If you could follow a salmon in the ocean, you might see why these fish come all the way to salt water to feed. The ocean is like a mega-grocery store compared to the corner market of the mountain stream. The cold ocean waters are dense with food. Billions of plankton, small fish, larval crustaceans, and other forms of sea life, float and swim and migrate through these salty waters. Salmon quickly gain weight by eating a variety of foods including krill, shrimp, squid, sardines, herring, and anchovies. The salmon follow their food wherever it goes in the ocean. Suddenly, swimming thousands of miles each year makes sense.

Coming Back Home

At some point in an adult salmon's life, it begins to swim toward home. Somehow, salmon know where they are in the ocean, when it is time to go home, and where home is. This great mystery of animal migration is known as homing, and scientists have some intriguing theories about how this migration occurs.

A salmon's ability to find a home began as soon as it hatched. At that time, the small fish was storing information about the stream's scents and geomagnetic characteristics. The fish continued storing such information about the waters as it swam downstream and out into the ocean. In this way, the young salmon created a trail to retrace in the future.

A combination of genetic impulse, day length, and level of maturity trigger the migration back home. The age at maturity is variable. Pink salmon mature at 2 years. Other species vary. Mature Chinook range in age between 2 to 7 years. The adult salmon may gather at the mouth of the home watershed, where they begin acclimating to fresh water again. And then they swim, and swim, and swim.

Consider what it must be like to have this undeniable urge to head for home. You have to walk or run hundreds of miles, and you will not eat much, if anything. Would you make it? Most humans couldn't even come close to accomplishing the journey that adult salmon must make. And salmon still have to find the energy to spawn!

Homing isn't completely accurate. Some wild salmon miss their home streams and spawn somewhere nearby. This straying of wild salmon can actually help the species by varying the genetics of the small populations in each stream. Hatchery salmon stray much more; this could pose a threat to the genetics of the wild salmon. Unlike wild salmon, the millions of hatchery salmon share only a few common parents. This limits their genetic diversity immediately, and can threaten their long-term survival and reproduction. If hatchery salmon spawn with wild salmon, they contribute their limited genetics to wild salmon, which weakens the survival of the wild species.

Spawning Time

The sleek bodies of ocean-going salmon change as the fish migrate upstream to their spawning sites. The lower jaw of all male salmon and trout elongate and develop a hook. The genus name, *Oncorhynchus*, means "hooked nose." Sockeye become bright red with green heads. Male sockeye also develop a hooked snout, and a humped back.

Changes in their outward appearances coincide with internal changes, like those of growing old. In salmon, these changes take place in a matter of days or weeks—not years. One scientist compares it to the aging process in humans, with salmon aging forty years in two weeks.

These well-traveled ocean veterans arrive at their spawning sites and begin one of the most spectacular displays of energy that you can see in the wild.

To spawn, all salmon must have clean and cool water with silt-free gravel. While spawning often occurs in shallow water, different species have varying needs for their spawning sites. For example, sockeye must be near a lake and Chinook can use the largest gravel up to fist-sized in diameter.

The female hovers close above a bed of gravel while facing the current. Above her, a male hovers. Downstream, another male or two might be holding position in the current. They occasionally dart in to challenge the dominant male, but he chases them away and quickly returns. The female is partner-less for only a few seconds.

She rolls onto her side so that her tail is flat against the gravel. With powerful flexes of her body, she turns her tail into a shovel and digs continually at the gravel, tossing it downstream and creating a depression in the bed. When it is deep enough, she turns rightside up and the male swims beside her. At the same time she releases her eggs into the nest, he releases his sperm. The eggs filter down into the gravel with the sperm. Almost all of the eggs will be fertilized.

The female swims upstream a few feet and begins all over again. The gravel from this new nest will cover the previous one, protecting those eggs from predators. One female will dig a number of nests and deposit hundreds of eggs in each one. Collectively, these nests are called a redd, from the Scottish word "to make ready."

After spawning, the male may swim off to court and mate with another female. But the spawned-out female stays by the redd to defend it from other salmon, other fish, and any other animal that might try to dig up the nest. (Other salmon pose a threat because they naturally might begin to dig where the gravel seems loose and easy to move.) Her defense lasts only a few days, though. Soon she dies, and her carcass joins those of other salmon decomposing at the bottom of the stream or caught in brush beneath the bank.

Recycle Salmon

A salmon's dramatic life ends with a flurry of spawning and then death. But its amazing legacy continues because dead salmon bring vast amounts of nutrients back to their home streams and habitats.

Until the 1980s, most scientists assumed that salmon carcasses were quickly washed downstream. When a salmon dies, it may be fished out of the stream by large meat-eaters such as otters, black bears, raccoons, and skunks. Scavengers fly and hop in to pick at the remains. Shrews and rodents gnaw on the bones.

Other salmon become lodged in underwater wads of roots and branches from fallen trees and shrubs. Aquatic insects take up residence in their gills and other body cavities, eating bits of flesh and scattering more of it into the water. A scientist counted more than 1,000 caddis fly larvae on one salmon head. This abundance of insects provides a feast for other fish.

Scientists have discovered these intricate connections, called nutrient webs, through ingenuity, persistence, and patience. One scientist attached radio transmitters to more than 1,000 salmon carcasses and then tracked what happened to them. Another scientist studied the

WATERSHEDS: The Link to the Ocean

A watershed is a drainage area where the water that runs off the land is "shed" (runs off) into a stream, river, lake or wetland. Almost all the area of a watershed is land, not water. Almost everything that influences the stream's ecological health occurs on that land. The amount of water carried by a stream, the shape of the channel, the chemical composition of the water, and the diverse life are all determined by the watershed and what happens within it. To fully understand a stream, one must look beyond its channels and learn about what is happening to the surrounding land.

The system of small streams which transports water, sediment and other materials from a watershed is called a *drainage network*. Watersheds and their drainage networks are interconnected land-water systems. When water falls to the earth as precipitation, the drainage network channels the water and substances it carries to a common outlet, such as the mouth of a main stream or river. From there it may flow into another large stream or river, or empty into a lake, estuary or ocean.

Like streams and rivers, watersheds vary in size. A watershed can be very small, perhaps only a few square kilometers, such as one that drains a small stream in your neighborhood. Or it can be very large, like the Sacramento River Watershed.

The highest points that surround a stream or river are called divides. If a drop of water falls on one side of a divide, it will eventually drain into that watershed's stream or river. A drop that lands on the other side of the divide will drain into the stream or river of a different watershed.

There are four basic features of a watershed that create its unique natural characteristics: geology, climate, soils, and vegetation. Geologic processes such as glaciers, volcanoes and plate tectonics determine the underlying rock formations and their changes over geologic time. Climatic processes erode and shape these rock formations through weathering and erosional agents such as rain, snow, and wind.

Streams occur in the topography as a result of precipitation, and their movement contributes to additional surface erosion. Streams break large rock materials down into smaller pieces; the finer materials, called sediment, are carried throughout the watersheds.

Sediment and organic matter make up the soils of a watershed and form an interface between the living and nonliving parts. Soils, in turn, have different textures, mineral content and water-holding properties. Soils therefore play a key role in watershed development because they determine which plants will grow there, how much water will run off the land, and how susceptible the land will be to erosion.

Finally, vegetation is a key feature of a watershed because plant roots slow and absorb runoff, releasing water slowly into groundwater and streams or back into the atmosphere. Vegetation also provides nutrients and habitat for fish and wildlife.

Each watershed, then, has a distinctive combination of soils and plant communities that support a diversity of habitats and a diversity of life.

The American River Watershed is a unique part of the Sacramento region. The American River is a major tributary to the Sacramento River, accounting for approximately 15% of the total Sacramento River flow. It enters the Sacramento River in the city of Sacramento. The American River drains about 1,900 square miles and ranges in elevation from 23 to over 10,000 feet. Average annual precipitation over the watershed ranges from 23 inches on the valley floor to 58 inches in the head waters. Approximately 40% of the American River flow results from snow melt. The American River has three major branches including the South Fork, Middle Fork, and North Fork. Average historical unimpaired runoff at Folsom Dam is 2.8 million acre feet (AF). (*1, DFG*) Lowest recorded runoff is 349,000 AF and the highest is 6.38 million AF.

Development of the American River began in the earliest Gold Rush days with the construction of numerous small dams and canals. Today, 13 major reservoirs exist in the drainage with total storage capacity of 1.9 million AF. Folsom Lake, the largest reservoir in the drainage, was completed in 1956 and is now operated with a 974,000 AF capacity. Proposed additional water project developments in the basin include Auburn Dam and the 224,000 AF South Fork American River project. Folsom Dam is located approximately 30 miles upstream from the mouth. Its major purpose is flood control. It is a major element of the Central Valley Project (CVP), which is operated by the United States Bureau of Reclamation as an integrated system to meet contractual water demands, instream flow, and water quality requirements. (*1, DFG*)

The American River historically provided habitat for steelhead trout and Chinook salmon, which spawned principally in the watershed above the valley floor. Each population probably exceeded 100,000 fish. Completion of Folsom and Nimbus dams in 1955 blocked access to the historical spawning and rearing habitat for each species, and altered the flow regime in the lower American River (LAR). Salmon and steelhead runs have declined significantly in the LAR due to the combined effects of project-induced low flows, severe flow fluctuations that expose and dry out redds and strand juvenile salmonids, and high water temperatures during salmon and steelhead development. (*1, DFG*)

Historically the American River supported three runs of salmon during the Spring, Fall, and late-Fall. The larger population of spring run left the ocean in the spring to migrate to higher mountain streams where they spawned in the early fall. By the early 1900s, small dams and habitat destruction caused by mining and lumbering had greatly reduced this run. By the 1940s, when Folsom Dam was planned, this run was extinct. The fall and late-fall runs, which enter fresh water through fall and reach their spawning beds in the lower stretches of the river shortly afterwards, had most (approximately 75%) of their spawning habitat covered by the reservoirs created by Nimbus and Folsom Dams. Of the approximately 125 miles originally used, only about 8 miles of river are now left for natural spawning.

(1 Restoring Central Valley Streams: A Plan For Action, DFG Nov 93)

Habitat and Interdependence

Healthy habitat conditions require a highly diversified ecosystem. An ecosystem has two parts: *eco*- the wildlife of an area (plants and animals); and *system*- their interaction with each other, and nonliving parts of the environment (air, water, and soil). Energy is the driving force that makes life possible for all the organisms in an ecosystem; the source of energy is the sun. The complex food chain ranges from microscopic diatoms and algae, to large fish, birds and mammals. The diversity of species and their numbers, particularly aquatic organisms such as fish, are important indicators of water quality, functioning foodwebs, and the health of the ecosystem.

The ideal wild salmon and trout spawning habitat is a fast-flowing stream. The water is cold, clear, and pollution-free. It meanders at varying depths over gravel and rocks, churns around boulders and fallen trees, and now and then swirls into quiet backwater pools.

The streamside, or riparian zone, is usually shaded by trees. The tree roots make the stream banks stable and provide hiding places for fish. Leaves from the trees fall into the stream and become food for insects, which are in turn eaten by salmon and trout.

As young salmon and trout grow larger, they move from shallow areas into deep pools. [Pools are scoured when water plunges, or around boulders and logs.] The "bubble curtain" is a favorite place for salmon and trout. They can't be seen by predators above and there is plenty of oxygen. The current brings insects and other small food items. At the end of pools, where the stream narrows, the current picks up and washes the gravels clean, making them ideal for nests.

Anadromous salmonids spend part of their lives in salt water. These fish leave their streams and migrate out to the ocean. At the river's mouth, fresh water flows into the sea. The seas also surge into the river, and salt water mixes with fresh water. This area of brackish water is the estuary. Migrating fish stay in the estuary for awhile before entering the ocean. They find new types of food to eat and grow larger, which helps them survive in the ocean. Their bodies also adjust to the salt water. In the ocean they find rich sources of food and grow rapidly, eating smaller fish and krill. They may swim many miles up and down the coastline between Monterey and Point

Cultural Perspectives and Human Impact

Salmon swim into the rivers around the northern rim of the Pacific–and everywhere that salmon swim, they have become a part of the local culture. The Ainu, who live on the island of Hokkaido in Japan, make ceremonial robes of salmon skins. On the Kamchatka Peninsula of Russia, salmon bones have been found mixed with the remains of a human community that is eleven thousand years old. And from Alaska to California, salmon have formed the base of tribal cultures.

California's First Settlers

California's first settlers probably arrived from the north 10,000 to 12,000 years ago and they settled near natural waterways.

California's first people found the land of the Great Valley to be a rich habitat with rivers, vast areas of grassland, fair quantities of variable woodland, and chaparral. The woodland provided deer, vegetables and the staple acorns; the grasslands provided antelope; the rivers provided salmon and other fish, and the large gallery forests along the riparian corridors provided more acorns. Fishing was important. Salmon, sturgeon and lampreys were taken primarily by net, and often in conjunction with reed rafts or boats made of tulles. The fish were usually roasted and eaten. However, much of the salmon was dried and stored to use throughout the year. Their material economy was based on the plants and animals in the valley, which they utilized for food and fiber as well as for medicine, utensils, dress and decoration. Tribes built villages with dome-shaped houses from a pole frame covered with tulles, brush and earth. They built ceremonial structures and sweathouses partly dug into the ground. The residents of each village cared for the land around them and maintained a spiritual connection with the river habitat.

For northwestern tribes like those of the Klamath and Trinity rivers, salmon was a large portion of their diet. Consequently, ceremonies thought to ensure the bounty of the salmon were of great importance. These tribes' life cycles, religions and wars focused on the rivers, particularly the salmon of those rivers.

Tribes of the central valley included the Valley Maidu, called the Nisenan, the Patwin to the west and the Interior Miwok to the south. These people were provided with an abundance of game, fish and plants due to seasonal variations. Salmon was a very important food; however, there is no documentation of salmon ceremonies. An interesting note is that the Interior Miwok people named the river that flows through their land the Cosumnes which means "returning salmon."

European-Americans

Captain Meriwether Lewis, of the Lewis and Clark expedition, encountered salmon immediately after crossing the Continental Divide into the watershed of the Lemhi River. Lewis and his companions were out of food. The Shoshone offered the men salmon, along with other food. In *Lewis and Clark: Pioneering Naturalists*, Paul Cutright quotes Lewis: "This was the first salmon I had seen, and perfectly convinced me that we were on the waters of the Pacific Ocean."

Adventurers soon followed Lewis and Clark using routes over the mountains and inland from the ocean. In the Sacramento Valley, miners stirred up streams in their search for gold and other precious minerals. Settlers cut down old-growth forests adjacent to the river. Farmers and ranchers devised irrigation methods that used rivers to water the semi-arid but fertile lands. And fishermen caught, trapped, netted and took every salmon as if the resource was limitless.

Since 1839 the Sacramento region has been populated by people of diverse racial, ethnic and national origins, including fur trappers, gold-seekers, farmers, miners and merchants.

In the Twenty-First Century

Today, salmon remain important for their cultural, aesthetic, recreational and economic value. The National Research Council stated in its 1996 report, *Upstream: Salmon and Society in the Pacific Northwest*, that

> *"Salmon have provided social continuity and heritage for many Americans–the American Indian tribes and non-Indian fishing communities that depend on salmon fishing, the generations of sport*

anglers proud of their pursuits of steelhead and other salmon, the general public of the Northwest who have adopted salmon as a regional symbol."

Impacts

Today, we are aware that salmon are in trouble. Commercial fisheries, biologist, and engineers have tried many methods for helping salmon. To boost population, hatcheries were built beginning in the 1870s; but, their success has been mixed. For any salmon recovery effort to succeed, we must look honestly and completely at the obstacles and make some difficult decisions.

Few of the naturally spawned salmon return to renew the population. Predation, disease, competition, and natural disasters take their toll as they have always done. The salmon population were adapted to these hazards and thrived, but during the past 150 years, human-created perils have greatly reduced the number of salmon. By the turn of the century, the American River spring run was nearly extinct due to habitat destruction and blockage of spawning beds; by the 1940s it was extinct. Nearly 125 miles of the American River and its forks provided spawning sites for salmon and steelhead; now, only eight miles remain between Ancil Hoffman Park and Nimbus Dam.

The completion of Sacramento's Folsom and Nimbus Dams in 1956 blocked 75% of the remaining beds on the American River. The U.S. Bureau of Reclamation, which owns the dams, built and funds the Nimbus Fish Hatchery to mitigate this loss of habitat. The hatchery is operated by the California Department of Fish and Game. In 1993, the hatchery was modernized and a visitor center was added. The visitor center and hatchery are open year round from 8 a.m. to 3 p.m. Visitors may watch artificial spawning of salmon and steelhead from inside the visitor center. Fish can be seen in the raceways outside and at the American River Fish Hatchery immediately downstream from the Nimbus Hatchery. (The American River Fish Hatchery raises mainly rainbow trout for release in freshwater streams and lakes in the surrounding 17 county areas.)

The salmon are drawn into the hatchery by their instinct to keep swimming upstream until they find their spawning beds. A fish ladder–a series of small pools connected by small waterfalls–allows them to move up to the holding pool of the hatchery. The fish ladder is not operated until the water is cool enough for successful spawning. A recorded message on the hatchery information phone attempts to keep the public aware of times when egg taking may occur. The number is (916) 358-2884.

Good sites to view spawning in Sacramento County include: the upper end of the riffles at Effie Yeaw Nature Area of Ancil Hoffman Park; in a side channel of the river about a quarter mile upstream from the Sunrise Bridge on the south side; and, for an overview, from the bluffs at the east end of the upper Sunrise area (enter from the road to Fish and Game Region II offices off Gold Country Boulevard). Another good place to watch fish is from the bicycle bridge between William Pond Park and Goethe Park. During the day the river between the Hazel Avenue Bridge and Nimbus Dam is always open. The spawning areas are seasonally closed to fishing (see Fish and Game regulations for exact dates and areas).

Obstacles

Dams present the most obvious and serious obstacles to salmon. The Nimbus Hatchery provides mitigation for the Folsom Dam, which prevents salmon from completing their migration upstream. Fish hatcheries seem to be a great way to protect salmon species from extinction. In protected and controlled environments, millions of salmon eggs hatch and millions of salmon fry grow to smolt without risk of predation. And all these millions of protected smolts can then be released into the rivers and the ocean to grow into adult salmon that will find their way home. That's the theory. However, hatchery management and release of billions of hatchery-raised salmon has not stopped the decline of "wild salmon." Hatchery salmon face the same problems as wild fish, such as having to dodge predators, navigate past dams, and find their way back home again to spawn.

Hatcheries can play an important role in providing recreational and commercial fish and are used as a tool of fisheries management. Hatcheries are continuely changing as more information is learned about the lives and needs of wild fish. The future of wild fish and hatchery management are partners in fish resource management.

Sedimentation is caused by excess amounts of silt and other particles entering streams and rivers. Surface erosion sends small amounts of particles into the water. Mass erosion (i.e. landslides) dumps huge amounts of dirt into water. Causes of surface erosion vary. Regardless of the source, sedimentation affects salmon by smothering eggs, reducing nutrients, and altering stream energy and velocity. Landslides and earth slumps can trap young salmon in their natal streams and block adult salmon from returning to spawn. Several things can be done to protect salmon from sedimentation: improved logging and road construction practices can reduce sedimentation by half, cattle can be kept out of streamside areas, recreationists can be educated to avoid trails that increase erosion, and everyone can decrease erosion by planting native plant species in streamside areas.

Loss of cover affects salmon in several ways. Tree trunks and root balls provide shelter for young salmon and help capture nutrients brought in by the water flow. Vegetation on stream banks also provide shade for salmon and keeps the water cool. Streamside vegetation can be protected by keeping cattle away and rerouting trails. New construction of roads, houses, and other development can be restricted from streamside areas.

Altered stream flow includes increasing or decreasing the amount and velocity of water in rivers and streams. Such alterations can throw off the timing of incubation, hatching, development, migration, and spawning.

Pollution of streams and rivers comes from point (traceable) sources, like factory discharge, and non-point sources, such as storm runoff and fertilizers. Until recently, people have often been careless about disposing of household wastes, such as used motor oil and cleaning supplies.

Alteration of wetlands through diking, draining, or filling, affects salmon directly and indirectly. Young salmon sometimes find shelter and abundant food in wetlands adjacent to streams and lakes. As such areas are drained or filled, salmon lose food and shelter.

What About Fishing?

Commercial salmon fishing has supported hundreds of thousands of people in the Pacific Northwest, and salmon provides much excitement and pleasure for sports anglers. Commercial and sport license fees fund many stream restoration and hatchery programs. Many people have blamed some of the salmon decline on commercial fishing. But, even when this industry has been restricted, salmon numbers have continued to decline.

Stewardship: Restoration Can Happen

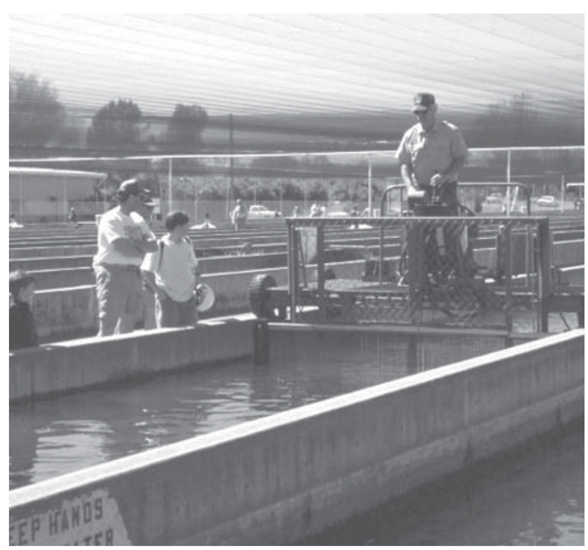
No matter how hopeless the plight of salmon might seem, scientists remain confident that salmon can be restored:

- Maintain genetic diversity; make this the primary goal of all salmon management.
- Consider the variability of ocean conditions when making fishery management decisions.
- Increase protection of river habitats.
- Improve smolt survival.
- Change hatchery focus from production to research, and become part of a coordinated regional plan for salmon restoration.
- Develop cooperative management that uses local knowledge, provides long term incentives for the future, and balances local interests.

How you can help

The story told in the book *Come Back, Salmon* by Molly Cone, is about one elementary school that adopts a stream, cleans it, tests the water for pollution, and raises salmon in their classroom to release into the stream. Two and 1/2 years later, salmon returned to a stream that had not had any salmon for over twenty years! Salmon need clean water to live and humans can help. No matter what your age or where you live, there is something you can do to help salmon.

- Conserve water; less wasted water can mean more water for salmon and other fish living in streams,



Salmonids at the Hatchery

(*Above)* Mature, adult spawning salmon are brought into the hatchery. Hatchery personnel select females that are ripe, or ready to release eggs.

(*Top right corner*) Eggs are removed from the female. Milt for the male is mixed with the eggs.

(*Middle*) The fertilized eggs are prepared for incubation. Egg development depends on carefully monitored water temperature.

Once the eggs hatch, the alevin or sac fry have a large yolk sac attached to their belly. This sac is the main source of their nourishment. Once the yolk sac is used up, the developing salmon are called fry.

(*Bottom*) The fry are placed in ponds, or raceways, and fed a starter diet. As they grow, the amount of food is steadily increased. Releasing hatchery

Fishy Facts

Objective
Students will identify the basic internal and external parts of a fish and how those parts help a fish live.

Curricular Areas
Science and Language Arts

California Content Standards
GRADES 3-8

Science

3rd Life 3 a, b, c, d; Investigations 5 e
4th Life 3 a, b, c, d, e; Investigations 6 c
5th Life 2 a, b, c, d, e; Investigations 6 h, i
6th Ecology 5 c, e; Resources 6 b, Investigations 7 c, d, e
7th Living Systems 5 a, b, c, d, g; Investigations 7 b, c, e
8th Life Science 6 a, b, c; 8 c, d

English Language Arts

3rd Reading 2.2, 0.3, 0.4, 0.5, 6.1; Writing 1.1, 0.3, 0.4, 2.2; Written/Oral 1.1, 0.2, 0.3, 0.4; Speaking 1.1, 0.5, 0.6, 0.4, 0.8, 2.1, 0.4
4th Writing 1.1, 0.2, 0.3, 0.5, 0.7, 0.8, 0.10; 2.1, 2.3; Written/Oral 1.0; Listen/Speak 1.0; Speaking 2.0
5th Reading 1.0, 2.0; Writing 2.0; Written/ Oral 1.0; Listen/Speak 1.0, 2.0
6th Reading 1.0, 2.0; Writing 2.0; Written/Oral 1.0; Listen/Speak 1.0, 2.0
7th Reading 2.0; Writing 1.0, 2.0; Listen/Speak 1.0, 2.0
8th Writing 1.0, 2.0; Speaking 1.0, 2.0

Method
Students research and use interview techniques in order to develop natural history information about fish.

Materials
- Time to complete: (1 or 2) 50-minute periods.
- writing materials
- *Fishy Facts Review*

Background
Although there are about as many kinds (species) of fish as mammals, birds, reptiles and amphibians put together, the habitat and behavior of fish make them difficult to observe in nature. Fish are aquatic animals adapted to life under water. Fish come in many sizes and colors. There are tiny fish, giant fish, flat fish, skinny fish, flying fish, electric fish, and fish that live in schools. Because of the variety of conditions within each habitat, many different fish can live together and flourish. Fish can be found wherever there is water; salt water (like the ocean) and freshwater (like lakes, streams and rivers).

The body, gills, eyes, nostrils and fins of fish allow them to live under water and survive in their habitats. Fish have streamlined body shapes which help them move through water and swim against the current.

Procedure
1. Discuss the job of a reporter; most students will identify with TV news reporters. Talk about techniques of interviewing and various styles of writing.
2. Students will play the role of a newspaper reporter and interview a fish (modeled by another student) to discover how a fish can live life in water.
3. Ask students what questions they would ask a fish. Make a list of these questions. Questions might be: Do fish breathe? Do fish sleep? Do fish think?
4. Divide the class in teams of two students. Each team will be given *Fishy Facts Review*. The teams will decide which student will be the reporter. The reporter will write a list of questions to ask and conduct the interview. The other student will assume the role of the fish and respond to the interviewer's questions. If the students wish, they may switch roles at mid-point of the interview.
5. The reporters record the information gathered from the *Fishy Facts Review* and from the interview.
6. Each team writes a newspaper article about the fish they interviewed.
7. Lead the class in a discussion of similarities and differences of fish, other wildlife, and humans.
8. Read the articles in class. Some of these articles may be used for the Unit 5 activity "River Valley Journal."

Extension
1. Have students do a fish print. (see "Fishy Facts for Early Childhood Education" extension)
2. Dissect a fish for observation.

Evaluation
- Name parts of a fish and how each helps the fish survive.

"Fish Facts Review" adapted with permission from *Some Things Fishy, A Teacher's Guide for the Feather River Fish Hatchery,* published by the CA Department of Water Resources, Office of Education.

Fishy Facts Review

Here are some general fish facts that you can learn and share with others.

Body Parts

All fish are cold-blooded vertebrates. Cold blooded means they have a body temperature that is close to that of the water in which they live. Vertebrate means they have a spinal column. Flexible backbones allow the wavelike swimming motion. The entire skeleton supports the body, and the brain case holds the brain (the skull has 40 to 60 bones).

Fish use their fins to control the direction of their movement. Unlike land animals, which only need to control their movement in a single plane, fish have the additional requirement of moving in three dimensions. The tail fin powers forward movement, helps brake, and controls direction, while the other fins control direction, help brake, steer and stabilize. Some slow-moving fish use their fins as oars.

To swim, fish use their muscles to wave their bodies from side to side. Fish swim in a manner that is not unlike the way a snake moves. A wave of muscle contractions moves along the body, starting with the head and ending with a snap of the tail. This undulating movement pushes sideways and backwards against the water, propelling the fish forward. There are variations among species, but one can estimate that the top speed of a fish is about seven miles per hour per foot of body length.

Overlapping scales protect a fish. Under a microscope scales show growth rings, which, like the growth rings of a tree trunk, can be used to estimate age. Fish don't grow more scales as they get older; the scales just get bigger. The scales, which are formed in the skin and overlap like shingles on a roof, protect against abrasion, disease, and predators. Some fish have large scales, some have small scales, and some have none at all. Slow-moving fish have large scales, while the more active cruisers have smaller scales.

Slime (mucus), which is produced by a fish's skin, protects against disease, fungus, and parasites. If you want to catch and then release a fish, you should wet your hands before touching it to keep from removing this sticky protective covering.

You can tell what kind of food a fish eats by looking at its mouth and teeth. The mouth structure and teeth of all animals give clues to the food that they eat. For example, salmon and steelhead have backward-pointing, needle-like teeth. These teeth form a one-way path for lively, slippery food that is swallowed whole. Salmon and steelhead also have teeth on their tongues and the roof of their mouths.

Senses

Fish have hearing organs that allow them to hear very well. Their ears are located under their skin on either side of the head. Sound travels five times faster in water than in air.

Fish are able to sense nearby objects and movement with their lateral line. The lateral line is a fluid-filled tube that runs along both sides of the fish. Vibrations enter the tube through tiny pores and activate sensory nerves. Changes in pressure and the patterns of vibrations warn the fish of nearby animals and objects. This is the sense that allows the precise coordination of schools of fish.

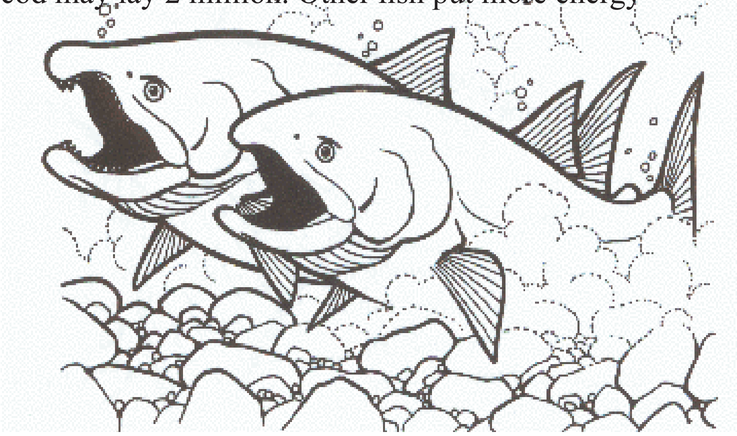
Most fish have good eyesight. Fish have excellent near-distance eyesight. Underwater, visibility is limited and far-distance vision is of no use. Some fish living in dark conditions (e.g., cave fish) are born blind. Since fish have no eyelids, water keeps the surface of the eyes moist. Fish near the surface can also see objects above the water. A fish's field of vision above the water is cone-shaped.

Fish use their nostrils for smelling but not for breathing. Most fish have two small openings located in front of their eyes. Water flows in one and out the other, passing over the sensory tissue. Smell can warn of danger, help find and identify food, and lead the fish back to their home stream. Some fish have a highly acute sense of smell.

Fish have taste buds inside their mouth and/or on the outside of their body. Fish can sense sweet, sour, salty, and bitter smells (as do humans). They may spit out food or a fishing lure if it does not taste correct. The importance of tasting depends on the lifestyle of the fish.

Reproduction

Most fish reproduce (have young) by laying eggs. Some fish lay many tiny eggs of which only a few survive; a striped bass can lay 200,000 eggs while a cod may lay 2 million. Other fish put more energy into larger and more protected eggs. A larger percent, but not a larger number, of these eggs survive. The number of eggs a female produces is somewhat dependent on her size (the larger the fish, the more eggs). Chinook salmon and steelhead lay about 5,000 eggs. Salmon can have between 3,000 and 12,000 eggs.



Additional Information

Biologists specializing in the study of fish are called Ichthyologists. These experts have a knowledge of the physical traits and the behavior of fish species.

Fish do have brains, although not as large or complex as humans. Many fishes can demonstrate a memory of colors and shapes. Some predatory fish seem to "plan" attacks by hiding, waiting, and then ambushing prey.

What is the plural of "fish?" If you have one guppy, you have a "fish." If you have two guppies, you have two "fish." If you have one guppy and one goldfish, you have two "fishes." "Fish" can be singular or plural as long as you mean only one kind of fish. "Fishes" is the plural when you are referring to two or more different kinds of fish.

How many different kinds of fishes are there is not exactly known. People have discovered or described or named over 21,000 different species (kinds) of fishes. There may be undiscovered species in places like the South American rain forest, the Arctic or deep in the ocean.

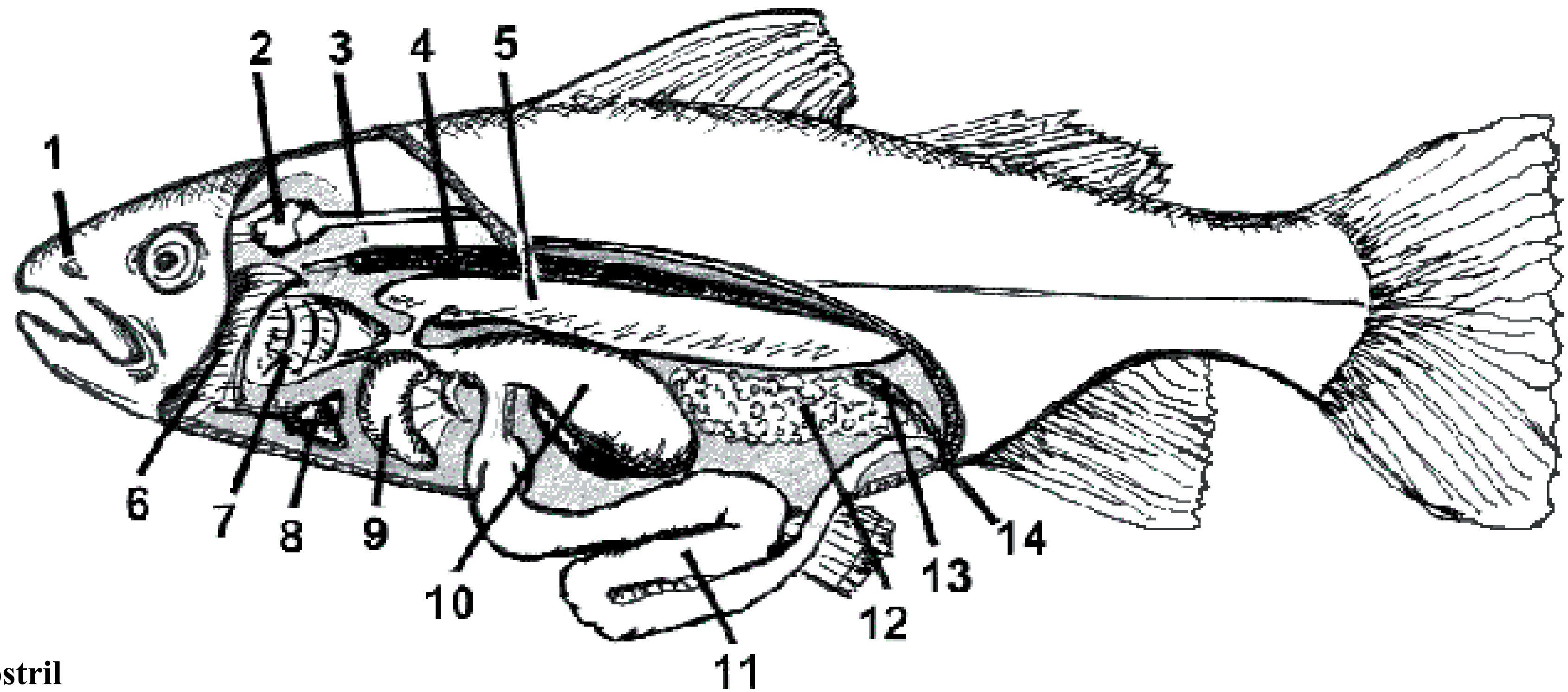
How long can fish live out of water depends on the kind of fish. The African lungfish is adapted to survive drought periods and can live as long as six ot seven years out of water. Many fish will die after as few as 15 seconds out of water.

Organs

A fish's heart is located between the gills, much like the human heart is located between the lungs. Blood is pumped from the heart to the gills where waste gases are given off and oxygen is absorbed from the water. From the gills, the blood flows through the rest of the body and returns to the heart.

The kidney helps control the amount of water in a fish's body. The two kidneys are located between the backbone and the swim bladder. In freshwater fish excrete great quantities of diluted urine; in salt water they excrete small amounts of concentrated urine. Few fish are able to live in both fresh and salt water.

Fish breathe by using their gills to take oxygen out of the water. In equal volumes of water and air, the water contains about 96 % less oxygen. Gills are efficient at removing available oxygen due to their great surface area. Fish are highly vulnerable to water pol-



1. nostril
2. brain
3. spinal cord
4. kidney
5. swim bladder
6. operculum
7. gills
8. heart
9. liver
10. stomach
11. intestine
12. gonads
13. urinary bladder
14. cloaca or vent

Fishy Facts Revealed

Fish Adapted to Life in the Water

Fish vary greatly in size and color. There are tiny fish, giant fish, flat fish, skinny fish, flying fish, electric fish, and fish that live in schools. Fish represent more than half of all vertebrate animals. All fish are adapted to life under water. Their streamline body is good for moving through the water. Fish can be found wherever there's water; salt water (like the ocean) and fresh water (like lakes, streams and rivers).

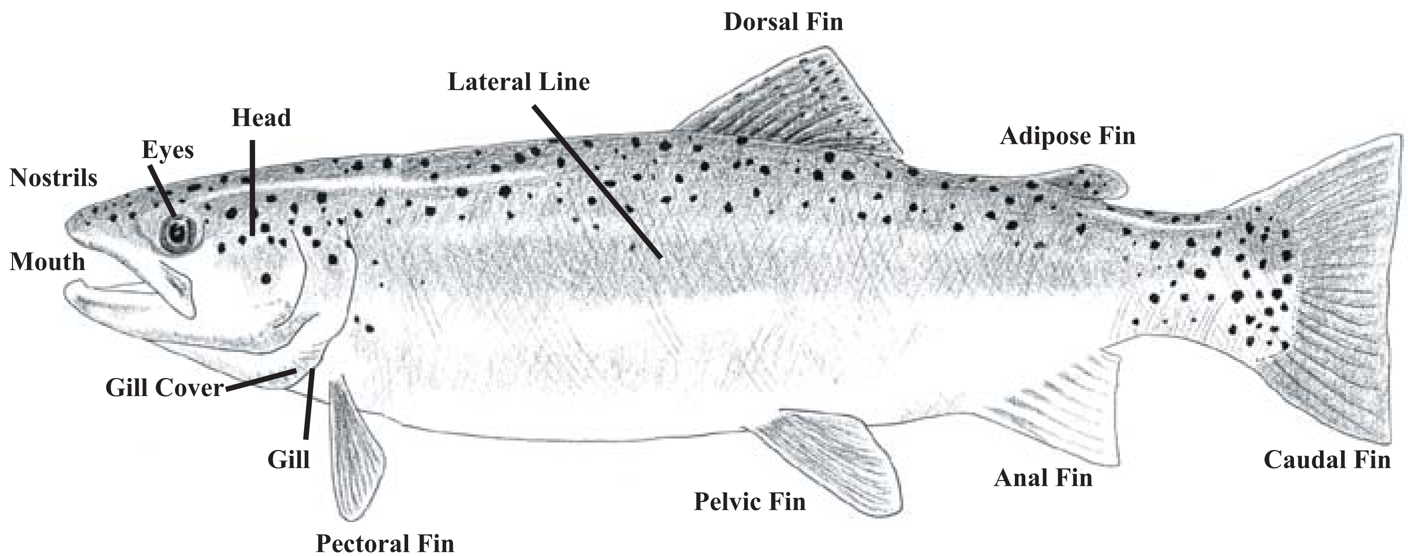
Gills – Las Agallas

Fish, like people, need to breathe oxygen in order to live. People get oxygen from the air they breathe. Fish get oxygen from the water which flows through their mouths and passes by their gills.

Gills are found under a flap just behind the head. They have many folds and pieces of skin which take oxygen from the water.

Eyes – Los Ojos

Fish have eyes that work independently. They can see in all directions. They can see in front and back at the same time.



Fins – Las Aletas

Fins help the fish swim. The dorsal and anal fins help keep the fish balanced so its body won't turn from side to side. Pectoral and pelvic fins are like arms and legs in animals. These fins are used for turning, backing up and stopping, in addition to balancing. The caudal or tail fin sweeps from side to side and moves the fish forward. The adipose fin is small and fleshy.

Lateral Line – La Linea

Most fish have a line running along each side of their body. The little holes in the line help the fish sense movements of other animals and objects in the water.

Nostrils – Las Narices

Fish use their nostrils for smelling but not for breathing. A sense of smell is used to find food. Some fish (like salmon) use smell for finding their way back to their home

Fishy Facts for Early Childhood Education

Objective
Students will identify the basic parts of a fish and how those parts help a fish live.

Curricular Areas
Science (fish and the parts of a fish); Math (puzzle making and geometric figures); Social Science (group work and class presentations); Art (creating a fish); Language Arts (reading names for the parts of a fish)

California Content Standards
Science
K Life 2, Earth 3, Investigations 4
1st Life 2, Investigations 4
2nd Life 2, Investigations 4
Math
K Measure & Geometry 2.0, Reasoning 1.0
1st Measure & Geometry 2.0, Reasoning 1.0
Social Science
K 1, 3
1st 1, 4
2nd 1, 4
Language Arts
K Written/Oral 1.0, Listening 1.0, 2.0
1st Reading 1.0, Writing 1.0, Written/Oral 1.0, Listening 1.0, 2.0
2nd Written/Oral 1.0, Listening 1.0, 2.0

Method
Students work in groups to create a fish using cards of various fish parts. They will color the fish in its habitat. Cards will have fish parts written in both English and Spanish.

Materials
- Coloring utensils
- Copies of the fish puzzle, one per student (use cardstock or heavy gauged paper)
- Paper
- Glue

NOTE: If possible bring in a model of a fish

Background
Fish are aquatic animals that have special adaptations in order to be able to live in the water. Their body, gills, eyes, nostrils and fins allow them to live underwater and survive in their habitats. These adaptations allow the fish to be better suited to the habitat in which it lives. Because of the variety of conditions within each habitat, many different fish can live together and flourish.

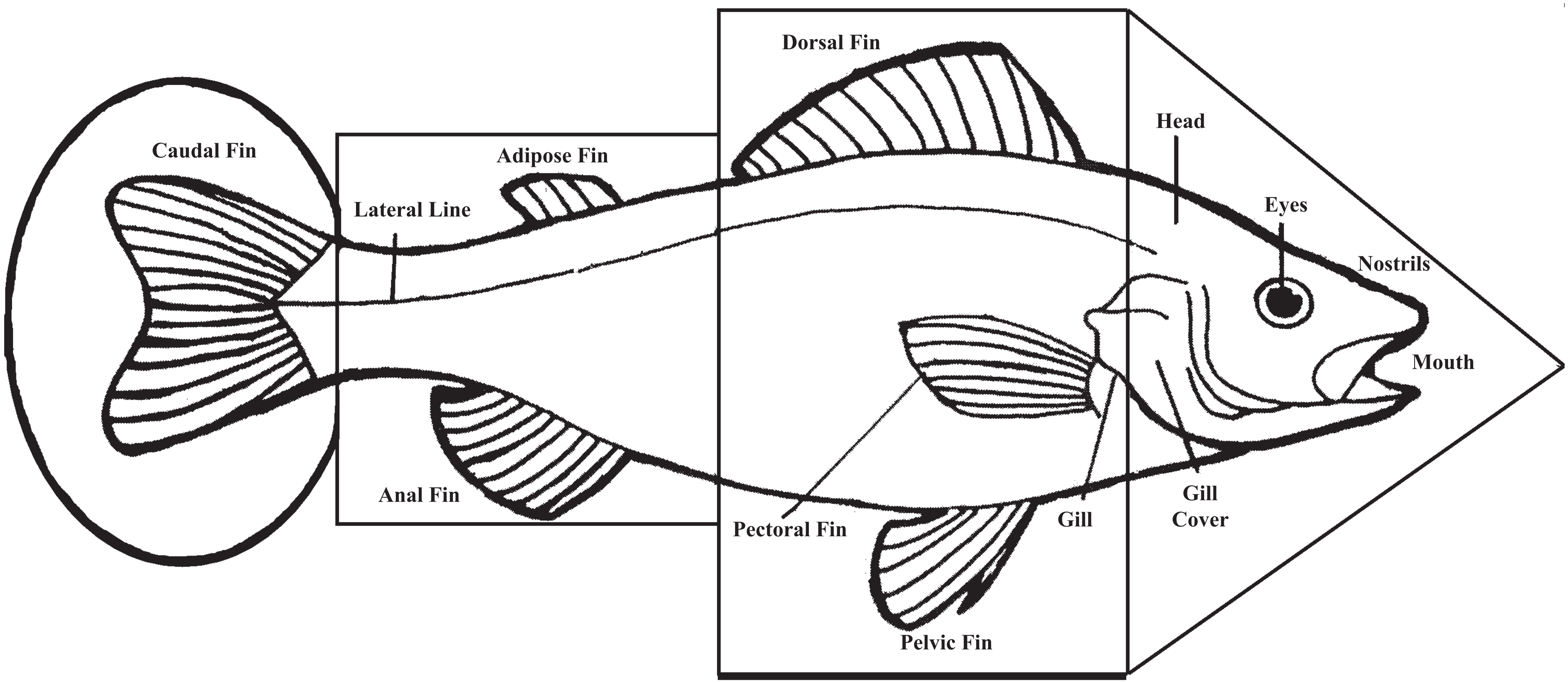
Procedure
1. Ask students how many have ever seen a real fish. What do students like about fish? Why is a fish different from other animals?
2. Read *Swimmy*, *The Rainbow Fish* or *El Pez Arco Iris* to the students; or show them many pictures of different fish. Ask students: How do fish breathe? What do fish eat? How do they swim? Where do fish live?
3. Divide class into 3 to 4 groups. Show students the cards and model how to create a fish and glue it together. Explain that it is a puzzle which they will color after the pieces are in place.
4. Pass out cards and discuss the body parts and the function of each part.-
5. Students create their fish, glue it to a sheet of paper and color the fish and its habitat (home).
6. Have students share their projects and explain the various parts of their fish.

Extensions
1. Observe actual fish. Have students discuss what they see–the body parts and elements of the habitat.
2. Have students do a fish print. Use a rubber fish replica available from classroom suppliers. This activity allows students to experience a Japanese cultural artistic expression called Gyotaku, the art of Japanese fish printing. The activity is similar to the way Japanese fishermen recorded their day's catch. The art of gyataku (gyo=fish, taku=rubbing) originated in Japan during the early 1800s and was first practiced by fishermen to preserve a record of their catch. A gyotaku is made when watercolors are painted on the actual fish and then rice paper or fabric is applied and gently rubbed. The result: a mirror image, rich in detail and color.
3. Dissect a fish for observation.

Evaluation

Activity reprinted with permission from the *CA Project WILD Aquatic Early Childhood Education Supplement*. For more information contact the CA Project Wild office (888) 945-3334 or email bwinn@dfg.ca.gov.

Fish Puzzle!



Extension

For centers, color several puzzles to represent flashy tropical fish. Cut them and have students mix and match to create their own new species. Have students decide the habitat, food, name, etc. for their fish. Older students can write a mini report on their new fish. Use these reports to create a class fish book.

Fashion a Fish

Objectives
GRADES K-2
Students will classify fish according to body shape and coloration.
GRADES 3-8
Students will (1) describe adaptations of fish to their environments, (2) describe how adaptations can help fish survive in their habitats, and (3) interpret the importance of adaptation in animals.

Curricular Areas
Science, Expressive Arts, Environmental Education, English Language Arts

California Contents Standards
GRADES K-8
<u>Science</u>
K Life 2 a; Investigations 4 e
1st Life 2 a; Investigations 4 b
2nd Life 2 c; Investigations 4 c, d, g
3rd Life 3 a, b, d
4th Life 3 b
5th Investigations 5 a
6th Investigations 7 d
7th Evolution 3 a
<u>English Language Arts</u>
K Reading 2.2; Listen/Speak 1.1, 1.2
1st Reading 2.6; Listen/Speak 1.1, 2.4
2nd Reading 2.5; Lesten/Speak 1.5, 1.6, 1.9, 2.2
3rd Writing 2.2; Listen/Speak 1.3, 2.3
4th Listen/Speak 1.1, 1.5, 1.8, 1.9, 2.1, 2.1c, 2.2
5th Reading 2.1, 2.4; Written 1.1, 1.1 a, 2.1; Listen/Speak 1.4, 1.5, 1.6, 2.1, 2.2
7th Reading 2.3; Listen/Speak 1.4, 1.5, 2.3

Method
Students design a fish adapted for various aquatic habitats.

Materials
- Time to complete: (1) 50-minute class period
- Cards for each adaptation
- Art materials
- Paper

GRADES K-2
- Body shape and coloration cards

GRADES 3-8
- Reproduction and mouth, body shape, and coloration cards

Optional:
- Picture of an animal with a special adaptation

Background
Aquatic animals are the products of countless adaptations over long periods of time. Those adaptations, for the most part, are features that increase the animals likelihood of surviving in their habitat.

When a habitat changes, either slowly or catastrophically, the species of animals with adaptations (that allow them many options) are the ones most likely to survive. Some species have adapted to such a narrow range of habitat conditions that they are extremely vulnerable to change. These species are usually more susceptible than other animals to death or extinction.

In this activity, the students design a fish. Students choose the adaptation that their fish will have; each choice would actually take countless years to develop. As those adaptations become part of the fish's design, the fish becomes better suited to the habitat in which it lives. Because of the variety of conditions within each habitat, many different fish can live together and flourish. Some adaptations of fish are shown on a chart following the activity.

Procedure

The first three steps in this activity are optional for younger students.

1. Assign students to find a picture or make a drawing of a species of an animal that has a special adaptation. For example, giraffes have long necks for reaching vegetation in tall trees, while owls have large eyes that gather light and aids with night vision.
2. Conduct a class discussion on the value of different kinds of adaptations in animals. As a part of the discussion, ask the students to identify different kinds of adaptations in humans.
3. Collect the students' pictures or drawings of adaptation. Categorize them into the following groups:
   - protective coloration and camouflage
   - body shape or form

   GRADES 3-8
   - mouth type or feeding behavior
   - reproduction or behavior
   - other (one or more categories the students establish, in addition to the four above that will be needed for the rest of the activity).
4. GRADES K-2

   Divide the adaptation cards into groups of two cards each: coloration and body shape.

   GRADES 3-8

   Divide the adaptation cards into groups of four cards each: coloration, mouth type, body shape, and reproduction.
5. Pass one complete set of cards to each group of students. *Suggestion*: Divide class into groups with 2 to 4 students in each group.
6. Ask the students to "fashion a fish" from the characteristics of the cards in the set they receive. Each group could
   - create an art form that represents their fish,
   - name the fish, and
   - describe and draw the habitat for their fish.
7. Ask each group to report on the attributes of the fish they have designed, including identifying and describing its adaptations. Ask the students to describe how this kind of fish is adapted for survival.

   GRADES 3-8

   Ask the students to make inferences about the importance of adaptations in fish and other animals.

Extensions

1. Take an adaptation card from any category, and find a real fish with that adaptation. NOTE: A collection of books about fish is useful. Do not be as concerned about reading level as much as the accuracy of the illustrations.
2. Look at examples of actual fish. Describe the fish, and speculate on its habitat by examining its coloration, body shape, and mouth.

Evaluation

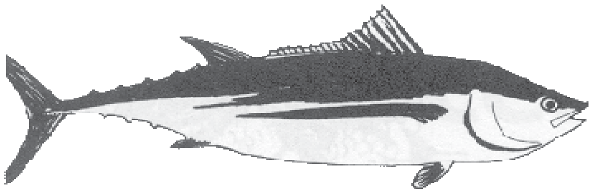
GRADES K-2
- Circle the fish with vertical stripes
- Circle the fish with the horizontal, flat shape.
- Circle the fish that would be difficult to see from above.

GRADES 3-8
- Name two fish adaptations in each of the following categories: mouth and feeding, shape, coloration, and reproduction. Then describe the advantages of each of these adaptations to the survival of the fish in their habitats.
- Invent an animal that would be adapted to live in your community. Consider mouth, shape, coloration, reproduction, food, shelter, and

Fish Adaptations

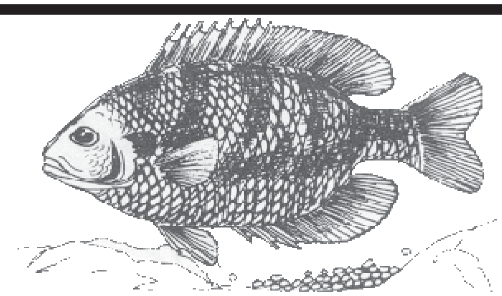
ADAPTATION	ADVANTAGE	EXAMPLES
Mouth		
sucker-shaped mouth	feeds on very small plants and animals	sucker, carp
elongated upper jaw	feeds on prey it looks down on	spoonbill, sturgeon
elongated lower jaw	feeds on prey it sees above	barracuda, snook
duckbill jaws	grasps prey	muskellunge, pike
extremely large 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 it from below	most minnow, perch, tuna, mackerel
dark upper-side	predators have difficulty seeing it from above	bluegill, crappie, barracuda, flounder
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, hogsucker
Reproduction		
eggs deposited on bottom	hidden from predators	trout, salmon, most minnows
eggs deposited in nests	protected by adults	bass, stickleback
floating eggs	dispersed in high numbers	striped bass

Coloration



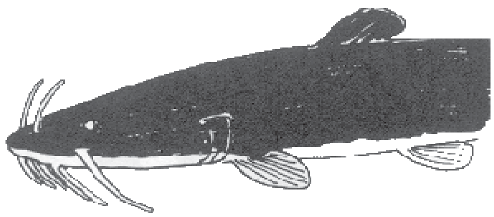
Light Colored Belly (Albacore)

Reproduction



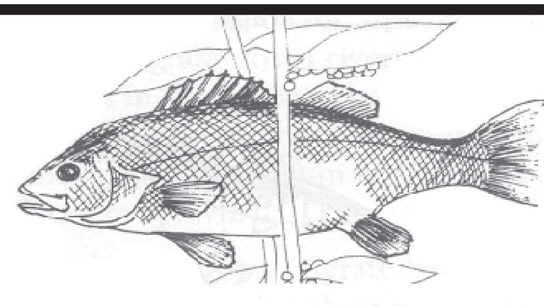
Eggs Deposited in Nests (Blue Gill)

Coloration



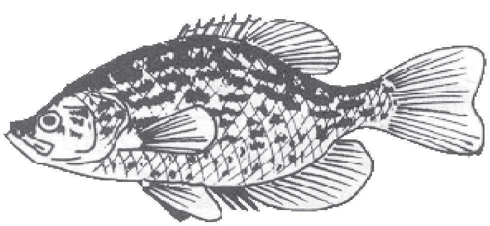
Dark Upperside (Catfish)

Reproduction



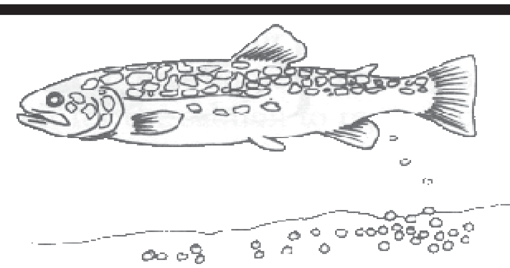
Eggs Deposited on Vegetation (Yellow Perch)

Coloration



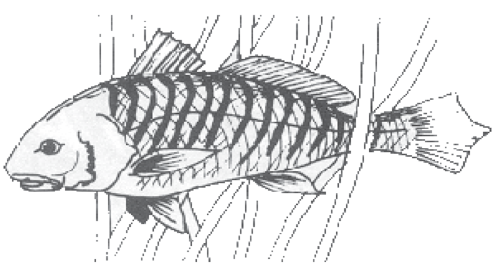
Mottled (Crappie)

Reproduction



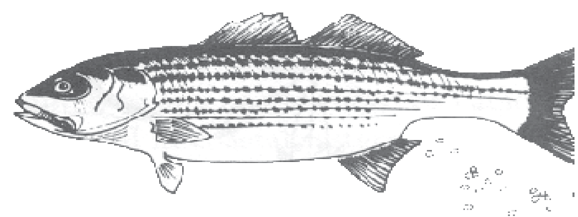
Eggs Deposited on Bottom (Trout)

Coloration



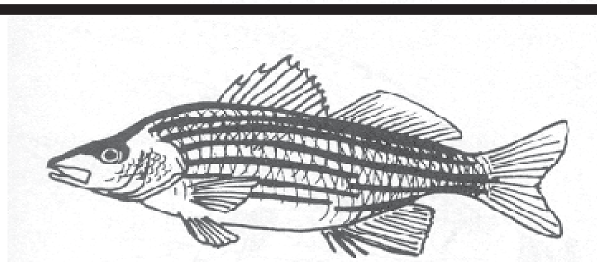
Vertical Stripes (Croaker)

Reproduction



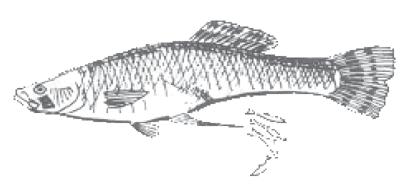
Free Floating Eggs (Striped Bass)

Coloration



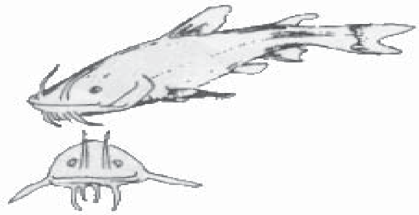
Horizontal Stripes (Yellow Bass)

Reproduction



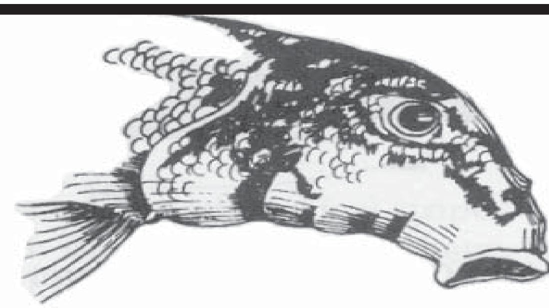
Live Birth (Gambusia)

Shape



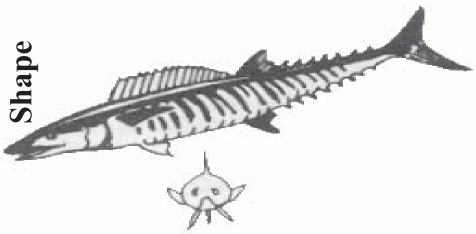
Flat Bellied (Catfish)

Mouth/Feeding



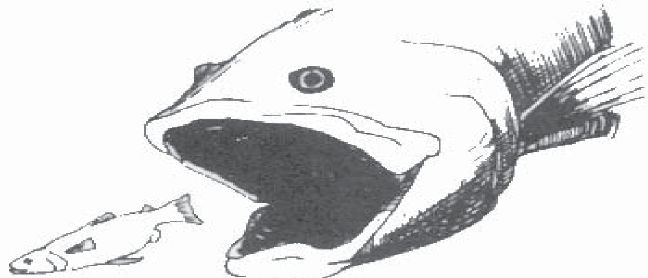
Sucker Shaped Jaw (Sucker)

Shape



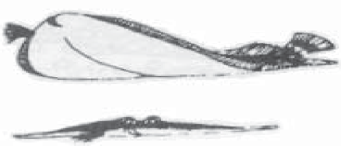
Torpedo Shape (Wahoo)

Mouth/Feeding



Extremely Large Jaws (Grouper)

Shape

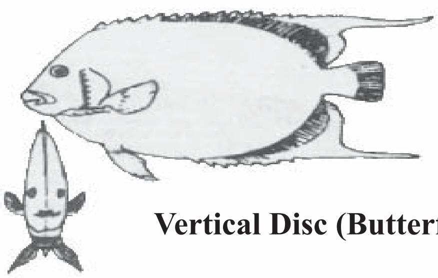


Horizontal Disc (Halibut)

Mouth/Feeding

Elongated Lower Jaw (Barracuda)

Shape

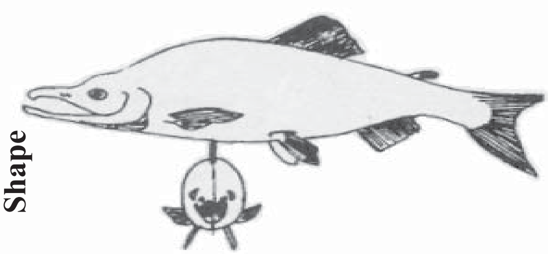


Vertical Disc (Butterfish)

Mouth/Feeding

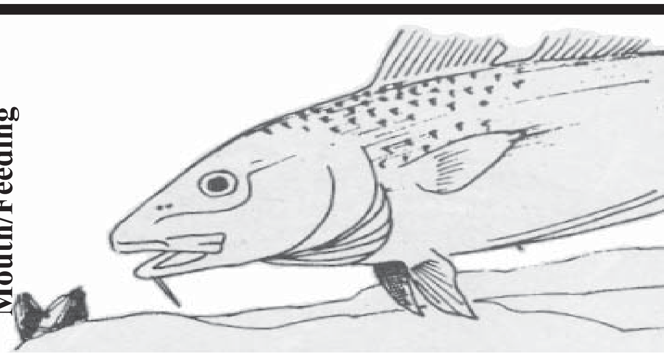
Duckbell Jaws (Muskellunge)

Shape



Humpbacked (Sockeye)

Mouth/Feeding



Elongated Upper Jaw (Cod)

Light Vision

Objectives

Students will (1) explain why color patterns easily seen in the air are difficult to see underwater, (2) make inferences about the problems of predators searching for camouflaged prey.

Curricular Areas

Science and Language Arts

California Content Standards

GRADES 3-8

Science

3rd Physical Science 2 b, c, d; Life 3 a, b, c; Investigations 6 a, c, d
4th Life 3 b; Investigations 6 a, c, d
6th Life Science 5 c, d, e; Investigations 7 d, e
7th Evolution 3 a; Living Systems 5 g; Physical Science 6 b, c, e, f; Investigations 7 a, c, e

Language Arts

3rd Speaking 1.0, 2.0
4th Speaking 1.0, 2.0
5th Speaking 1.0, 2.0
6th Speaking 1.0, 2.0
7th Speaking 1.0, 2.0
8th Speaking 1.0, 2.0

Method

Students will create and observe a simulated underwater environment and role-play a predator-prey relationship.

Materials

- Time to complete: (1) 50-minute class period
- blue cellophane (found at school art supply store)
- stapler
- clear tape
- string
- underwater photographs cut from magazines that show bright colors and others that are of wide views that are predominantly blue (SCUBA magazines or *National Geographic* are good sources)
- red construction paper, 4" x 8"
- other contruction paper or poster stock 4" x 11"
- scissors
- pencil
- template for goggles (follows activity)

Background

Light is necessary for vision, an important sense for many animals. Aquatic animals that depend on vision as a sense are restricted to relatively shallow water, considering the ocean depths are measured in thousands of meters. In addition to the amount of light there is also a different absorption of different colors (wavelengths) of light by water. Red and orange are absorbed most effectively while blue penetrates best. The brilliant colors associated with some kinds of marine animals, like sponges, are invisible in their natural habitat! Other marine organisms, like the colorful coral reef fish, live in shallow water where their colors show. These facts have interesting consequences for color and color patterns and their distribution among animals that live in water. Fish that live in shallow, well-lit water may have color vision. But what do most fish see? Fish that live in murky or muddy water may be almost blind and depend on touch or electrical fields to sense their surroundings.

Procedure

Students may do these two procedures at home and bring items to class.

1. Have students review their knowledge of external fish anatomy by drawing and cutting out a fish made of red construction paper. Did they remember paired pectoral and pelvic fins, the tail (caudal), dorsal and anal fins? Explain that the red color is typical of some California saltwater fish in 10m (33 ft) or more of water. Red is a common color for deep sea animals and shallow water nocturnal fish.
2. Have each student construct a pair of goggles using the pattern provided.
   a. Inexpensive blue cellophane available

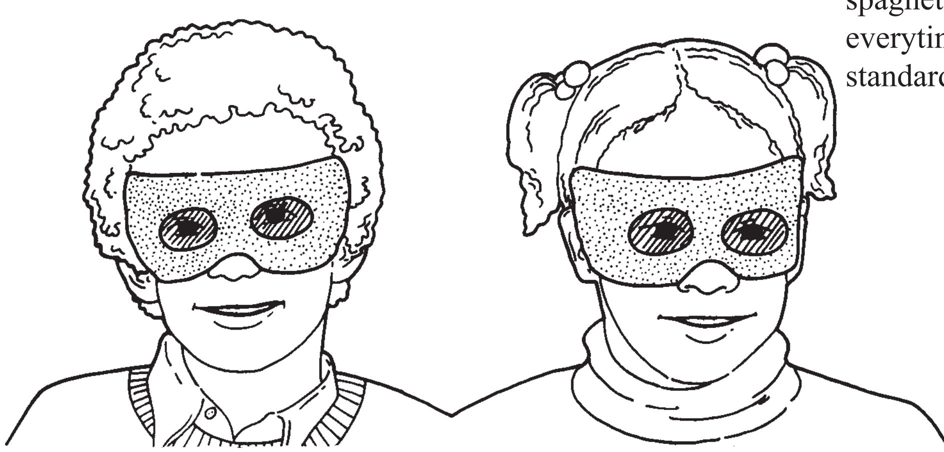
in rolls from school art supply stores is folded to make *four* layers over the eye holes.

b. Tape the cellphane in place.

c. Staple, tape or tie strings to hold the goggles in place. Explain they will use the goggles for no more than five minutes. To do so may bleach (temporarily) some of their visual pigments.

During class:

1. When the students are not in the classroom, distribute all the red fish around the room against *dark* backgrounds. Turn the classroom lights off and create dim light. It is dark in 10 meters of water. Pin or tape the fish to bulletin boards, prop on shelves, put them in corners on the floor. Hold a pair of goggles up to check that you are placing the fish against backgrounds with the same value.
2. Meet the class outside the room with the goggles. When the goggles are in place, have the students enter the room and sit down. Tell them they are predators searching for red fish in 10 meters of water. They are wearing the goggles because blue is the primary color of light that penetrates very far into water. Have them start searching for the fish at the same time. Time them if you want to repeat the exercise without the goggles.
3. Stop them before all the fish are found and have them sit back down. Remove their goggles. Now can they see the fish they missed? Why were the fish hard to see? The filter allowed only blue light through. The fish reflect only red. Under water there would be no red to see. If you wish, repeat the exercise without the goggles to compare the time it takes to find the fish when red is visible.
4. Conclude with a discussion. How is camouflage different in water? A fish that appears very colorful to us (red) may, in fact, be very well camouflaged from predators. What makes vision different in water? The fish is hard to see because red light is missing as it is being absorbed by the water and, therefore, cannot be reflected to the fish predator's eyes.
5. Have students discuss how vision might effect the predator/prey relationship. How might predators compensate for limited vision? What if the predator has the less visible coloration? How would the prey compensate?
6. Look at the color photographs. Any colorful underwater photograph was shot with a flash which provided all the wavelengths of light. Any photo in which the predominant color is blue shows what it really looks like underwater. Discuss problems in making judgments about animals based on human perceptions.

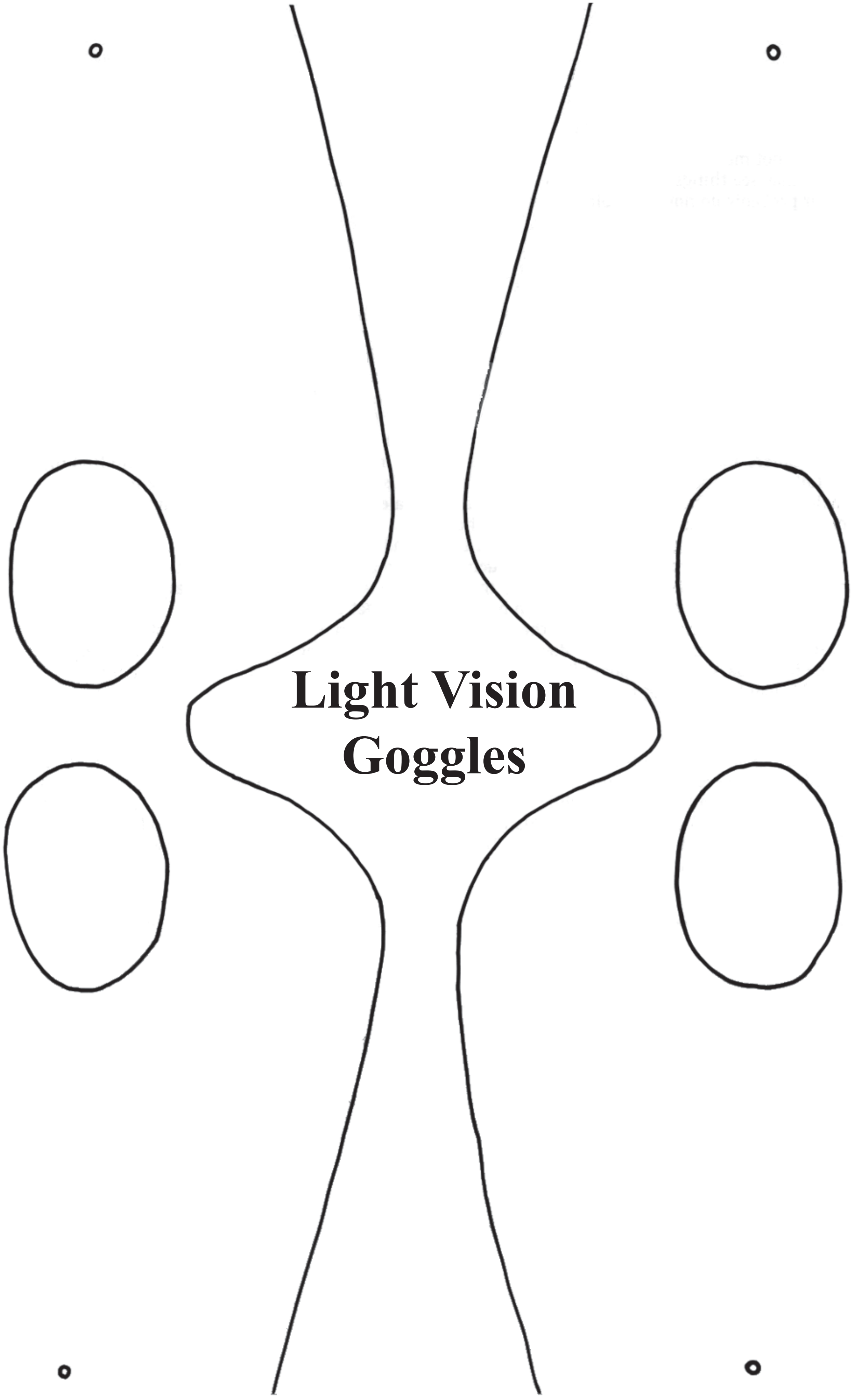


Extension

1. What about fish that live in very murky water and depend on touch and taste (or smell) to decide what to eat? Could you put together a variety of food items, some desirable and some not, which your students could find while blindfolded? Would they be willing to decide whether or not to eat something they could not see? Many animals must do so. Catfish use whiskers to feel their food and sense its chemical composition. This activity might make a great Halloween party with spaghetti for worms, etc. Just make sure that everyting is edible, if not good to eat by kids' standards.

Evaluations

- Explain why color patterns that are easy to see in the air may be hard to see underwater.
- What problems do predators face when searching for camouflaged prey?
- Develop strategies for these


Light Vision
Goggles

Variations on a Theme

Objectives
Students will: 1) review the classification system for categorizing animals as it relates to Pacific salmon and steelhead, 2) describe similarities and differences between Chinook (king) salmon and steelhead, 3) create and use a grid scale and draw a life size salmon or steelhead.

Curricular Areas
Math, Science, Language Arts, Art

California Content Standards
GRADES 3-8

Science

3rd Life 3 a, b, c; Investigation 5 e
4th Life 3 b; Investigation 6 a, c, e
5th Investigation 6 g, h
6th Ecology 5 c, d, e; Investigation 7 c
7th Life Sciences 2 b, 3a, d, e; Investigation 7 d

English Language Arts

3rd Reading 2.2, 0.3, 0.4, 0.5, 6.1; Writing 1.1, 0.3, 0.4, 2.2; Written/Oral 1.1, 0.2, 0.3, 0.4; Speaking 1.1, 0.5, 0.6, 0.4, 0.8, 2.1, 0.4
4th Writing 1.1, 0.2, 0.3, 0.5, 0.7, 0.8, 0.10; 2.1, 2.3; Written/Oral 1.0; Listen/Speak 1.0; Speaking 2.0
5th Read 1.0, 2.0; Writing 2.0; Written/ Oral 1.0; Listen/Speak 1.0, 2.0
6th Read 1.0, 2.0; Writing 2.0; Written/Oral 1.0; Listen/Speak 1.0, 2.0
7th Read 2.0; Writing 1.0, 2.0; Listen/Speak 1.0, 2.0
8th Writing 1.0, 2.0; Speaking 1.0, 2.0

Math

3rd Reasoning 1.0, 3.0
4th Data 1.0, Reasoning 1.0, 2.0
5th Data 1.0, Reasoning 1.0, 2.0
6th Algebra 2.0, Reasoning 1.0, 2.0
7th Algebra 3.0, Measurement 1.0, Data 1.0, Reasoning 1.0, 2.0

Method
Students will use a Venn diagram as a mental organizer when comparing the two types of fish. Students use computational, graphing and measuring techniques to draw life size replicas of either a salmon or steelhead. A true or false game will review the information about the species.

Materials

- Time to complete: (2-3) 50-minute class periods
- Copies of *Salmon & Steelhead Fact Sheet*
- Copies of Venn diagram handout
- Butcher paper (about 4 feet per student)
- Crayons or marking pens
- Grid paper, rulers
- Newspaper, stapler, string

Background
In the scientific community, living organisms are grouped into categories based on similar characteristics. Taxonomy is the branch of science by which plants and animals are classified. The kingdom group for animals is subdivided into phylums. The phylums are divided into class, order, family, genus and species. The division is based on shared characteristics and move from general to more specific. In the upper categories, species share many characteristics; while at the genus level, there are generally only a few species. In other words, the hierarchy of scientific names is used to identify like individuals. An easy way to remember these categories is to think of the phrase: "**P**eople **C**ross **O**ver **F**ences **G**oing **S**outh." The basic unit of the naming system is the genus and the species name. For Pacific salmon and trout, the genus is *Oncorhynchus*.

Scientific Name	**Common Name**
Pacific Salmon	
Oncorhynchus tshawytscha	Chinook or king salmon
Oncorhynchus kisutch	coho or silver salmon
Oncorhynchus nerka	red salmon, sockeye, or kokanee
Oncorhynchus keta	chum or dog salmon
Oncorhynchus gorbuscha	pink or humpback
Trout	
Oncorhynchus mykiss	steelhead or rainbow trout

Some of the characteristics shared by salmon and trout are: the capacity to be anadromous; fine (small) scales; an adipose fin (small, fleshy fin on the back just before the tail fin); relatively large eggs; strong swimmers; the need for cooler, highly oxygenated waters; and spawning males that develop a distinctly hooked lower jaw (kype).

Steelhead has recently been reclassified from the genus Salmo to Oncorhynchus. Atlantic salmon are the genus Salmo. Studies show steelhead is more closely related to Pacific salmon. A steelhead is a rainbow trout that has spent part of it's adult life in the ocean.

All five species of Pacific salmon have been caught in California's river systems; however, only king, steelhead, and to a lesser extent, coho, are ordinarily found in California.

Procedure

Part 1

1. Introduce the word taxonomy and briefly review the classification of Pacific salmon and trout.
2. Ask students if they are familiar with the Venn diagram format. As a review, create one on the board and have students provide the information to compare two familiar subjects (perhaps a dog and a cat).
3. Provide students a copy of the *Salmon & Steelhead Fact Sheet* and a Venn diagram. Each student should complete a Venn diagam using the Fact Sheet.
4. Have the class discuss their diagrams by creating a large class Venn diagram on the board.

Part II

1. Provide students with grid paper. Explain that they will learn how to use grids to draw a life size Chinook salmon or steelhead.
2. To learn how to use the grid, students should draw an outline of their hand on the grid paper. Once the outline of the hand is finished, have students make a grid on larger paper (flip chart paper or butcher paper). The grid squares on the large paper should be three to four times bigger than the squares on the smaller grid paper. Once the students have a larger grid made, have students transfer the small drawing of their hand to the larger paper. Number the squares on both pieces of paper; transfer the drawing by matching the numbers of the squares (Diagram 1).
3. Students will use the same method to draw the fish. First, have students copy the picture of either the salmon or steelhead from Diagram 2 or Diagram 3 onto grid paper. Using this picture, determine the scale of the copy to create a two foot fish. This will determine the size for the larger grid. Example, if the 4 inch copy is placed on a one inch grid, each one inch squares would represent six inches. Therefore, 4-6 inch squares could be used to transfer the fish, creating a two foot representation.
4. Create the larger grid on butcher paper to produce a two foot fish. The fish may be cut out (double the paper to create two copies) and colored using the species information page. Place the two cut-out fish together and staple the perimeter edges, leaving an opening large enough to stuff crumpled newspaper into the interior, and staple closed. Attach string to hang fish.

Part III

1. To review the similarities of Chinook salmon and steelhead, students will play a true-false game called "The Salmon & Steelhead Game."
2. Divide the class into two equal groups. Have the groups face each other approximately eight feet apart. Place boundary lines behind each group approximately 20 feet back.
3. One group is designated as the salmon, the other as the steelhead. The leader stands at the end of the two lines and reads a true or false statement, for example:
    - If the statement is true, the salmon chase the steelhead across the back boundary line behind the steelhead, trying to tag the steelhead.
    - If the statement is false, the steelhead chase the salmon across the boundary line behind the salmon, trying to tag the salmon.
    - All participants should only use one hand in tagging. If a participant in the opposite group is tagged, then they move over to that group.
    - After everyone lines up again, another statement is read and the game continues.

Extension

1. Have students write a brief report on how Chinook and steelhead use their habitat differently. (They have different spawning sites, steelhead need streams that have cool, fresh water throughout the year.)
2. Discuss with students the question of who would need to know the difference between Chinook and steelhead. (An angler would need to know because of different fishing regulations for each. Also, a scientist would need to know in order to study the fish or their environment. Finally , a planner should know in order to regulate the stream).

Evaluation *Refer to Venn Diagram*

- Describe at least three similarities of salmon and steelhead.
- Describe at least three differences between salmon

Venn diagram and fact sheets adapted with permission from *Some Things Fishy, A Teacher's Guide for the Feather River Fish Hatchery,* published by the CA Department of Water Resources, Office of Education.

Enlarge a Drawing by Using a Grid

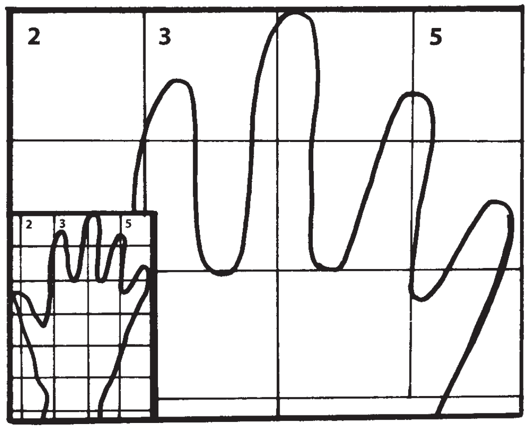


Diagram 1

Chinook Salmon

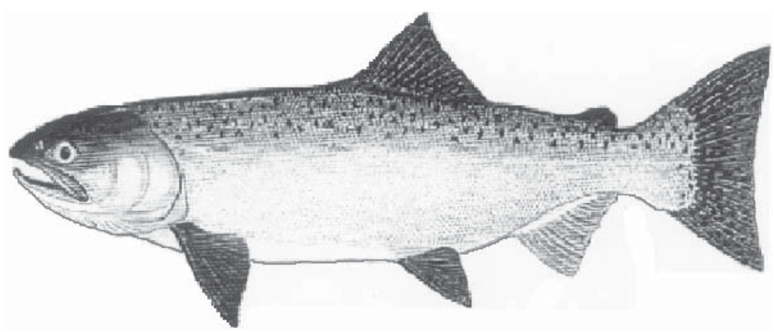


Diagram 2

Steelhead Trout

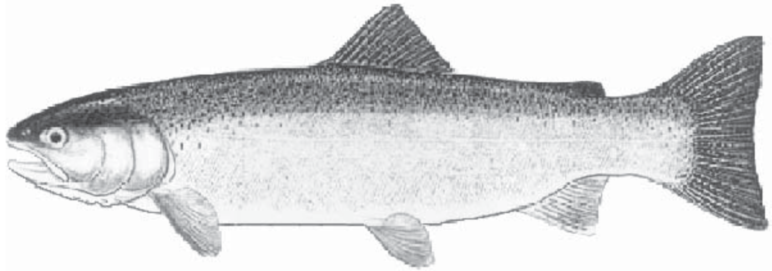


Diagram 3

Salmon & Steelhead Fact Sheet

CHINOOK SALMON
Oncorhynchus tshawytscha

Chinook salmon (also called king salmon) are anadromous fish that live in the cold water of the Pacific Ocean north from California and the streams flowing into it. When they are in the ocean, Chinook are silvery in color with a bluish or gray back and large, blotchy, black spots. Commercial salmon fishing provides jobs for many people, from catching fish to processing it for retail sales. The salmon from the American River watershed swim to the ocean through San Francisco Bay and stay within 70 miles of the coast of California.

After two to six years in the ocean, adult salmon return to their home streams to spawn (the process of reproduction). In California, most are three years old. Returning Chinook turn dark in color. The males often become red and develop a hooked jaw. They spawn in river gravels containing rocks up to 6 inches across. Chinook salmon always die after spawning.

Most young Chinook start migrating to the ocean shortly after hatching. Salmon migrate to the ocean unless they are landlocked; that is, trapped in water that does not flow to the ocean.

The largest Chinook salmon caught weighed 135 pounds. In California, the average fish weigh from 12 to 17 pounds and are 2 to 2.5

STEELHEAD TROUT
Oncorhynchus mykiss

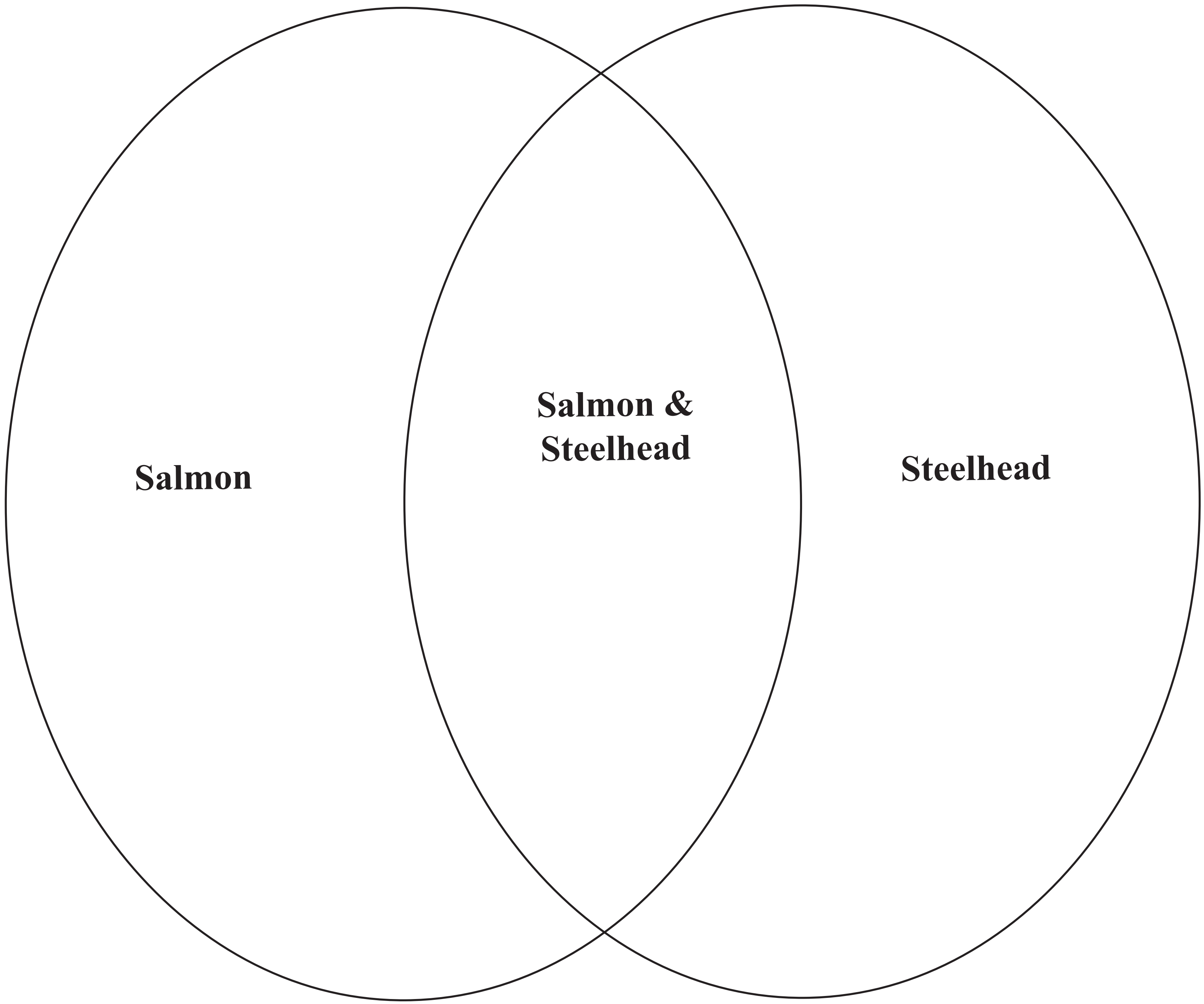
Steelhead trout are anadromous fish that live in the Pacific Ocean and the streams flowing into northern California. When they are in the ocean, steelhead are silvery with a bluish back and have many small, black dots on their back, head, and tail. Since steelhead are rarely caught in the ocean, it is a mystery where they go while in the ocean.

After two to four years in the ocean, adult steelhead return to their home streams to spawn (the process of reproduction). Their colors become more like the colors of freshwater rainbow trout. They have a green back, pink stripes on their sides, and a silver belly. The males are brighter and have a hooked jaw. They look for clean, small gravel in which to spawn.

Steelhead may spawn two to four times during their life. They swim back to the ocean and stay there two years before returning to spawn again. Before migrating to the ocean, young steelhead stay in fresh water one to two years (sometimes longer). Some never migrate. These are called rainbow trout.

Although the largest steelhead caught weighed 42 pounds, most weigh around 5 to 10 pounds and are about 2 feet long. After a steelhead has spawned the first time, it does not get much larger.

Venn Diagram



Salmon & Steelhead Game

This game is played like Joseph Cornell's "Owls and Crows." The large group is divided into two, and these two groups face each other approximately eight feet apart. Place boundary lines behind each group approximately 20 feet back. The leader stands at the end of the two lines and reads a true or false question. If the question is true, the salmon chase the steelhead across the back boundary line behind the steelhead, trying to tag the steelhead. If the question is false, the steelhead chase the salmon across the boundary line behind the salmon trying to tag the salmon. All participants should only use one hand in tagging. If a participant in the opposite group is tagged then they move over to that group. After everyone lines up again, another question is read and

Questions:

1. Salmon and steelhead can climb ladders.
2. Steelhead are rainbow trout that go to sea.
3. A fish's body is just right for flying.
4. Salmon lay their eggs in swimming pools.
5. Baby salmon carry lunch bags in their fins to eat from.
6. The word for fish which are hatched in fresh water, but migrate to salt water are called anadromous fish.
7. Another name for King salmon is Prince salmon.
8. Steelhead return to the ocean after spawning.
9. Chinook salmon can grow to be 10 feet long.
10. Salmon use their ears to hear their way back to the river where they hatched.
11. Chinook can weigh up to 100 pounds.
12. Another name for King salmon is Chinook salmon.
13. Steelhead return to their home stream to spawn.
14. Female salmon dig their nest with a shovel.
15. Keeping streams and rivers clean and cool help young salmon survive.
16. Steelhead are often caught in the ocean.
17. Salmon have fins to help them swim.
18. The river that we are nearest to in which the Chinook return to is called the Mississippi.
19. Clean, cold water kills salmon.
20. Steelhead in freshwater are colored much like the rainbow trout.
21. Fish are warm blooded.
22. Salmon have teeth.

Answers:

1. True
2. True
3. False. Fish live in water and they swim.
4. False. They lay their eggs in gravel nests called redds.
5. False. Baby salmon have a yolk sac that provides nourishment.
6. True
7. False. The other name is Chinook salmon.
8. True
9. False. They average about 2 to 2.5 feet in length.
10. False. Salmon use their sense of smell.
11. True
12. True
13. True
14. False. Female salmon use their tail and body.
15. True
16. False. Steelhead are seldom caught in the ocean.
17. True
18. False. The river is the American River.
19. False. Salmon need clean, cold water to live.
20. True
21. False. Fish are cold blooded.
22. True
23. False. Steelhead are smaller then Chinook.

Adapted from Joseph Cornell's activity and written by Beth Etgen from Effie Yeaw Nature Center.

Finger

Five Kinds of Pacific Salmon for Early Childhood Education and pre K-2

Objective
Students will identify five kinds of Pacific salmon.

Curricular Areas
Science, Language Arts, Art, and Math

California Content Standards
Science
K Number 1.0
Math
K Number 1.0
English Language Arts
K Listening/Speaking 1.0, 2.0
1st Listening/Speaking 1.0, 2.0
2nd Listening/Speaking 1.0, 2.0

Method
Students will use their fingers to help them learn the names of Pacific salmon, and using a color key, they will color salmon drawings.

Materials
- Time to complete: (1) 50-minute class period
- Coloring utensils
- Copies of the five salmon page
- Enlarged copies of the Chinook salmon
- Tissue paper
- Stapler
- String

Background
Salmon are fish born in freshwater. They live in their birth river for several months and then swim to the ocean to live their adult life. When it is time for salmon to spawn (lay their eggs), they migrate back to the river where they were born.

Five kinds of salmon live in rivers along the Pacific coast: the Chinook (or king), the coho (or silver), the sockeye (or red), pink (or humpback), and the chum (or dog). Chinook are the biggest. Some Chinook can weigh over 100 pounds. Pink salmon are the smallest, usually weighing between 3 to 5 pounds.

Procedure
1. Ask students how many have ever seen a salmon. Ask students what they know about salmon. Have they ever eaten salmon? Do they know something that salmon do that makes them very different from most other fish?
2. Read *The Salmon* by Paula Z. Hogan or *Salmon Stream* by Carol Reed-Jones.
3. Explain that there are five kinds of Pacific salmon. Name the five kinds: Chinook, sockeye, coho, chum, and pink.
4. Tell students there is a fun way they can learn and remember the kinds of Pacific salmon by using their fingers.
   - Have students hold up one hand
   - The thumb will be the chum (notice the rhyme)
   - The pointer will be the sockeye
   - The big finger is the Chinook because it is the biggest salmon
   - The ring finger is the coho
   - Of course, the pinky is the pink salmon, which is the smallest salmon

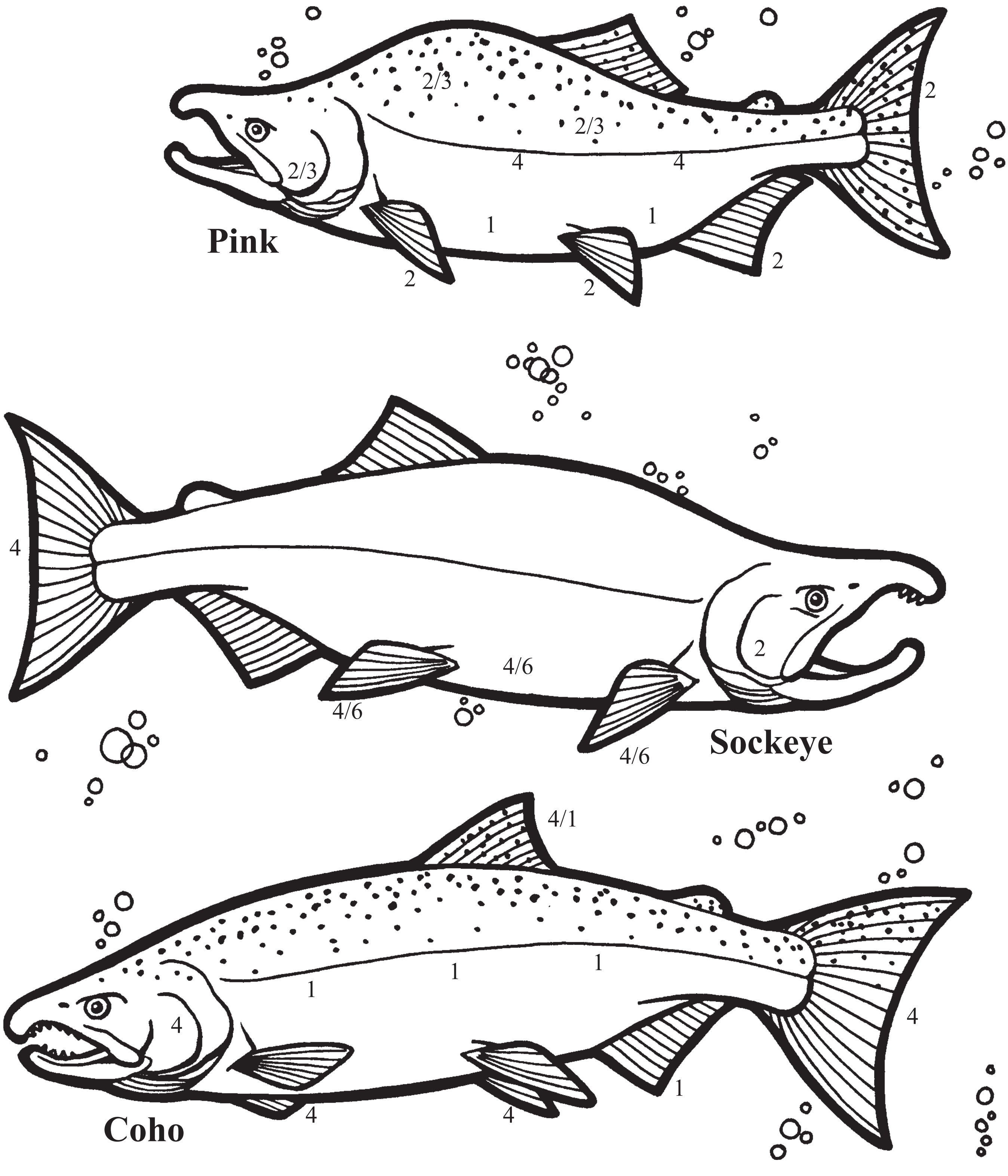
   Have student recite the names of the salmon using their fingers as they say the name.
5. Pass out copies of *Color the Fish!* color page and color key. Instruct students to color the fish using the color key.

Extensions
1. Explain that Chinook is the salmon in the American River. Ask students what they remember about the Chinook? (It is the biggest salmon). To create a three-dimensional Chinook, enlarge the drawing from the color page. Students can color and cut out the copy (double the paper to create two sides). Place the two cut-out fish together and staple the perimeter edges, leaving an opening large enough to stuff crumpled tissue paper into the interior, and staple closed. Attach string to hang fish.

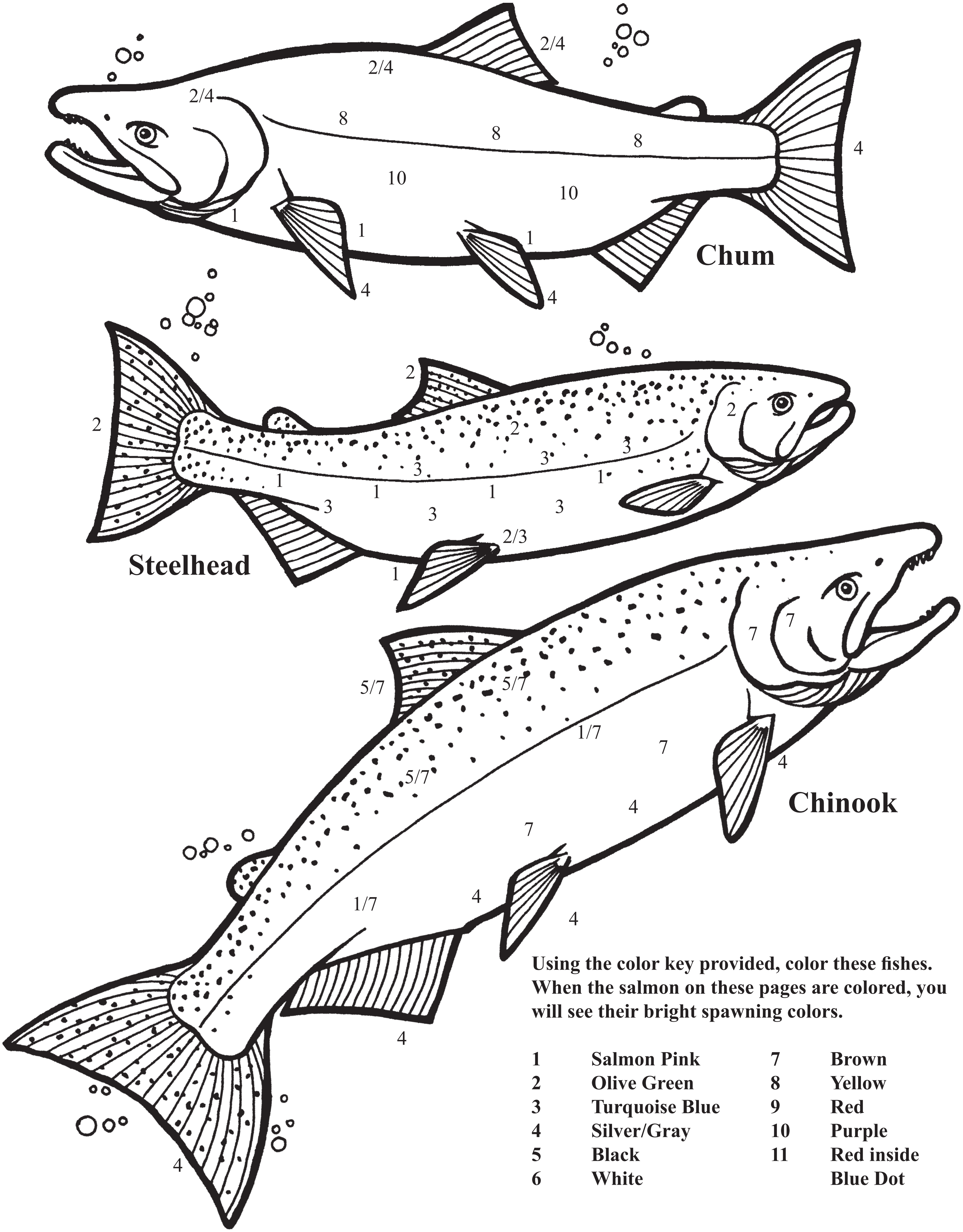
Evaluation

Adapted from an activity by Beth Etgen from Effie Yewn Nature Center.

Color the Fish!



Fish drawn by Gary Whitley from the *Pacific Salmon and Steelhead Coloring Book,* published by the U.S. Fish and Wildlife Service, Pacific Region.



Using the color key provided, color these fishes. When the salmon on these pages are colored, you will see their bright spawning colors.

1	**Salmon Pink**	**7**	**Brown**
2	**Olive Green**	**8**	**Yellow**
3	**Turquoise Blue**	**9**	**Red**
4	**Silver/Gray**	**10**	**Purple**
5	**Black**	**11**	**Red inside Blue Dot**
6	**White**		

Salmon and Steelhead Life Cycle

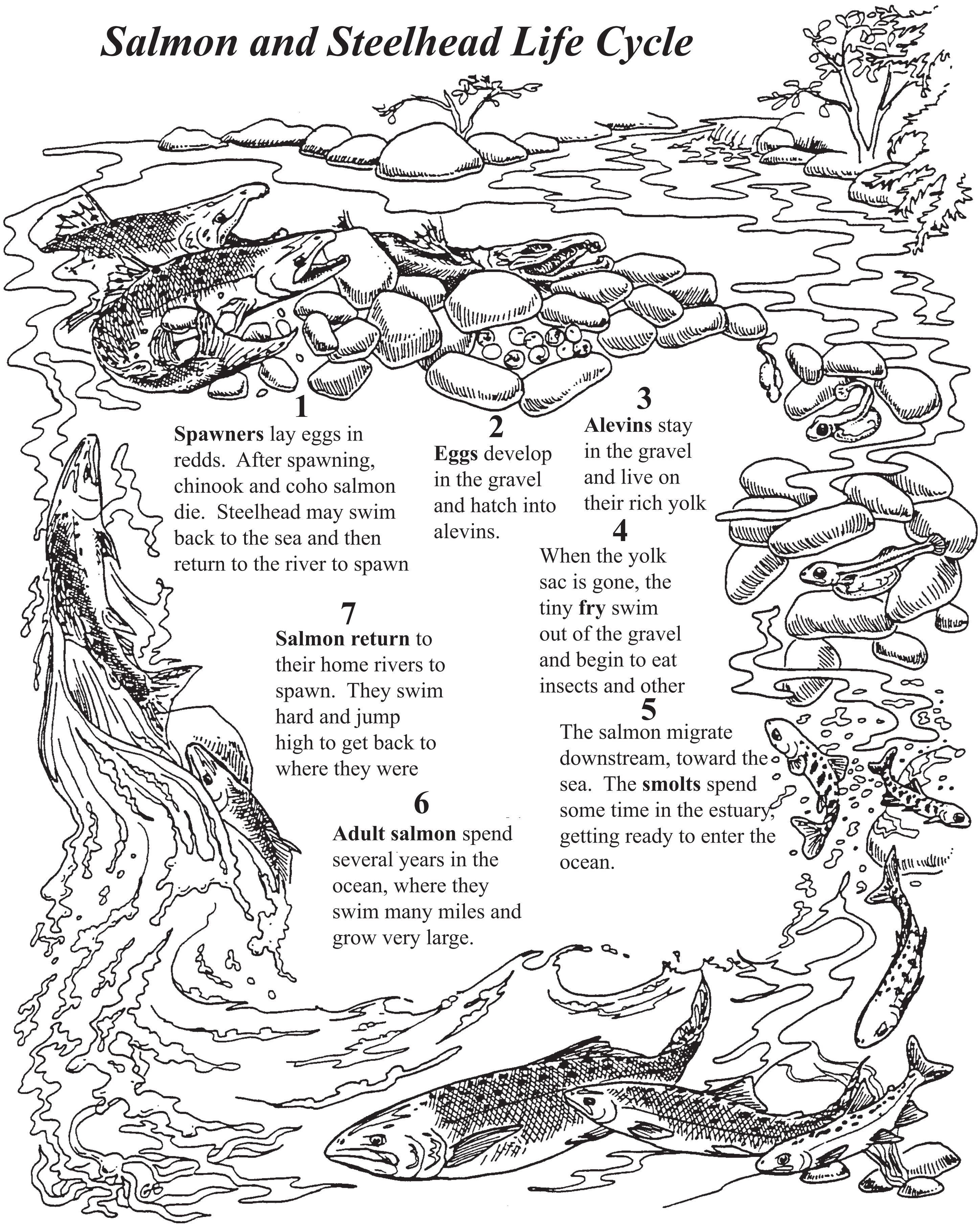


Illustration and text from *Salmon and Trout Go to School: An Illustrated Manual for Hatching Salmon and Trout Eggs in Classroom Aquarium-Incubators*, written by Diane Higgins, illustrated by Gary Bloomfield, and funded by Steelhead Trout Catch Report-Restoration Card.

The Salmon Story

Objectives
Students will: (1) describe the parts of the salmon life cycle and (2) Identify hardships and obstacles salmon encounter during the migration cycle.

Curricular Areas
Language Arts, Science, Math, Art, and Social Studies

California Content Standards
GRADES preK-4

Science

K	Life 2 b, c; Earth 3 a; Investigations 4 c, d, e
1st	Life 2 a, b, c; Investigations 4 d
2nd	Life 2 a, b; Investigations 4 c, d (Extension)
3rd	Life 3 a, c, d
4th	Life 2 b, 3 c

Math

K	Numbers 1.0, 2.0; Algebra 1.0; Data 1.0; Reason 1.0, 2.0
1st	Numbers 1.0, 2.0; Data 1.0, 2.0; Reason 1.0, 2.0
2nd	Data 1.0; Reasoning 1.0, 2.0

Social Studies

K	K.4, K.5
1st	1.2, 1.5
2nd	2.1, 2.2
3rd	3.1
4th	4.1

English Language Arts

K	Written/Oral 1; Listen/Speak 1.0, 2.0
1st	Written/Oral 1; Listen/Speak 1.0, 2.0
2nd	Written 2.0 (Extension); Written/Oral 1.0; Listen/Speak 1.0, 2.0
3rd	Written 1.0, 2.0 (Extension); Written/Oral 1.0; Listen/Speak 1.0, 2.0
4th	Written 1.0, 2.0 Extension; Written/Oral 1.0; Listen/Speak 1.0, 2.0

Method
Students create a salmon life cycle bracelet using eight to twelve different colored beads. Each bead represents a part of the cycle in a story they construct.

Materials
- Time to complete: (1) 50-minute class period
- Storybook: *Salmon Stream* or *The Salmon*
- Medium sized Pony beads; at least 12 colors (more if possible)
- Satin or leather cording

Background
The life cycle of a Chinook salmon begins when the female deposits eggs in a shallow gravel depression. Once deposited, the male fertilizes the eggs. Newly hatched salmon, called "alevin," live in the gravel and survive by absorbing proteins from their yolk sacs. After a few weeks, the yolk sacs are gone and the small fish, known as 'fry,' move into deeper water to find food on their own. Salmon remain in freshwater streams feeding and growing for many months or even years before migrating downstream to the ocean. These small ocean-bound salmon are called fingerlings. Before the fingerlings enter the ocean they spend time in an estuary, an area where saltwater and freshwater meet and mix. In the estuary, the fingerlings' body changes in preparation for the ocean saltwater. This process is called "smoltification" and the salmon are now called "smolts." Chinook smolts grow to adults in the Pacific Ocean. In the ocean the salmon grow rapidly by feeding on other fish, shrimp and crustaceans. The salmon also encounter many dangers including sharks, killer whales, other marine mammals, and humans who are also fishing for salmon. After two to five years in the ocean, they begin the journey that guides them back to their birth site. Salmon have an inherent ability to return to their original streams. Juvenile salmon imprint or memorize the unique odors of their home stream. As returning adults they use their sense of smell to guide them upstream to where they hatched. Once in their home stream, salmon spawn and then die.

Procedure
Before class:
Create a salmon life cycle bracelet to use as an example.
During class:
1. Ask students if they have heard the term migration. Define the term and provide an example (ducks migrate each year). Do other

animals migrate? Introduce the fact that some fish migrate.

2. Read students the book, *Salmon Stream* or *The Salmon*. The story follows the life cycle of the Pacific salmon. After the story, have students discuss each stage of the salmon's life. Use the life cycle illustration before this activity.
3. Explain that each student is going to create a story about the life of a salmon. Show the students the salmon life cycle bracelet. Explain that the bracelet forms a circle like the life cycle. The bracelet, which is a form of art, can be used to tell a story about the salmon. Throughout time people of all cultures have used art to tell stories and to teach. Ask if anyone knows a culture that uses storytelling and art to teach. Write down ideas, for example, totems and cave paintings.
4. Show the students the colored beads. Each student will decide the colors they will use to represent each stage of the life cycle. Students can designate colors for obstacles or hazards that their salmon will encounter during its life. Each bead will tell a part of the story about the salmon as it grows, changes, and travels.
5. Have students choose about 8 to 12 beads of different colors. Cut a piece of cording approximately 12" per student. Knot one end of the cord and have students create their story bracelet.
6. Have students share their stories first in small groups of 3 to 5, then to the class. Encourage students to share the story bracelet with their family.

Extension

- Have students write out their salmon life story and illustrate it.
- Use music or rhythm to add to the story.
- Create a life cycle puzzle. Provide each student with a copy of a large circle. Have students divide the circle into six equal parts (like slicing a pie). In each section have them write the word for one part of the salmon life cycle (spawning adults, eggs, alevins/fry, fingerlings, smolts, ocean salmon). Have students draw a picture to represent each stage. When drawings are complete, the circle can be cut out and the sections cut apart. Students can then assemble and reassemble this circle as a puzzle.

Suggestions for Color of Beads and their

SALMON STAGES	PREDATORS
Orange–salmon egg Red–alevin Light Blue–fry Teal Blue–smolts Light Blue–fingerlings Gray–ocean salmon Light Green–returning adults	Purple–large fish Dark Gray–seal Black–whale Yellow–humans Brown–bear
HABITAT	**FOOD**
Clear–fresh water Dark Blue–ocean	Light Brown–insects Pink–shrimp

The Great Anadromous Fish Game

Objectives

Students will: (1) describe the seasonal migration of anadromous fish, (2) identify a variety of natural and human factors that affect the reproductive success of anadromous fish, and (3) apply mathematical skill to biological problems.

Curricular Areas

Science (observing, organizing, communicating), Math (multiplication by fractions or decimals, subtraction, rounding off), Mechanical (use of a calculator, graphing)

California Content Standands

GRADES 4-8

Science

4th Life 2 a, b; 3 a, b, c
5th Earth 3 a; 4 a, b, c
6th Earth 4 a, b; Ecology 5 a, b, c, d, e; Resources 6 a, b, c; Investigations 7 b, e, g, h
7th Evolution 3 a, d, e; Living Systems 5 a, b, d; Investigations 7 a, c

Social Studies

4th 4.1, 4.5

Math

3rd Number 1.0, 2.0, 3.0; Data 1.0; Reason 1.0, 2.0, 3.0
4th Number 1.0; Data 1.0, 2.0; Reason 1.0, 2.0, 3.0
5th Number 1.0, 2.0, Data 1.0; Reason 1.0, 2.0, 3.0
6th Number 1.0, 2.0; Data 1.0, 2.0, 3.0; Reason 1.0, 2.0, 3.0
7th Number 1.0; Data 1.0; Reason 1.0, 2.0, 3.0

English Language Arts

4th Speaking 1.0, 2.0
5th Speaking 1.0, 2.0
6th Speaking 1.0, 2.0
7th Speaking 1.0, 2.0

Materials

- Time to complete: (1) 50-minute class period

For each group of 2-8 players:

- game board (follows activity)
- worksheets to keep score
- sets of cards (make a set of cards for each 3 players)
- a die
- 2-8 salmon or other markers for players to move
- storage box such as a shirt box
- vocabulary sheets
- calculator if not doing math by hand

Background

Migration is the movement of animals from one area to another. Many species migrate seasonally. In this game, salmon seasonally migrate from the open ocean through estuaries and into freshwater rivers and streams where they spawn (lay their eggs). The newly hatched young must then migrate back down the rivers to the ocean. Fish that follow this pattern are said to be anadromous from the Greek word for "running upward." Both the adults and the young face a number of hazards, some natural and some from humans. As the students play this game, they will learn about these hazards.

Procedure

Before class:

1. Construct the game board and game cards. For repeated use, laminate game pieces. Copy the cards and glue to different colors of construction paper. Copy the worksheet.

During class:

2. Ask students what they know about migration. Have students name animals that migrate. Why do animals seasonally migrate? Is it climatic changes that affect food supply and reproductive potential? Example, humpback whales migrate to cold northern waters to feed in summer and move south to warmer water to calve during the winter. Canadian geese migrate each spring to breed in the northern U.S. and Canada, and then they migrate south each fall to winter feeding grounds in the southern regions of the United States. What about fish?
3. Review the life cycle of the salmon.
4. Introduce the Great Anadromous Fish Game. In this game, students will be salmon migrat-

ing from the ocean (where they feed and grow to adults) into rivers and creeks to spawn and release eggs, which are fertilized outside the female's body.

5. Have the students predict some of the hazards they are likely to encounter during their migration. Make a list of the prediction on the board.
6. The students will keep track of their population size on worksheets. Graph the decline of fish as they swim upriver and the decrease of offspring as they swim down to feeding grounds in the sea.
7. To conclude, review the students list of hazards. Did they include:
    - predation by a wide variety of predators
    - food supplies
    - changes in water level from lack of rainfall
    - abnormal temperatures
    - unusually severe storms
    - parasites and diseases
    - water pollution
    - sediment from runoff
    - obstructions to migration such as dams
    - fishing
8. Which of these hazards are natural and which are a result of humans? Discuss the fact that even if humans were completely out of the picture, far more salmon are spawned than will ever survive to reproduce. Each species of animal or plant is capable of producing more offspring than are needed to just replace the individuals already alive. This allows species to survive predation and recover from natural changes or disasters. It also means that when natural controls, such as predators, are removed, populations may explode in size.

Extensions

1. What would happen if human-caused fish deaths were reduced? Have students choose one set of conditions to change. For example, fishing is no longer allowed. Replace these cards with blank cards and see what happens. Would they continue to increase forever? What are the possible consequences? Would the predator population increase? How would the competition for the food supply be effected?
2. Have students choose an aquatic or marine species that migrates and make their own

Activity adapted from *Living in Water Activity Guide*, written by Dr. Valerie Chase and published by the National Aquarium of Baltimore, Baltimore, Maryland 21202.

U.S. Fish and Wildlife Service, Paul Kerris

The Great Anadromous Fish Game

You have a run of salmon trying to reach the spawning grounds. There are 1,000 fish in this run. There are many dangers ahead. Each time you meet a hazard, deduct the number of fish that died. Use this chart to keep track of your fish population.

GOING TO THE SPAWNING GROUNDS: Number of fish to begin

OCEAN	ESTUARY	STREAMS

The number of adult fish that reached the spawning ground is_______ .
Now how many alevin (sac fry) were produced ? Calculate as follows:

1. Roll the die. Your number was______ .
2. Multiply this times 10________ .
3. Multiply this number by the total number of adult fish to get the number of baby salmon that start down stream ______ .

Now the fingerling/fry salmon head for the ocean. Keep track of the changes in the number of fish as they swim.

RETURNING TO THE OCEAN Number of fingerlings headed to the ocean

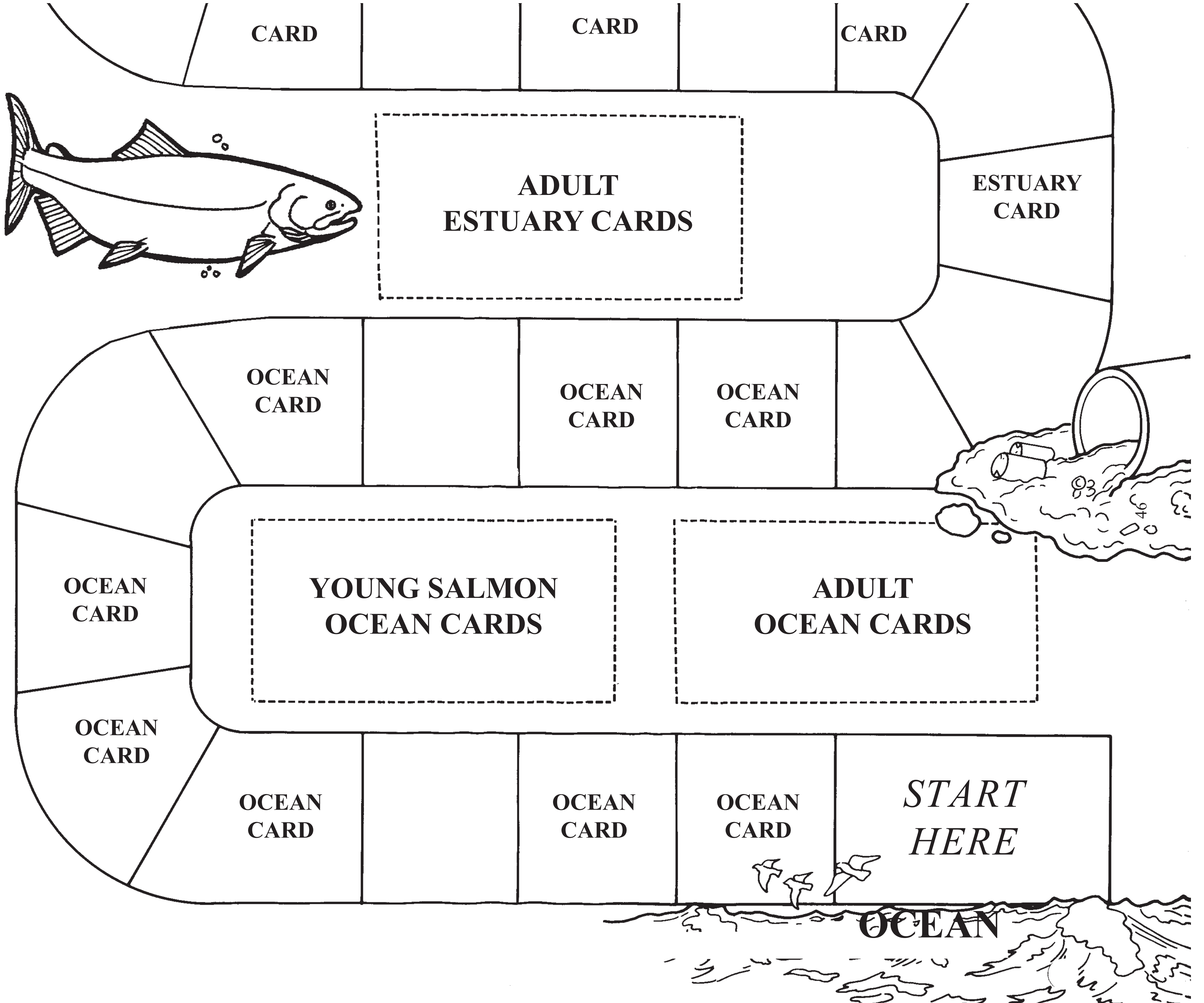
OCEAN	ESTUARY	STREAMS

The number of young salmon that reached the ocean is_______ .

The average number of young salmon that reached the ocean for the group playing the game (Add all young together and divide by the number of players)_______ .

Are the total number of salmon increasing each year or decreasing?

If you were a fisheries biologist, what actions would you take which could increase the number of salmon in future years?


CARD
CARD
CARD
ADULT
ESTUARY CARDS
ESTUARY
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CARD
YOUNG SALMON
OCEAN CARDS
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START
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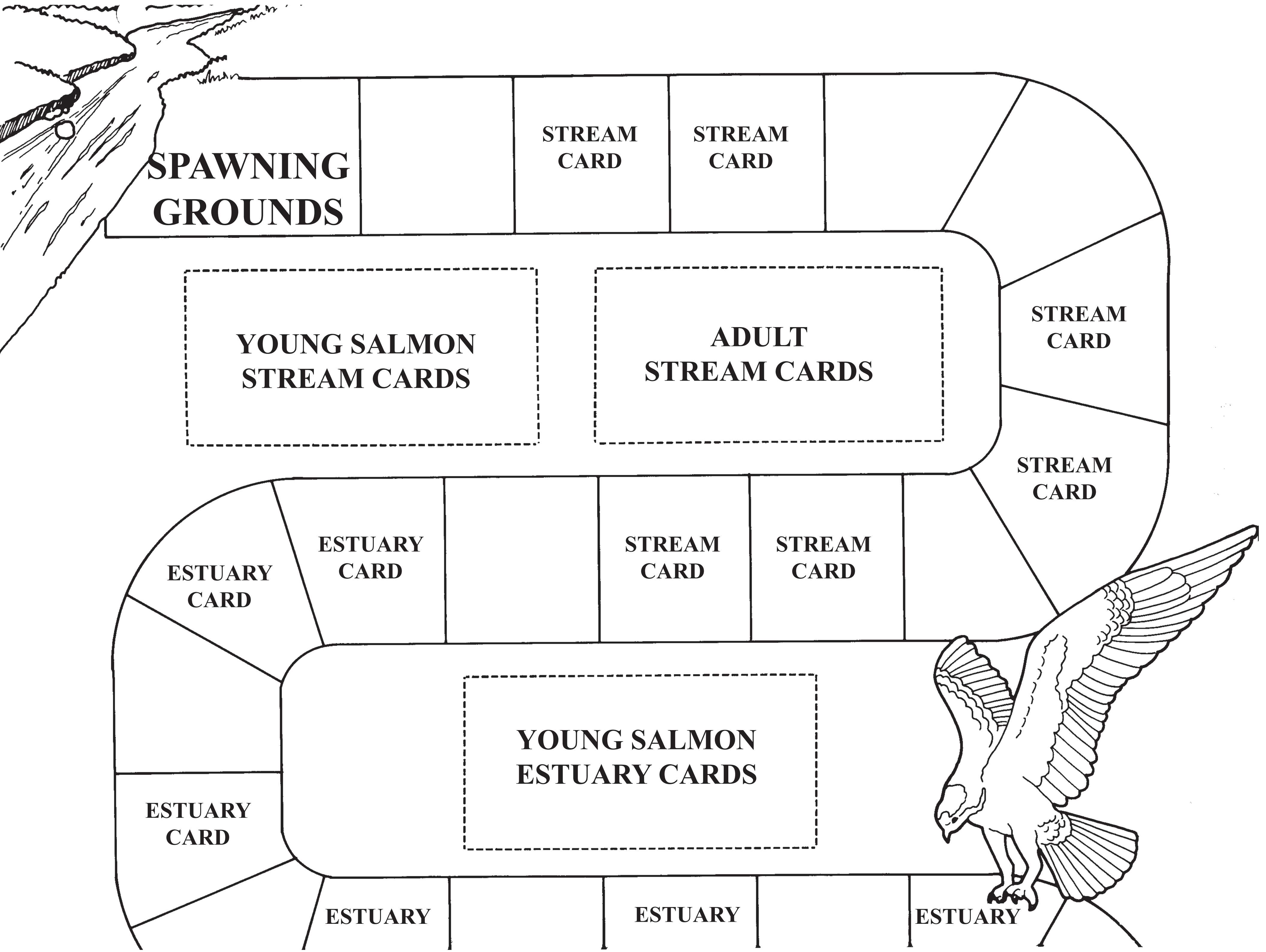
OCEAN



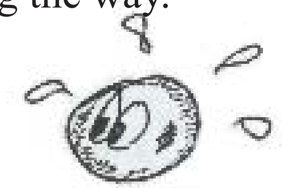
SPAWNING GROUNDS
STREAM CARD
STREAM CARD
YOUNG SALMON STREAM CARDS
ADULT STREAM CARDS
STREAM CARD
STREAM CARD
ESTUARY CARD
ESTUARY CARD
STREAM CARD
STREAM CARD
YOUNG SALMON ESTUARY CARDS
ESTUARY CARD
ESTUARY
ESTUARY
ESTUARY

Game Rules

Goal:

You are a salmon, and you are to produce as many offspring as possible by successfully swimming to the spawning grounds. After the spawning and hatching of young salmon, the fingerlings/fry swim back to the ocean. The player with the most fingerlings/fry making it to the ocean wins! But beware, there are many hazards lurking along the way.

ATTENTION: *The game board may look strange because you begin at the bottom right. Remember adult salmon swim upstream to reach the spawning grounds.*



How to play:

1. Shuffle the hazards card sets and place them in the marked locations.
2. Select your marker and place it in the Open Ocean. From the ocean you will swim into the estuary and then upstream to spawn. Young salmon then swim back to the ocean.
3. To start you have 1,000 salmon; record this number on the worksheet.
4. Roll the die. The highest number starts first. Play proceeds clockwise.
5. Roll the die to determine number of spaces to move. If you land on a space instructing you to draw a card, do so and read it aloud. Record the change in the number of fish on your worksheet.
6. While going to the spawning grounds, draw only ADULT cards.
7. Salmon may lay as many as 5,000 eggs, but not all of them hatch. Use the instuctions on the worksheet to determine the number of alevin or sac-fry that will grow into fingerlings/fry and head back to the ocean.
8. When returning to the ocean, draw only YOUNG SALMON cards.
9. The player who gets the **most** fish back to the ocean wins, not

Ocean Adult 1/2 of your school is caught by commercial anglers.	**Ocean Adult** 1/2 of your school is eaten by a school of hungry whales which herd the fish while eating them.
Ocean Adult 1/4 of your school is caught by a party boat of sports anglers.	**Ocean Adult** 1/2 of your school is lost. It is an El Nino year. There is a lack of plankton and consequently less krill for the salmon to eat.
Ocean Adult 1/4 of your school is caught by commercial anglers for the retail market.	**Ocean Adult** 1/4 of your school is eaten by predators including sharks and seals.
Ocean Adult None of your school dies; it has found enough food, has not been caught by predators, and has encountered normal weather.	**Ocean Adult** 1/2 of your school dies as a result of large ocean storms which upset the food balance.
Ocean Adult None of your school dies as the weather has been perfect. Advance one space.	**Ocean Adult** 1/4 of your school has eaten small fish which have consumed plastic pollution. They do not supply enough nutrients for you to live.

Young Salmon Stream 1/2 of your school is eaten by predatory fish in the stream.	**Young Salmon Stream** 1/2 of your school dies when they enter a water diversion pipe without a screen cover.
Young Salmon Stream 1/4 of your school is killed by pesticide runoff from a nearby farm.	**Young Salmon Stream** 1/2 of your school dies because insects and larvae are not available to feed the young salmon.
Young Salmon Stream 1/2 of your school is killed before it even hatches when mud from a new housing development smothers the eggs.	**Young Salmon Stream** 1/4 of your school dies after swimming into an area of very hot water where the stream is being used to cool heavy
Young Salmon Stream 1/2 of your school dies after passing through toxic chemicals leaking into the stream from an illegal waste dump.	**Young Salmon Stream** None of your salmon die as the spawning grounds are protected by laws which preserve their natural state. Advance one space.
Young Salmon Stream 1/4 of your school dies after entering a section of the stream where industrial pollutants have been dumped.	**Young Salmon Stream** 1/4 of your school is left stranded in shallow pools by a passing flood. They cannot get back to the creek, so they die.

Stream Adult
1/4 of your school are caught by commercial anglers. They are sold fresh to a seafood market.

Stream Adult
1/2 of your school dies after entering a stream that has high pesticides because of runoff from a farm.

Stream Adult
1/2 of your school dies because improper farming methods have choked the stream with mud.

Stream Adult
1/2 of your school dies in very low water because it has not rained or snowed this winter or early spring.

Stream Adult
1/4 of your school are caught by eagles and bears.

Stream Adult
1/2 of your school dies because the forest along the stream was cut and stumps and logs have formed dams which many cannot cross.

Stream Adult
1/2 of your school dies because of a flood control project. Your home stream has been cut into channels. Many of the places to spawn have been destroyed.

Stream Adult
1/4 of your school are eaten by predators such as a family of hungry bears.

Stream Adult
None of your school dies because the stream you enter is protected as part of a park. Dams have been removed, sediment is kept from running into the water, and fishing is limited. Advance one space.

Stream Adult
1/4 of your school are caught by poachers with nets and traps in the shallow, narrow creek.

Estuary Adult 1/4 of your school are eaten by sea lions.	**Estuary Adult** 1/2 of your school are caught by commercial and sport anglers.
Estuary Adult 1/4 of your school dies because the water level of the estuary is too low due to drought this year.	**Estuary Adult** None of your school dies because it has found the conditions for the trip through the estuary and up the river to be excellent. Advance one space.
Estuary Adult 1/4 of your school dies because much of the wetlands has been drained and filled for development.	**Estuary Adult** 1/2 of your school dies because part of the school takes a fork in the river that leads to a dam with no way around.
Estuary Adult 1/2 of your school dies from small sedimentation that has altered the waterway and decreased the water level.	**Estuary Adult** 1/4 of your school dies due to a toxic spill in the estuary.
Estuary Adult None of your school dies. The estuary has been restored.	**Estuary Adult** 1/4 of your school are caught by sport fishermen lining the banks of a narrow river channel.

Young Salmon Estuary
1/2 of your school dies after swimming through an area polluted with industrial wastes that would not have harmed the adults, but are toxic to young salmon.

Young Salmon Estuary
None of your school dies as it manages a safe passage toward the sea. Advance one space.

Young Salmon Estuary
1/2 of your school dies when it swims into an area where an algal bloom has died, using all the oxygen in the water as the algae decompose.

Young Salmon Estuary
1/4 of your school dies after being attacked by fish leeches, which are parasites that weaken the young salmon.

Young Salmon Estuary
1/4 of your school are eaten by a herd of sea lions, which target salmon.

Young Salmon Estuary
1/4 of your school dies from lack of food caused by salinity changes in the water due to unusually dry weather.

Young Salmon Estuary
None of your school dies as it has avoided predators, has not been exposed to toxic wastes because laws have helped control wastes, and has found normal food supplies and weather.

Young Salmon Estuary
1/2 of your school dies after swimming through water polluted with runoff from farms.

Young Salmon Estuary
1/4 of your school dies after swimming into the intake pipe of a hydro-electric plant.

Young Salmon Estuary
1/2 of your school are eaten by a large school of hungry bass. The rest escape as sport fishermen scare the bass away while moving their boats through the school trying to catch the bass.

Young Salmon Ocean None of your school dies as they have found sufficient food and escaped the notice of predators.	**Young Salmon Ocean** None of your school dies as you have escaped predators and found plenty of plankton to eat.
Young Salmon Ocean A boat of poachers has captured 1/2 of your school. They will be caught by a warden at the dock. Cut your number by half and then advance one space.	**Young Salmon Ocean** 1/2 of your school dies due to lack of sufficient plankton, the food on which you depend.
Young Salmon Ocean 1/2 of your school is eaten by a hungry school of bass.	**Young Salmon Ocean** 1/4 of your school dies due to lack of food during an El Niño year when the ocean temperatures are higher.
Young Salmon Ocean 1/2 of your school is caught by commercial fishermen in international waters.	**Young Salmon Ocean** 1/4 of your school are caught by a party boat of sports anglers.
Young Salmon Ocean 1/4 of your school are eaten by a pod of killer whales.	**Young Salmon Ocean** 1/4 of your school are eaten by a pod of sperm whales.

Hooks And Ladders

Objectives

Students will (1) describe how some fish migrate as part of their life cycles, (2) identify the stages of the life cycle of one kind of fish, (3) describe limiting factors affecting Pacific salmon as they complete their life cycles, and (4) generalize that limiting factors affect all populations of animals.

Curricular Areas

Social Studies, Science, Environmental Education, Expressive Arts, English Language Arts

California Content Standards

GRADES 3-8

Science

3rd Life 3 a
4th Life 2 b, 3 b; Investigations 6 c, d
6th Ecology 5 b; Resources 6 b
7th Evolution 3 a

English Language Arts

3rd Listen/Speaking 1.0
4th Listen/Speaking 1.0
5th Listen/Speaking 1.0
6th Listen/Speaking 1.0
7th Listen/Speaking 1.0

Method

Students simulate the Pacific salmon and the hazards faced by salmon in an activity portraying the life cycle of these aquatic creatures.

Materials

- (1) 50-minute class period
- large playing area (100 feet x 50 feet)
- 500 feet of rope or string or six traffic cones for marking boundaries (masking tape may be used if area is indoors)
- two cardboard boxes
- 100 tokens (3” x 5” cards, poker ships, macaroni, etc.)
- jump rope

Background

Many fish migrate from one habitat to another during their lives. Both the Atlantic and Pacific salmon are examples of fish that endure a spectacular migration.

The life cycle for Pacific salmon begins when the female deposits 1,000 to 5,000 eggs in her freshwater spawn. The eggs are deposited in a shallow gravel depression that she digs by flapping her tail from side to side. Once the eggs are deposited, the male fertilizes them; then both nudge the gravel back over the eggs to offer as much protection as possible. The eggs are susceptible to factors such as predation or oxygen deprivation. Within a few days, both the male and female salmon have completed their reproduction cycle and soon die.

Newly hatched salmon, called alevins, live in the gravel and survive by absorbing proteins from their yolk sacs. After a few weeks, the yolk sacs are gone and the small fish, known as “fry,” move into deeper water to find food on their own. Salmon remain in freshwater streams feeding and growing for many months or even years before migrating downstream to the ocean. These small ocean-bound salmon are now called “smolts.” These salmon will feed in estuaries where fresh and salt water mix. After a few weeks of adjusting to the brackish water, the young salmon swim into the ocean.

In the ocean, the salmon grow rapidly by feeding on a rich food supply that includes other fish, shrimp, and crustaceans. Young salmon may encounter many limiting factors, including sharks, killer whales, other marine mammals, and humans who are fishing for salmon for commercial and personal uses.

After two to five years in the ocean, the Pacific salmon begin the journey that guides them to their own hatching sites. Pacific salmon spawn only once in their lives. Salmon have an inherent ability to return to their original streams. Juvenile salmon imprint or memorize the unique odors of their home streams. As returning adults, they use their sense of smell to detect those odors and guide them upstream to where they were hatched. Once there, the salmon spawn and then die.

Salmon face a variety of limiting factors in the completion of their life cycle. A limiting factor is a reason or cause that reduces the population of an organism. Some limiting factors are natural, and some result from human intervention into natural systems.

Natural limiting factors include drought, floods, predators, and inadequate food supply. Throughout their lives, salmon depend on a habitat that provides plants to shade streams and deep pools of water for spawning and resting. Incorrect logging practices, grazing, mining, road building, and development often destroy streamside vegetation, erode land, and fill streams with silt that covers gravel beds.

Dams are another limiting factor that block or slow migration to and from the ocean. Salmon become disoriented by the reservoirs formed by dams and become exposed to unhealthy conditions like high water temperatures and predators. Fish ladders can be installed to help salmon through the dams. Fish ladders can be water-filled staircases that allow migrating fish to swim around the dam.

Another threat to salmon is overfishing. Overfishing, combined with habitat destruction, is viewed by biologists as a cause for the decline of salmon populations.

NOTE: All possible conditions are not covered by the design of this activity. However, the activity does serve to illustrate three important concepts:

life cycle

migration

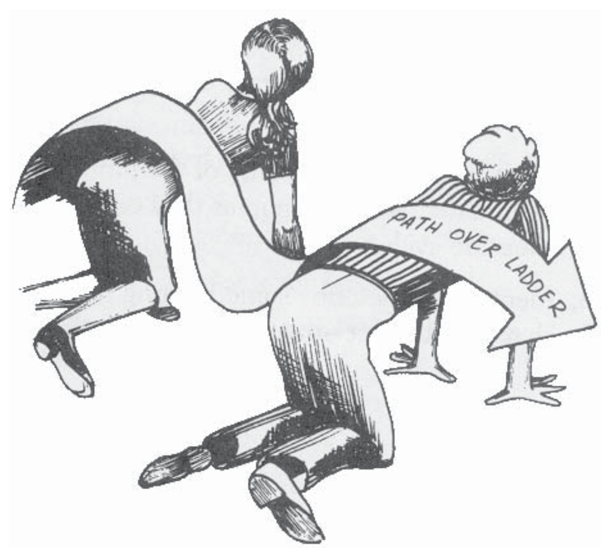
limiting factors

Procedure

1. Ask the students what they know about the life cycles of fish that live in their area. Do any local fish migrate to spawn? If yes, which ones? (Mullet, shad, lake trout, striped bass, suckers, carp, and salmon are examples of fish that migrate to spawn.)
2. Set up a playing field as shown in diagram A, including spawning grounds, reservoir, downstream, upstream, and ocean. The area must be at least 100 feet by 50 feet. Assign roles to each of the students. Some will be salmon; others will be potential limiting factors to the salmon. Assign the students roles as follows. NOTE: These figures are based on a class size of 25 to 30 students. If the group is larger or smaller, adjust the number of people who are fishing and predatory wildlife accordingly.
   - Choose two students to be the turbine team. They will operate the jump rope, which represents the turbines in hydroelectric dams. Later in the simulation, when all the salmon have passed the turbine going downstream, those students move to the upstream side to become the waterfall-broad jump monitors. (See Diagram A)
   - Choose two students to be predatory wildlife. At the start of the simulation, the predators will be stationed in the reservoir above the turbines to catch the salmon fry as they try to find their way out of the reservoir and move downstream. Then they will move to below the turbines where they catch salmon headed downstream. Later in the activity, when all the salmon are in the sea, these same two predators will patrol the area above the "broad jump" waterfalls. There, they will feed on salmon just before they enter the spawning ground. (See Diagram A)
   - Choose two students to be humans in fishing boats catching salmon in the open ocean. The students in the fishing boats

must keep one foot in a cardboard box to reduce their speed and maneuverability.
- All remaining students are salmon.

3. Begin the activity with all the salmon in the spawning ground. The salmon first move into the reservoir above the dam. They must stay in the reservoir while they count to 30. This pause simulates the disorientation that salmon face because of a lack of current in the lake to direct them on their journey. During this time the predators may catch the salmon and escort them one at a time, to become part of the fish ladder. The salmon then start their journey downstream. The first major limiting factor that the salmon encounter is the turbines at the dam. At most dams, escape weirs guide migrating salmon past the turbines. The student salmon cannot go around the jump-rope. Any salmon that "dies" at any time in this activity must immediately become part of the fish ladder. The student is no longer a fish, but becomes part of the physical structure of the human-made fish ladders now used by migrating salmon to get past barriers such as dams. The students who are the fish ladder kneel on the ground as shown, with one body space between them.
4. Once past the turbines, the salmon must pass some predatory wildlife. The predators, who have moved from the reservoir area to the area below the turbine, must catch the salmon with both hands–tagging isn't enough. Dead salmon are escorted by the predator to become part of the fish ladder. Later, the salmon that survive life in the open ocean will pass through the fish ladder to return to the spawning ground. NOTE: Both the



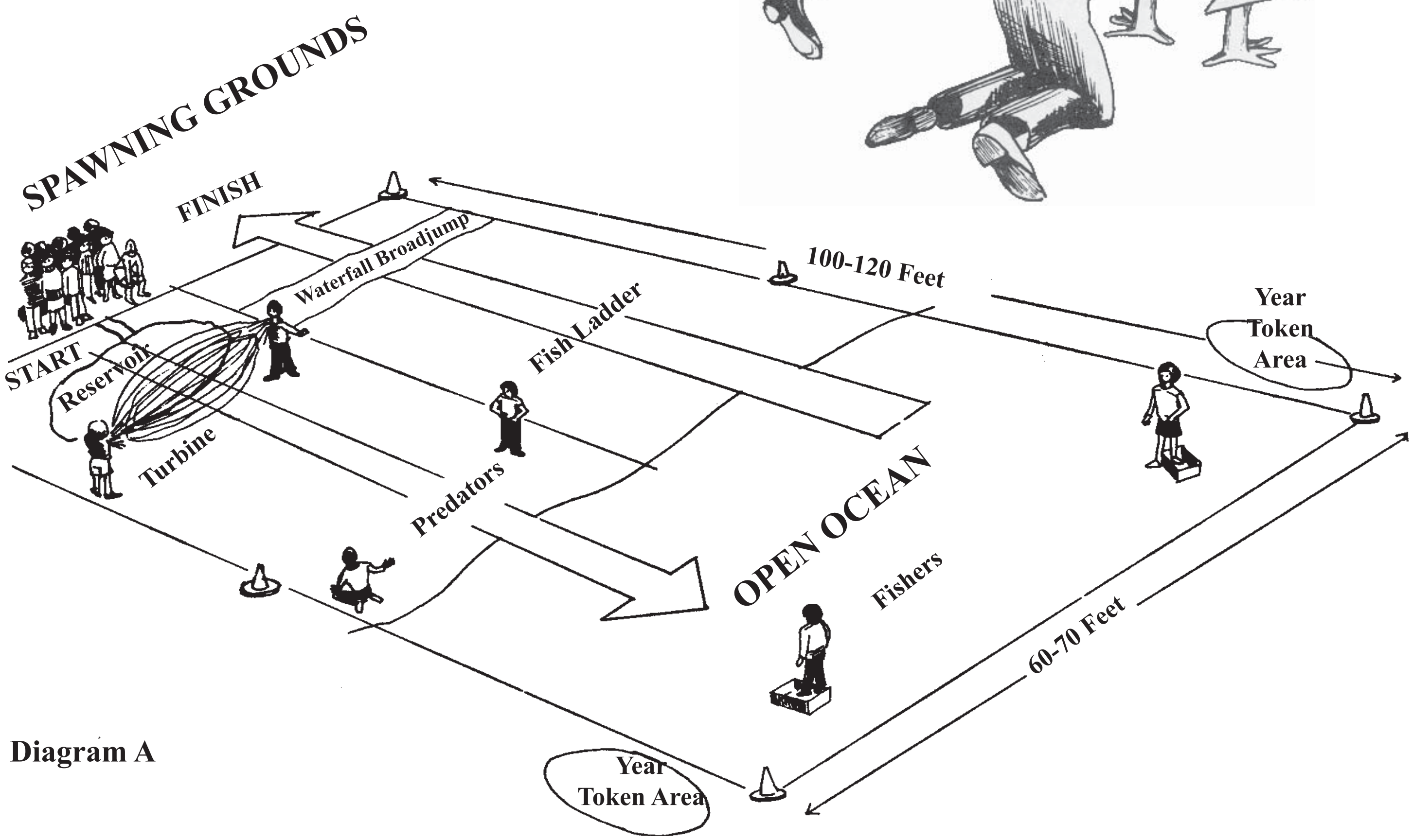


Diagram A

predatory wildlife in the downstream area and the people fishing in the open ocean must take dead salmon to the fish ladder site. This action moves the predators and fishing boats off the field regularly, helping to provide more realistic survival rates.

5. Once in the open ocean, the salmon can be caught by fishing boats. The salmon must move back and forth across the ocean area in order to gather four tokens. Each token represents 1 year of growth. Once each fish has four tokens (4 years growth), that fish can begin migration upstream. The year tokens can be picked up only one at a time on each crossing. Remember, the salmon must cross the entire open ocean area to get a token. The "4 years" that these trips take make the salmon more vulnerable; thus they are more readily caught by the fishing boats. For this simulation, the impact of this limiting factor creates a more realistic survival ratio on the population before the salmon begin the return migration upstream.
6. When four of the year tokens have been gathered, the salmon can start upstream. The salmon must walk through the entire pattern of the fish ladder. This enforced trip through the fish ladder gives the students a hint of how restricting and tedious the upstream journey can be. In the fish ladder, predators may not harm the salmon.
7. Once through the ladder, the salmon face the broad-jump waterfall. The waterfall represents one of the natural barriers salmon face going upstream. Be sure the jumping distance is challenging but realistic. The two former turbine students will monitor the jump. The salmon must jump the entire breadth of the waterfall to be able to continue. If the salmon fails to make the jump, then it must return to the bottom of the fish ladder and come through again.

NOTE: When playing indoors, the broad-jump waterfall may be changed into a stepping-stone jump defined by masking tape squares on hard floors.

8. Above the falls, the two predators who started the simulation as the predators below the turbines have now become the last set of limiting factors faced by the salmon. They represent bears–one example of predatory wildlife. Again, remember that the predators must catch the salmon with both hands. If they catch a salmon, they must then take the student they caught to become part of the structure of the fish ladder.
9. The activity ends when all the salmon are gone before the spawning ground is reached–or when all surviving salmon reach the spawning ground.
10. Next, engage the students in a discussion. Explore topics such as:

- the apparent survival or mortality ratio of salmon,
- the role of the barriers,
- the role of the predatory wildlife and the people fishing,
- where the losses were greatest,
- where the losses were least,
- what the consequences would be if all the eggs deposited made the journey successfully, and what seemed realistic about this simulation and what did not.

11. Ask the students to summarize what they have learned about the life cycle of salmon, the salmon's migration, and limiting factors that affect salmon. Make sure the students have a clear working definition of limiting factors. Encourage the students to make the generalization that all animals–not just the Pacific salmon–are affected by limiting factors. Ask the students to give examples of limiting factors. They might mention the availability of suitable food, water, shelter, and space; disease; weather; predation; and changes in land use and other human activities.

Variation: Atlantic Salmon

This activity can easily be adapted to feature Atlantic salmon. The most significant difference between Pacific and Atlantic salmon is that the Atlantic salmon can spawn more than once. Many Atlantic salmon make their complete migratory journey and spawn two or more times. All Pacific salmon die after spawning only once. To adapt this activity for Atlantic salmon, students are to make as many complete migratory trips as possible. After the activity is finished, ask students to report how many times they successfully completed the migratory cycle. Graph the data. Have the students explain how age influences mortality rates and susceptibility to limiting factors.

Extensions

1. Write a report on the life history of one of the species of salmon (e.g., Chinook or king, chum or dog, pink or humpback, coho or silver, sockeye or red, Atlantic). Create a mural showing the life cycle of this salmon.
2. Research and illustrate the life cycle of any local fish. If possible, look for one that migrates.
3. Compare how the life cycle of a Pacific salmon is similar to and different from the life cycle of one or more local fish.
4. Investigate similarities and differences in the migration and life cycles of an Atlantic and a Pacific salmon. Investigate the life cycle of salmon in the Great Lakes region of the United States.
5. Visit fish hatcheries that work with migratory species and investigate how they function.
6. Explore ways that dams can be modified to let fish safely pass downstream and upstream. Design the "perfect" fish ladder.
7. Investigate and discuss commercial fishing for salmon. Investigate and discuss personal and recreational fishing for salmon.
8. Find out about laws protecting migratory species, including fish. Consider this approach, and try the activity again: In the past 100 years, salmon have experienced many new, human-caused limiting factors. Dams, commercial fishing, timber harvest, and road construction have had a tremendous impact on salmon population. In 1991, the Snake River sockeye salmon was placed on the federal endangered species list. In the past, tens of thousands of sockeyes would make the 900-mile return trip from the sea to Idaho's mountain streams and lakes. There they spawned and died. Their offspring hatched and began their early development in fresh water. The actual migration to the Pacific Ocean could be completed in as few as 9 days. Today that trip takes more than 60 days. In 1991, only four Snake River sockeye salmon returned to their spawning grounds.

   To simulate these increases in salmon limiting factors, play several rounds of "Hooks and Ladders." Allow each round to represent the passage of 25 years. Start in 1850. In that year, do not include dams or commercial fishing operations in the scenario. As time passes, add the human commercial fishing operations. Build dams (jump ropes) as the scenario progresses into the 21st century.

   Describe some of the possible effects on salmon from increased limiting factors as a result of human activities and interventions. Discuss possible positive and negative effects on both people and salmon from these increases in limiting factors affecting salmon. When the activity reaches "the present," predict what

Early Childhood Education Hooks and Ladders

Objective
Students will explore the concept of migration. They will identify hardships and obstacles that salmon encounter during the migration cycle.

Curricular Areas
Physical Education (moving through a simulated migration), Language Arts (discussion of vocabulary), Social Science (aquatic jobs), Science (migration), Math (counting)

California Content Standards
GRADES K-2

Science

K Life 2, Earth 3, Investigations 4

1st Life 2, Investigations 4;

2nd Physical 1, Life 2, Earth 3, Investigations 4

Math

K Numbers 1.0, Geometry 1.0, Data 1.0, Reasoning 1.0, 2.0;

1st Numbers 2.0, Algebra 1.0, Measurement 1.0, 2.0, Statistics 1.0, Reasoning 1.0, 2.0

Social Science

K 3, 4, 5;

1st 1, 2, 6;

2nd 2, 4

Language Arts

K Written/Oral 1.0, Listening 1.0, 2.0;

1st Written/Oral 1.0, Listening 1.0, 2.0;

2nd Reading 2.0, Listening 1.0, 2.0

Method
Students will simulate the migration of the Pacific salmon and the hazards faced by salmon in a kinesthetic activity.

Materials
- Storybook, *Salmon Stream*
- Large play area (100 feet x 50 feet)
- Chalk, 500 ft rope or yellow plastic hazard tape (available at hardware or lumber stores) to make boundaries
- 18 cones
- Cardboard boxes or plastic dishpans (needed for fishing boats)
- 2 containers and 100 tokens (3”x5” cards, poker chips, macaroni, etc.)

Background
Many fish migrate from one habitat to another during their lives. Pacific salmon are examples of fish that endure a spectacular migration. The life cycle for Pacific salmon begins when the female deposits eggs in a shallow gravel depression. Once deposited, the male fertilizes the eggs.

Newly hatched salmon, called “alevins,” live in the gravel and survive by absorbing proteins from their yolk sacs. After a few weeks the yolk sacs are gone and the small fish, known as “fry,” move into deeper water to find food on their own. Salmon remain in freshwater streams feeding and growing for many months or even years before migrating downstream to the ocean. These small ocean-bound salmon are now called “smolts.” In the ocean the salmon grow rapidly by feeding on a rich food supply that includes other fish, shrimp and crustaceans. Young salmon may encounter many dangers, including sharks, killer whales and other marine mammals, along with humans who are fishing for salmon. After two to five years in the ocean, the Pacific salmon begin the journey that guides them to their own hatching sites. Pacific salmon spawn only once in their lives. Salmon have an inherent ability to return to their original streams. Juvenile salmon imprint or memorize the unique odors of their home streams. As returning adults they use their sense of smell to detect these odors and guide them upstream to where they were hatched. Once there, the salmon spawn and then die.

Salmon face a variety of limiting factors in the completion of their life cycle. A limiting factor is a reason or cause that reduces the population of an organism. Some limiting factors are natural, and some result from human intervention with natural systems. Dams are a limiting factor that block or slow migration to and from the ocean. Fish ladders can be installed to help salmon through the dams.

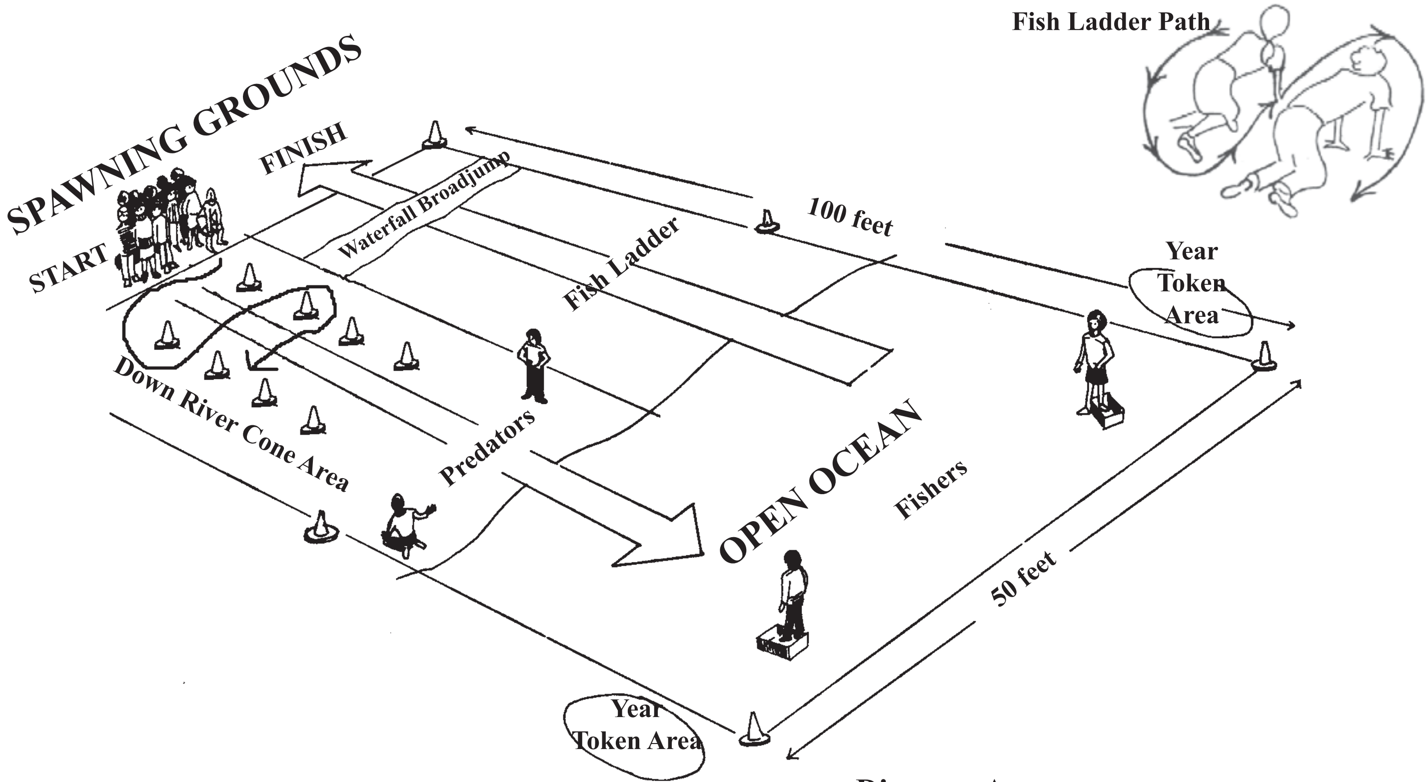


Diagram A

Fish ladders can be water-filled staircases that allow migrating fish to swim around the dam.

Procedure

This lesson can span over two days. The first day read the book *Salmon Stream*, and introduce the concept of migration and vocabulary. On the second day have students play the Hooks and Ladders game. Parent assistance during the outside activity is helpful.

1. Ask the students if they have heard the term migration. Define the term and provide an example (ducks migrate each year). Ask if students can think of any animals that migrate. Write these animals down on a class list. Introduce the fact that some fish migrate. Talk about the Pacific salmon and how it is one of the types of fish that migrate. If possible show pictures of animals that migrate and the habitats they move to and from. This will help the students visualize the process.
2. Read the book *Salmon Stream* to the class. The story follows the life cycle of the Pacific Salmon. After the story, have students discuss each stage of the salmon's life.
3. Set up the playing field as shown in diagram A. The area needs to be at least 100 feet by 50 feet. Use the chalk, rope or hazard tape to mark the boundaries. 10 cones will be used to represent the curves and natural hazards within the river. Set up the cones in two rows of five allowing space in between for the students to run in a zig-zag motion to the end of the row. Assign the students roles as follows.
   - Choose two students to be predators. Predators are stationed just past the river hazards. They catch the salmon fry as they head downstream on the way to the ocean. Later in the activity, when all the salmon are in the sea, these same two predators will be patrolling the broad jump area, which represents the waterfall.
   - Choose two students to be humans in fishing boats catching salmon in the open sea. The students need to keep one foot in the cardboard box or plastic dishpan at all times; this will help to reduce their speed as they try to tag the salmon.

- All remaining students are salmon.

4. Begin the activity with all the salmon in the spawning ground (see diagram). *SUGGESTION: do a walk through of the activity to help orientate students to its features.* The salmon fry first move into deeper water from the gravel area of their birth. They stay in this deeper stream area to the count of 20. This pause simulates a time of growth and the imprinting of the river area on the salmon fry before they begin their journey. During this time the predators may try to catch the salmon by tagging them. When a student is tagged, they are to be escorted by the predator to the fish ladder area. The predator then returns to catch more salmon fry. After the count of 20, the salmon can then move downstream. As they move downstream, they will zigzag through the cones; if a cone is hit or knocked over the student must join the fish ladder. This represents a natural hazard encountered by the salmon fry.
NOTE: during the entire activity, any salmon that "dies" (gets out) becomes part of the human-made physical structure called the fish ladder. Students who are part of the fish ladder kneel down with one body space between them (see illustration).
5. Next, the salmon must pass some predatory wildlife. The predators have moved from the deeper water area to the area below the cones; these are river hazards. Predators must tag the salmon with both hands. Caught salmon are dead and must go to the fish ladder. NOTE: both the predatory wildlife students and the people fishing must escort the dead salmon to the fish ladder area. This allows for a more realistic survival ratio.
6. Once in the ocean, the fishing boat can catch the salmon. The salmon must move back and forth across the ocean area four times. Each time the student successfully crosses the ocean they gather a token. Students must gather four tokens. Each token represents one year's growth. Once the student has four tokens (crossed the ocean four times) they can then move to the fish ladder.
7. As the salmon start upstream, each salmon must walk through the entire pattern of the fish ladder. Have someone at the beginning of the fish ladder to collect the tokens. This activity will provide the students with the idea of how restricting and tedious the upstream journey can be. While in the fish ladder, predators cannot harm the fish.
8. Once through the ladder, the salmon face the broad-jump waterfall. The waterfall represents one of the natural barriers salmon face going upstream. Be sure the jumping distance is challenging but realistic for the age group participating. Have two parents or students (depending on the age of the participants) monitor the salmon. The salmon must jump the entire breadth of the waterfall in order to continue. If a salmon fails to make the jump then they must return to the bottom of the fish ladder and come through again.
NOTE: the waterfall may be changed into a stepping-stone jump defined by masking tape squares.
9. Above the falls, the two predators that started the simulation as predators now become the last danger faced by the salmon. Again, the predators must tag the salmon with both hands.
10. The activity ends when all the salmon are either dead or in the spawning ground.
11. After the activity ask the students to discuss:
    - In what areas did most of the fish die?
    - What was the hardest part?
    - What other types of predators do the salmon face?
    - How hard is it for the salmon to survive?
    - Why is it so hard?
12. Have the students draw or write about their experience after the discussion. Invite students to share their work with the rest of the class.

Extensions

1. Create a storybook about an aquatic animal that migrates; older students can write and illustrate their book; younger students can do a picture story.

Activity reprinted with permission from the *CA Project WILD Aquatic Early Childhood Education Supplement*. For more information contact the CA Project Wild office (888) 945-3334 or email BWinn@dfg.ca.gov.

Homing Instincts

Objectives

Students will 1) trace and label the migratory route that Chinook salmon take from the ocean to the American River, 2) describe one theory about how a salmon can find its birth stream, and 3) explain how adaptations enable some species to survive and maintain their populations.

Curricular Areas

Science, Language Arts, and Environmental Education

California Content Standards

GRADES 3-8 *(can be adapted for K-2)*

Science

3rd Life 3 a, b, c, d; Investigations 5 b, d, e
4th Life 3 a, b; Investigations 6 a, d
5th Earth 3 a; 4 a, b, c; Investigations 6 b, d, h
6th Earth 2 b; Investigations 7 d, e, f, g, h
7th Genetics 2 c; Evolution 3 a, b, e; Living Systems 5 a, b, c, d, 6 a; Investigations 7 a, c, d, e

Social Studies

3rd 3.1
4th 4.1, 4.4

English Language Arts

3rd Speaking 1.0, 2.0
4th Speaking 1.0, 2.0
5th Speaking 1.0, 2.0
6th Speaking 1.0, 2.0
7th Speaking 1.0, 2.0

Method

Students participate in map and simulation exercises that help them understand the migration of the Chinook salmon.

Materials

- Time to complete: (1) 50-minute class period
- A map of the California river system (or local maps)
- pencils
- crayons and markers
- 35 envelopes
- facial tissue
- ball of blue yarn
- five scents such as garlic, vanilla, lemon, pineapple, maple, peppermint, chocolate or anise
- slips of paper, numbered from 1 to 5 (seven of each number)

Background

Salmon begin life as eggs in the gravel of a stream. They migrate down rivers and spend several years in the ocean. Then, at a certain time, the salmon swim back to their "home" rivers and migrate upstream to their exact birthplaces to spawn.

For many years, the mechanism by which salmon and steelhead found their home stream was a mystery. Scientific research indicates that salmon may use currents as well as an orientation to the earth's magnetic field and celestial (sun) navigation. However, once they enter the rivers, the sense of smell is their guide home. Each stream has its own characteristic scent developed from the vegetation along the stream, the rocks that the stream covers, and the water entering the stream from small streams and springs. This adaptation is important for the salmon to reproduce and survive. Students might give some thought to how well they would find their own homes if they had to rely only on smell.

The purpose of this activity is to demonstrate that organisms exhibit adaptations to the environment in which they live, and that these adaptations maximize the survival of the species.

Procedure

Before class:

Prepare the scent envelopes.

- Make six envelopes for each scent (except peppermint).
- Put two drops of a scent on a tissue and seal it in an envelope.
- Clearly label only one envelope of each scent with a number (1 to 5).
- Make five envelopes with crumpled tissue without scent.

Around the room (or outside) set up your river system (see Diagram 1). Blue yarn will represent the river. Place the unmarked envelopes according to their number. Under the last envelope place a piece of paper with the number.

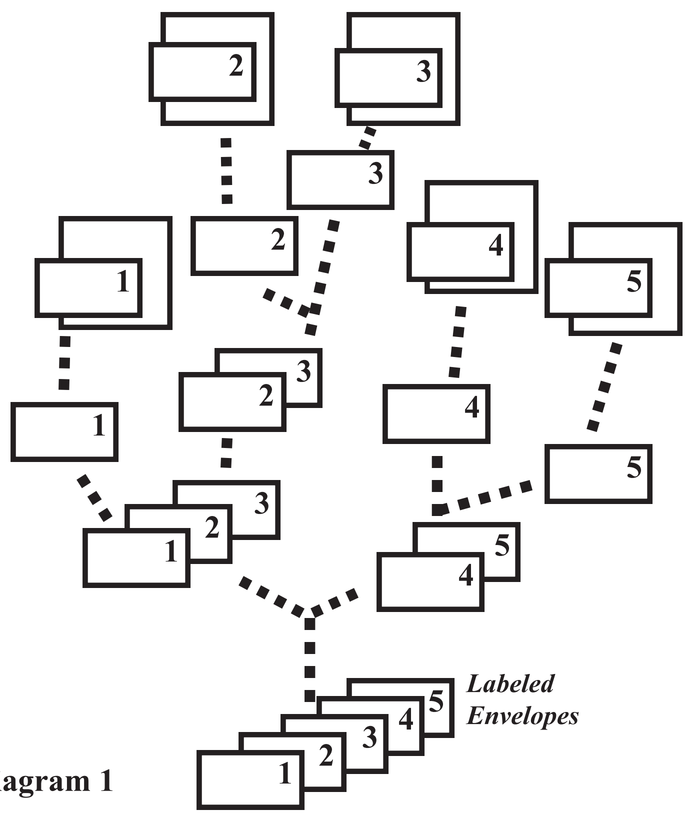


Diagram 1

During class:

1. Discus the sense of smell, and ask students if any odors cause them to remember something special.
2. Review the fish anatomy. How do salmon smell? Salmon use the two comma-shaped holes on either side of their head, below the eyes. Water flows in one hole and out the other over the olfactory receptors, which absorb molecules from water that convey information to the fish about its environment. With these receptors, salmon can detect minute amounts of dissolved substances. A salmon's sense of smell is much more acute than a human's.
3. Briefly review the life cycle of the salmon. This activity covers the return of the salmon to their home stream.
4. Students will have the opportunity to see how they would do at finding their home stream. Pass out the numbered slips of paper. The number represents the student's home stream. Provide each student with the corresponding number envelope; this is the smell of their home stream. As salmon fry, they imprint this scent to use for their return migration. Collect the envelopes for use later.
5. Divide students into groups of four. Provide each group with a map showing the Sacramento Valley water ways and drainage system. (Map included at activity conclusion). Time spent on this activity will simulate the time spent in the ocean.
6. Ask students to trace the route of the Chinook from the ocean to the American River spawning grounds. They need to locate and label the ocean, bays, delta, rivers and dams along the Chinook journey.
7. Discuss the groups' results. What is the class's concensus of the journey?
8. Bring the class to the mouth of your river system. Explain that they are to find their home river by following the smell. Students must remember the scent in their envelope.   After all students have arrived at their spawning grounds, check the numbers. Ask how many were sucessful in their return.
9. If time permits, modify and repeat the scent activity. While students return to their groups and list obstacles from the mapping activity that the salmon encountered on their return trip, rearrange the river system (see Diagram 2). Add peppermint (representing scent pollution) to all number 1 envelopes. Replace number 4 envelopes with the unscented ones (representing a stream without water-drought

or diversion).

10. Have students return to your river system for a second migration. What were the results of this second migration? What did the peppermint represent? What happens when there is a dry stream?
11. Review the students' list of obstacles from the mapping activity. Were any of the obstacles similar to those experienced by the students during their migration activity?
12. Have a class discussion of the following:
    - The scent of each river or stream is unique and continuous throughout the river system
    - Conditions in each stream are different; chances for survival are better in a salmon's home stream
    - Fish that "stray"(return to systems other than their own) can add genetic diversity, allowing a population to have genetic makeup to adapt to changing conditions. However, too many strays can dilute the genetic makeup of the population, making it less adapted to its unique conditions.
13. Ask students what kind of experiments scientists might have used to discover the means by which salmon find their home streams. Scientists captured salmon returning to a hatchery and then released them after blocking their vision or sense of smell. They also released some that had not been altered. Few of the fish whose sense of smell had been blocked returned, while many of the others did.

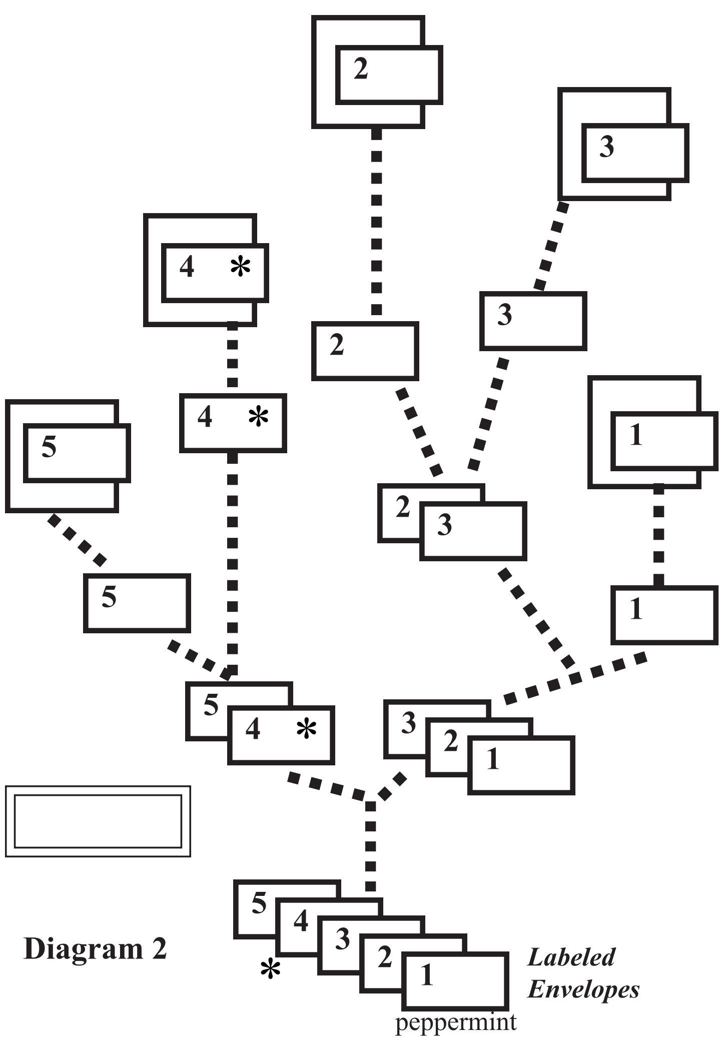


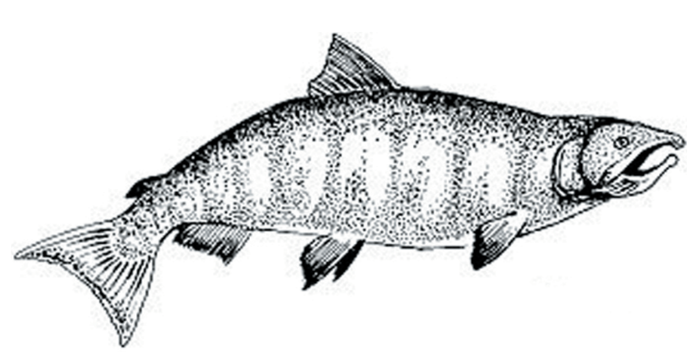
Diagram 2

Extensions

1. Ask students to create either visual images or a piece of creative writing that describes the life of the Chinook.
2. Ask each group to choose another animal that migrates (bald eagle, yellow-rumped warbler, monarch butterfly, elk, etc.) and to develop a class presentation (verbal or visual) describing that migration.
3. Ask each group to choose another species of salmon and investigate its life cycle and migration.

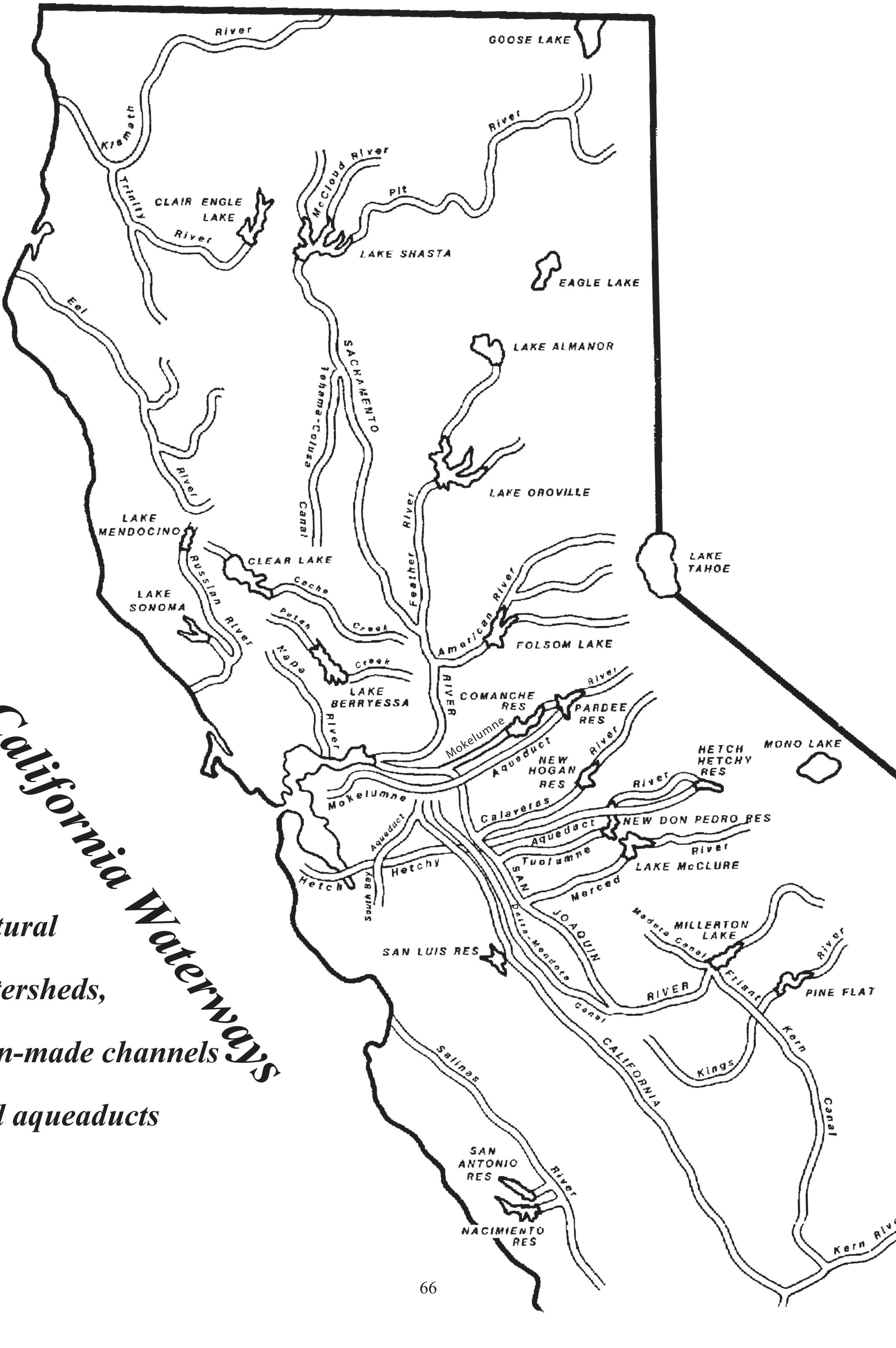
Evaluation

- Participation in the closing discussion can



Activity adapted with permission from *Some Things Fishy, A Teacher's Guide for the Feather River Fish Hatchery,* published by the CA Department of Water Resources, Office of Education.

California Waterways



Natural watersheds, man-made channels and aqueaducts

Watershed Model

Objectives

Students will understand that water flows through a path that connects watersheds, and wherever you are, you are in a watershed. Students will: investigate drainage patterns, observe how watersheds distinguish different land areas, and discover the origin of the water used in their local community.

Curricular Areas

Science skills (observing, predicting, hypothesizing, analyzing), Language Arts, Social Studies

California Content Standards

GRADES 4-8

Science

4th Earth 5 a, b, c; Investigations 6 a, c, d

5th Earth 3 a, b, c, d, e; 4 a, b, c; Investigations 6 a, b, c, g, h

6th Earth 1 f, 2 a, b; Investigations 7 a, b, d, e, f, g, h

7th Earth Life 4 a, c; Investigations 7 a, c, d, e

Social Studies

4th 4.1, 4.4

English Language Arts

4th Speaking 1.0, 2.0

5th Speaking 1.0, 2.0

6th Speaking 1.0, 2.0

7th Speaking 1.0, 2.0

Method

Where does your water come from? Students will build a model watershed and predict where the water will travel across the land.

Materials

- Time to complete: (2) 50-minute class periods. For permanent watershed model, allow at least three days for materials to dry before conducting experiments.
- Transparencies of "Branching Patterns" and "Watershed in Your Hands"
- Blue food color
- Spray bottles, one for each model
- Drawing paper and pencil
- Blue pencils, blue and brown washable markers (one set for each group)
- Tracing paper or blank transparency sheets
- Photocopies of a local map showing rivers ("California Waterways" illustration), one for each student
- Overhead projector

For Model:

NOTE: Allow extra time to make this model. Begin it at least three days before the experiments are to be conducted-the papier-mâché needs to dry overnight, and then the paint needs time to dry completely.

- Five to ten rocks, ranging from 2 to 6 inches (5 to 15 cm) in height.
- If groups of students are making their own models, each group will need its own rocks.
- Square or rectangular aluminum tray, large enough to hold rocks. A large disposable baking or turkey roasting pan will work.
- Plastic wrap (thick plastic wrap from a grocery or butcher shop works best).
- Papier-mâché materials (strips of newspaper dipped in a thick mixture of flour and water)
- Water-resistant sealer and white paint

Background

Wherever you are, you are in a *watershed,* which is the land area from which surface runoff drains into a stream channel, lake, ocean, or other body of water. A watershed is a system. It is the land area from which water, sediment, and dissolved materials drain to a common watercourse or body of water. For each watershed there is a drainage system that conveys rainfall to its outlet. The boundaries of a watershed are determined by the guiding contours of the land surrounding the stream, river, lake or bay.

A watershed is more than just a geological feature. It is a hydrologic system linking all living things within its boundaries. Not only is all plant and animal life dependent upon the water within each watershed, but the watercourses are also conduits that transport water, organisms, nutrients and other materials within the system. What affects one watershed eventually affects other sites downstream.

When the ground is saturated or impermeable to water (when water cannot soak into the ground) during heavy rains or snowmelt, excess water flows over the surface of land as runoff. Eventually this water collects in channels such as streams. The major stream and river that drains a land area provides the name for the watershed. In Sacramento we live in the Sacramento River watershed, the largest watershed in California; it includes the American River watershed, as well as many others. The smaller watersheds drain into the Sacramento River, which carries water from the entire watershed toward the Pacific Ocean.

Ridgelines, or divides, separate watersheds from each other by areas of higher elevations. Near the divide of a watershed, water channels are narrow and can contain fast-moving water. At lower elevations, the slope of the land decreases, causing water to flow more slowly. Eventually, water collects in a wide river that empties into a body of water, such as a lake or ocean.

By investigating drainage patterns, we can better understand how watersheds distinguish different land areas. The pattern water makes as it flows through a watershed is familiar to students who have drawn pictures of trees or studied the nervous system.

From a bird's eye view, drainage patterns in a watershed resemble a network similar to the branching pattern of a tree. Tributaries, similar to twigs and small branches, flow into streams, the main branches of the tree. Like other branching patterns (e.g., road maps, veins in a leaf), the drainage pattern consists of smaller channels merging into larger ones.

Watersheds are either closed or open systems. In closed systems, such as Mono Lake in northeast California, water collects at a low point that lacks an outlet. The only way water is removed is by evaporation or seeping into the ground. Most watersheds are open. That means water collects in smaller drainage basins that overflow into outlet rivers and eventually empty into the sea.

Procedure

Before class:

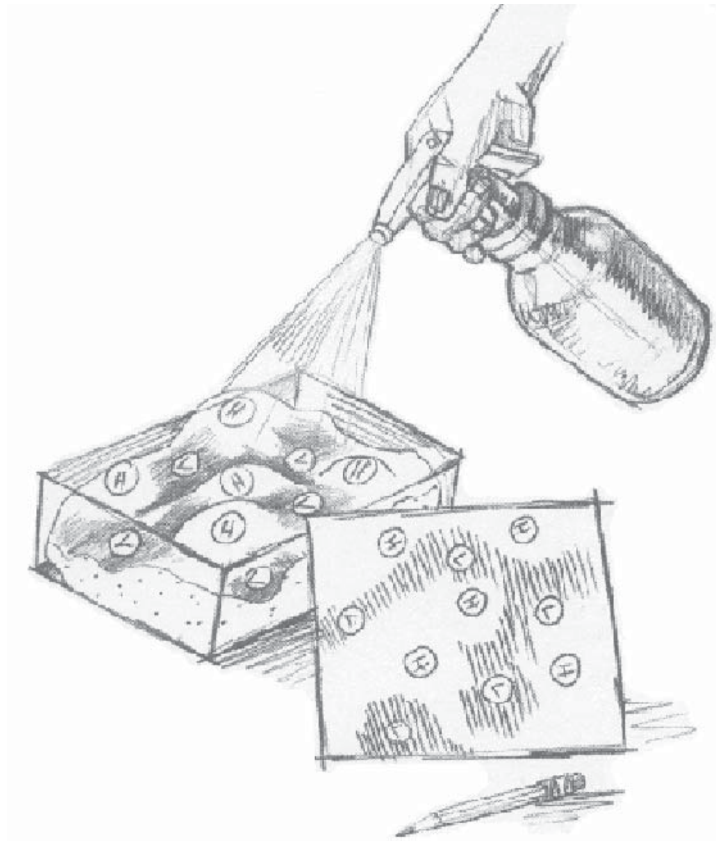
1. Purchase or have students bring in appropriate materials (see list)
2. Photocopy map of the area with rivers and streams. One copy for each student.
3. Photocopy onto overhead transparency "Branching Patterns" sheet.

During class:

1. Ask students what they know about watersheds. Do they live in a watershed? (Trick question: wherever you live, you are in a watershed, even in the middle of a city. The water falls on the asphalt and runs-off into a drainage system.) Assist the students in defining a watershed. Tell them they will build a model that will help them understand how the water flows through the drainage system.
2. The first model will be a very temporary one. It will provide students with a basic understanding and aid in the development of the more permanent model.
3. Group students into small groups of 3-4 students.
   a. Cover table with plastic tablecloth
   b. Provide each group with a brown and blue washable marker and a sheet of paper
   c. Instruct students to crumple the sheet of paper. Place the paper on the table and open so that there are high and low areas. With the markers draw lines on the ridges of the paper (the high areas). Use both colors together.
   d. Now it is going to rain. With the spray bottle, spray water above the paper.
   e. The colored ink will run along the creases of the paper from the highest to the lowest points.
   f. This is how a watershed works. What do the colors represent? Why would the brown color be used?
   g. Have students think about the word "shed." It can mean something that stores things, like a garden shed, or it can mean to let something run off, like an umbrella that sheds water. A watershed does both! Some rain that falls on the watershed runs

off, carving the land into hills and valleys in a slow process called "erosion." As water flows it causes erosion, and small particles of mud, sand, and rock are transported downstream.

4. Show overhead transparency, "Branching Patterns." Is this like the crumpled paper model?
5. Tell students that each small group will make a permanent watershed model and conduct experiments with their model. If possible, make a sample model to show students. Distribute materials to each group.
    a. Instruct students to lay rocks in a square or aluminum tray, with larger rocks near one end.
    b. Snugly cover the rocks and exposed areas of the tray with plastic wrap. Apply strips of papier-mâché to cover the rocks. For a sturdier model, apply several layers of papier-mâché.
    c. When the mâché has dried, coat the model with white paint and waterproof sealant, or waterproof white paint.
6. Once the model is complete, have students sketch a bird's eye view of the model. They should mark points of higher elevations with "H" and low spots with "L" to identify possible ridgelines; connect the "H"s.
7. It is now time for a rainstorm. Where will the water flow and collect in the model? Have them sketch their prediction on their drawings. Indicate the crevices in their models and possible locations of watersheds.
8. Students will spray blue-colored water (food coloring in water) over the model and note where it flows. Water may need to be sprayed for several minutes to cause a continual flow. Assist students in identifying branching patterns as water from smaller channels merges into larger streams.
9. Have students use blue pencil to mark on their drawings the actual branching patterns of water. Some imagination and logic may be required. Ask them to confirm the locations of watersheds by checking where water has collected in the model.
10. Ask students to determine if smaller



watersheds overflow into larger ones. Does all the water in the model eventually drain into one collection site (open watershed system)? Does the model contain several closed water systems (collection sites that lack an outlet)?
11. Have students place tracing paper or an overhead transparency over their drawings and draw the drainage patterns. Groups compare and contrast each other's drawings. Discuss how the networks of smaller channels merge together to become larger.
12. Hand out photocopied maps of local areas with streams, rivers, and lakes. Students locate streams and rivers and draw a circle around land areas they think drain into the river.
13. Students pick one river on the map and follow its path in two directions (upstream and downstream). If the entire river is pictured, one direction should lead to the headwaters or source, and the other direction should merge with another river or empty into a body of water.
14. As a review, use the transparency "Watershed in Your Hands." Have students create a model of the Sacramento River watershed with their hands and identify the features of the watershed.

Extensions

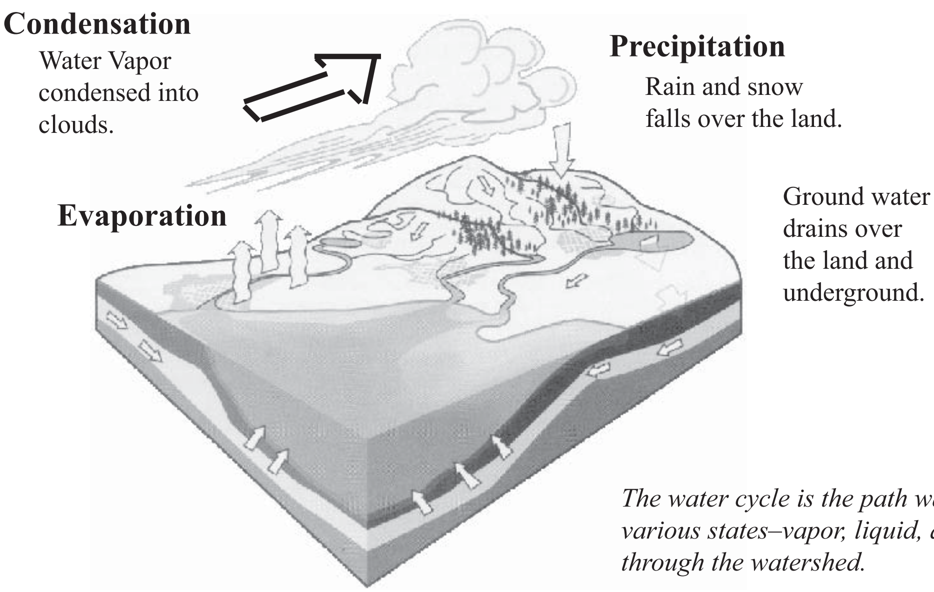
1. If the model was a real land area, would the drainage patterns be the same thousands of years from now? Students should consider

the affects of natural and human-introduced elements (e.g., landslides, floods, erosion, evaporation, water consumption by plants and animals, runoff from agricultural fields, droughts, and dams). Have students write one page describing what the future watershed looks like.

2. Students may finish their models by painting landscapes and constructing scale models of trees, wetlands, and riparian areas. Introduce human influences, such as towns and roads.
3. Students may make a topographic map of their model. First, they totally waterproof the model.

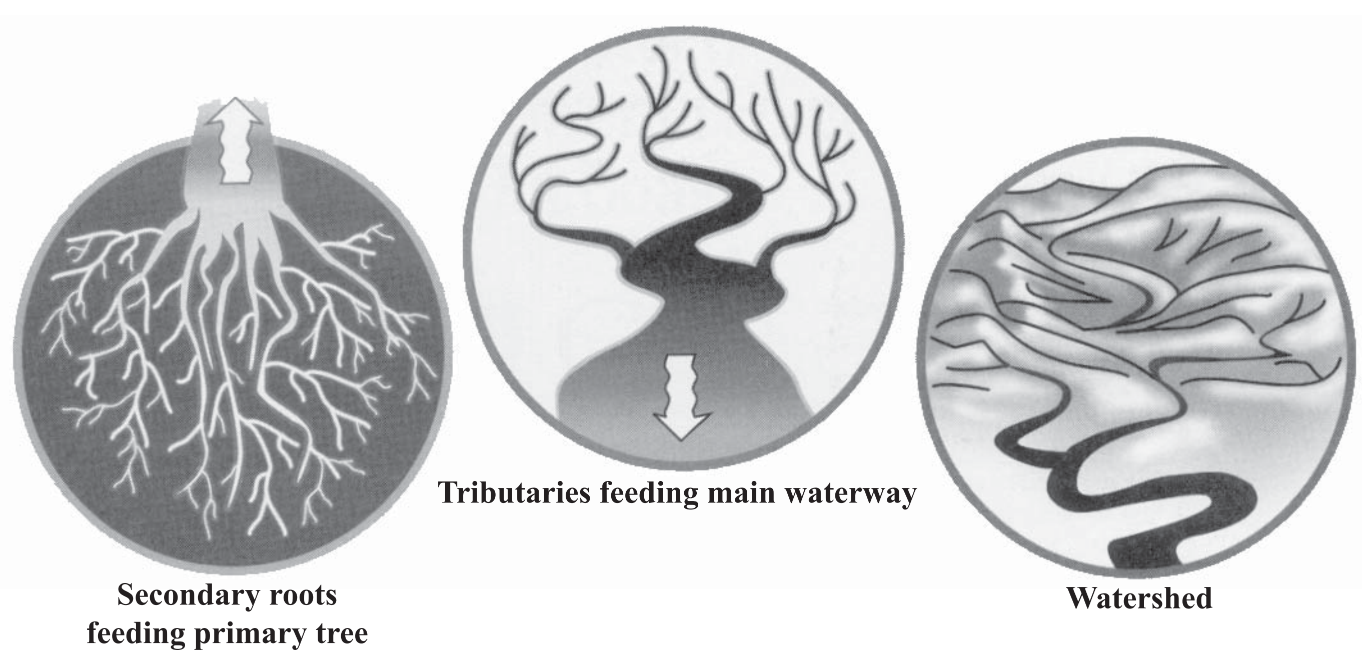
Activity adapted with permission from *Waves, Wetlands and Watersheds*, published by the California Coastal Commission (www.coastforyou.gov) and *Project WET Curriculum and Activity Guide*. For more information about Project WET (Water Education for Teachers), contact the national office at (406) 994-5392, or the California Project WET Water Education Foundation (916) 444-6240, www.watereducation.org.

The Water Cycle

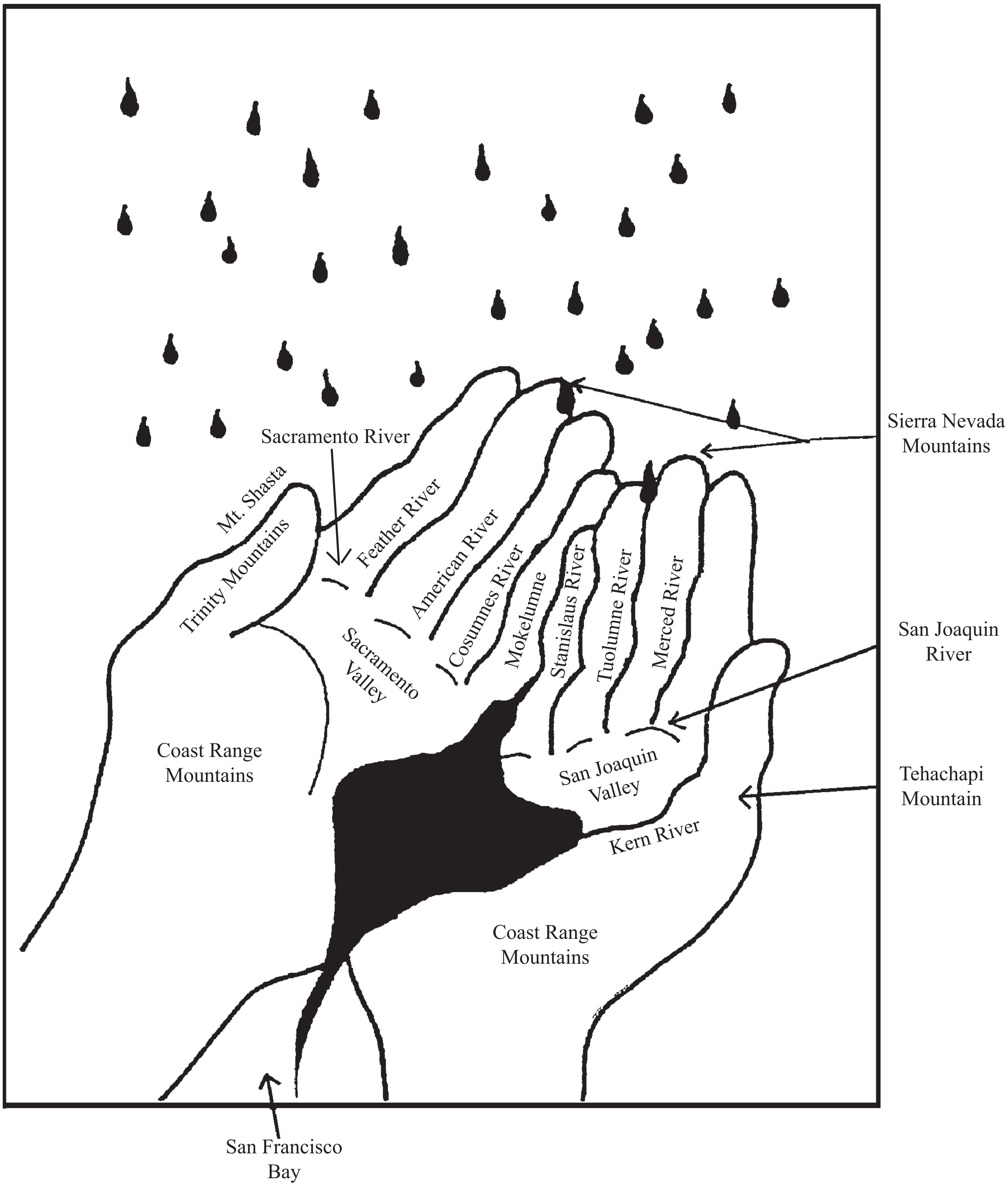


The water cycle is the path water takes through its various states–vapor, liquid, and solid–as it moves through the watershed.

Branching Patterns



Watershed In Your Hands



Activity adapted with permission from the CA State Water Resources Control Board.

Home Wet Home

Objectives
Students will: (1) describe the stream or river components necessary for salmon spawning, (2) relate stream morphology to salmon survival and (3) identify structures in and near streams which benefit salmon.

Curricular Areas
Science, Environmental Science, English Language Arts

California Content Standards
GRADES 4-8
Science
4th Life 2 a, b, c; 3 a, b, c; Earth 5 c; Investigations 6 a, c
5th Physical Science 1 f, g; Life 2 a, f, g
6th Earth 2 a, b; Ecology 5 a, b, c, d, e; Resources 6 a, b, c
7th Earth/Life 4 c; Living Systems 6 a, b, c
8th Motion 1 a; Forces 2 a

Method
Students will assess a stream diagram and describe the components that provide suitable habitat for salmon. Students will explore the importance of riffles and pools by reading a narrative and completing a worksheet analysis.

Materials
- Time to complete: (1) 50-minute class period
- Copies of *Home Wet Home Facts*
- Copies of *Riffles and Pools Worksheet*
- Copies of *The River from Above*

Background
Habitat is the key to survival. The ideal salmon and steelhead environment is a fast-flowing stream with cold, clear, and pollution-free water. The stream or river should meander and offer a variety of depths and rock and gravel size. Streamside vegetation, known as riparian, should include a thick canopy and lush understory.

Water quality is important and can be influenced by streamside habitat, pollutants, and upstream development. Water levels should be stable during the course of the run and after redds (nests for fertilized eggs) are established. Water level in a stream is a critical factor since water temperatures fluctuate with the flow level of the stream. If the stream flow is too low, the water will be warm, and adult salmon may not enter the stream to spawn. Warm water temperatures during egg incubation may mean that eggs hatch before the spring food supply is available and may be more susceptible to fungus. Floods can destroy nests or cover them with silt. Droughts can cause a detrimental warming trend.

Gravel, rocks, and boulders are essential elements for salmon survival. They break up the flow of water and allow oxygen to aerate the water. The fast-moving cold water can carry oxygen to the eggs and keep them clear of silt and waste. Rocks also provide breeding grounds for insects, which serve as food for the young salmon. Hiding spaces between boulders and within white-water areas offer protection for young salmon.

The meandering of a river or stream causes different flow rates within the stream. Therefore, rocks and vegetation are deposited to form pools, riffles, and rapids. Lateral areas along the outside edge of a meander are calmer and provide habitat for young fish and other organisms.

Pools are areas of deeper and slower water. They are important feeding and resting areas for fish. They are generally formed around bends in the stream, root wads, or boulders. Pools have three distinct areas:
1. Head: Turbulent water at the head of the stream provides higher levels of dissolved oxygen and food carried from upstream.
2. Body: Slower water allows the organic materials to settle, decompose, and produce carbon dioxide and other nutrients needed by plants. The drifting organic particles provide food for invertebrates.

3. Tailout: Depending on the gradient, gravel collects with the faster moving water and provides spawning areas for salmon. Stable gravel beds clear of sediment usually are located here. It is crucial that the beds can withstand flooding, which could disturb spawning beds.

Riffles are portions of a stream that are relatively shallow, fast, and steep. They often have bedrock, cobbles, and sometimes boulders. Cobbles and boulders create rapids and cascades. In shallow riffles the sunlight encourages algae to grow on the rocks. The gravel and cobbles provide nooks and crannies for insect larvae to hide and feed. Biologists consider a one-to-one pool to riffle ratio as part of a healthy spawning stream.

Lateral areas along the edges of streams are shallow and quiet. Boulders, root wads, or logs can form small pools or eddies. Fine sediments and gravels are found here.

Accumulations of organic materials provide rich food sources for invertebrates. These areas provide important rearing habitat for young fish. However, predators wait for young salmon in these areas.

Streamside vegetation or riparian habitats provide bank stability, temperature control, and insect habitat that provide a food source. Undercut banks, stable natural debris, and overhanging vegetation provide protection from the sun and predators for young fish. In colder climates, streamside vegetation can keep the water slightly warmer for young fish. Leaf litter assists with the aquatic insect production. Riparian vegetation also protects banks from erosion, thereby limiting the amount of silt that can damage incubating eggs in the spawning stream.

Limiting factors establish the salmon and steelhead carrying capacity of a stream. They must be considered for all phases of a life cycle. When spawning grounds are limited, excessive numbers of adults dislodge previously deposited eggs. Therefore, quantity and quality of riffle areas and spawning gravel in a stream are limiting factors for spawning production. If too many juveniles exist in rearing areas, competition for food and space force juveniles into less suitable areas. Predation, lack of food, and sun exposure may limit these populations. Therefore, quantity and quality of juvenile nursery areas or pools are limiting factors for rearing juvenile salmon and steelhead ready for migration to the ocean.

Salmon and steelhead populations fluctuate from year to year because of varying environmental factors.

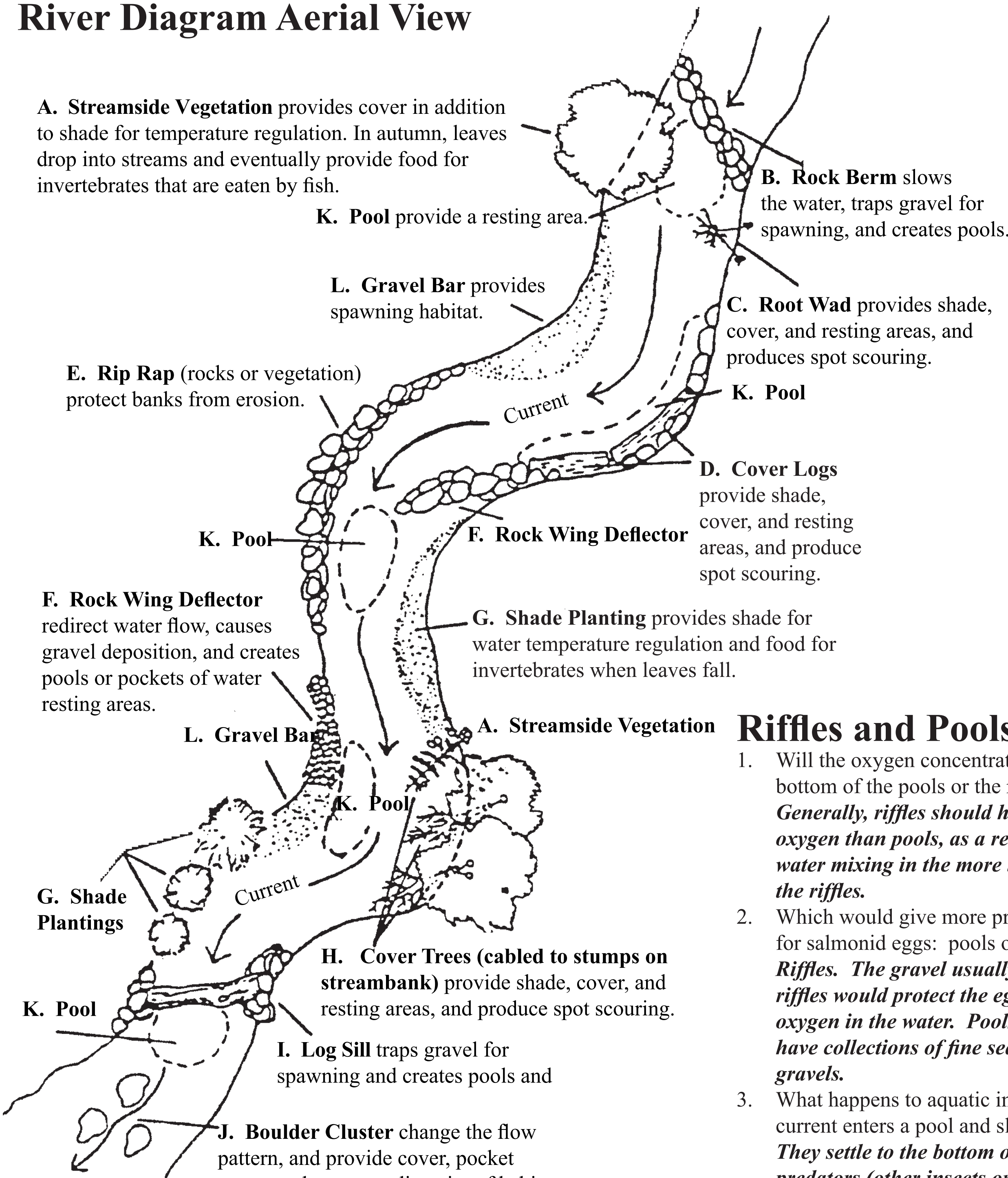
Procedure

1. Ask students to name the four components necessary for a good habitat (food, water, shelter and space). These elements are needed in the proper arrangement to provide for an animal's survival. Where is a salmon's habitat? Does a good salmon habitat involve more than just the water?
2. Have the students read the *Home Wet Home Facts.*
3. Pass out the *The River from Above* and the *Riffles and Pools Worksheet*. (The *Teacher Reference* sheet has the answers to these activities.) Have the students work in pairs to assess the value that each letter, A to J, of the river diagram holds for salmon habitat, and record assessment for class discussion. Complete the *Riffles and Pools Worksheet*.
4. Review and discuss worksheets. Lead students in a discussion of the importance of spawning habitat.
   - How could limited spawning habitat affect the salmon runs in the future?
   - If salmon could not find enough habitat, would salmon in the later part of the run build their redds on top of nests deposited from fish in the earlier part of the run?
   - If water flow is controlled by an upstream dam, how could these flows impact spawning habitat?
   - The vegetation along the river is important to the quality of salmon habitat. How does vegetation relate to water quality?

Activity adapted from *Some Things Fishy*, by the CA Department of Water Resources, Office of Education and *The Fish Hatchery Next Door...* from the Oregon Department of Fish and Wildlife.

Teacher Reference

River Diagram Aerial View



Riffles and Pools Answers

1. Will the 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 protection and oxygen for salmonid eggs: pools or riffles? Why?
   Riffles. The gravel usually found in the riffles would protect the eggs. Riffles help put oxygen in the water. 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 salmonid fry to wait for lunch? Why?
   Fry should wait at the head of a pool or tail of a riffle in order to be first in line for drifting insects.
5. Where would salmonid fry use the most energy catching food? Why?
   Salmon fry would use the most energy on the riffles; it is harder to maintain position in the faster water of a riffle.

Home Wet Home Facts

Salmon and steelhead are important to us; their presence helps indicate the health of the waterway. Biologists refer to salmon as an "indicator or keystone species" because they are one of the first organisms to be affected with habitat change.

What are the habitat needs for salmon and steelhead?

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

Salmon need lots of oxygen to live, and they get all their oxygen from the water. Salmon must have cold water; it has more oxygen than warm water. Shade helps by cooling the water and keeping its oxygen content high. Trees and bushes provide shade for streams and rivers. Also, oxygen is added to water when it flows over fallen trees, rocks, waterfalls and riffles; scientists call this "dissolved oxygen." Riffles are rocky shallows where the water flows swiftly, making little waves and putting more oxygen into the water.

Salmon need to lay their eggs in clean gravel without silt. Silt is soil dissolved in water. Silt can smother salmon eggs or alevin. It clogs the gills of older fish, too, so that they can't breathe. Trees, bushes and grasses help prevent silt because the roots keep the soil in place.

Young salmon eat aquatic insects and larvae. These insects and larvae, in turn, depend on nutrients that seep into the water from organic matter such as leaves, fallen submerged trees, and the decaying carcasses of spawned-out salmon.

Salmon need pools and ponds where they can rest and hide from predators. Trees that fall in streams form pools. Pools may be formed by beaver-created dams. Also, large rocks may be placed in a way that creates pools. Pools are usually areas of slower moving water. Aquatic insects tend to be found in this area because the

Riffles and Pools Worksheet

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

Riffle flowing into pool

Direction of flow

Figure 1

1. In figure 1, will the dissolved oxygen concentration be higher at the bottom of the pools or in the riffles?

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2. In Figure 1, would pools or riffles provide more protection and oxygen for salmon eggs? Why?

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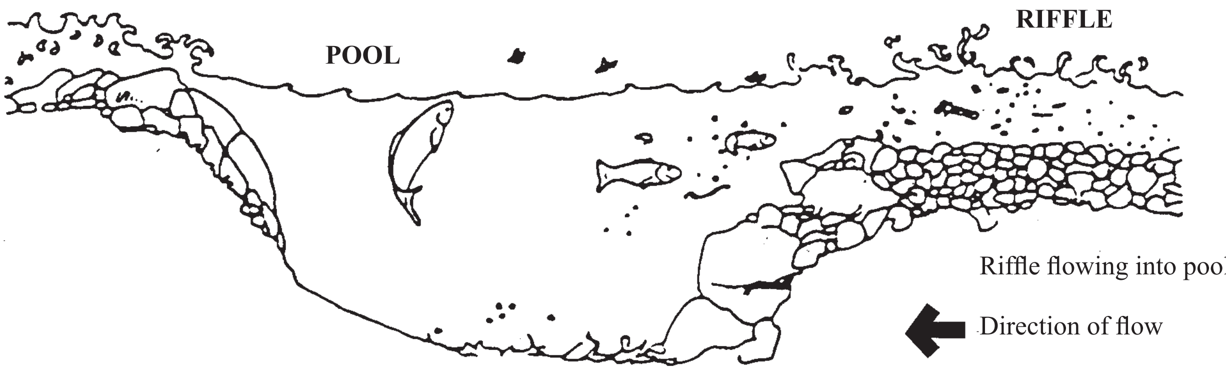


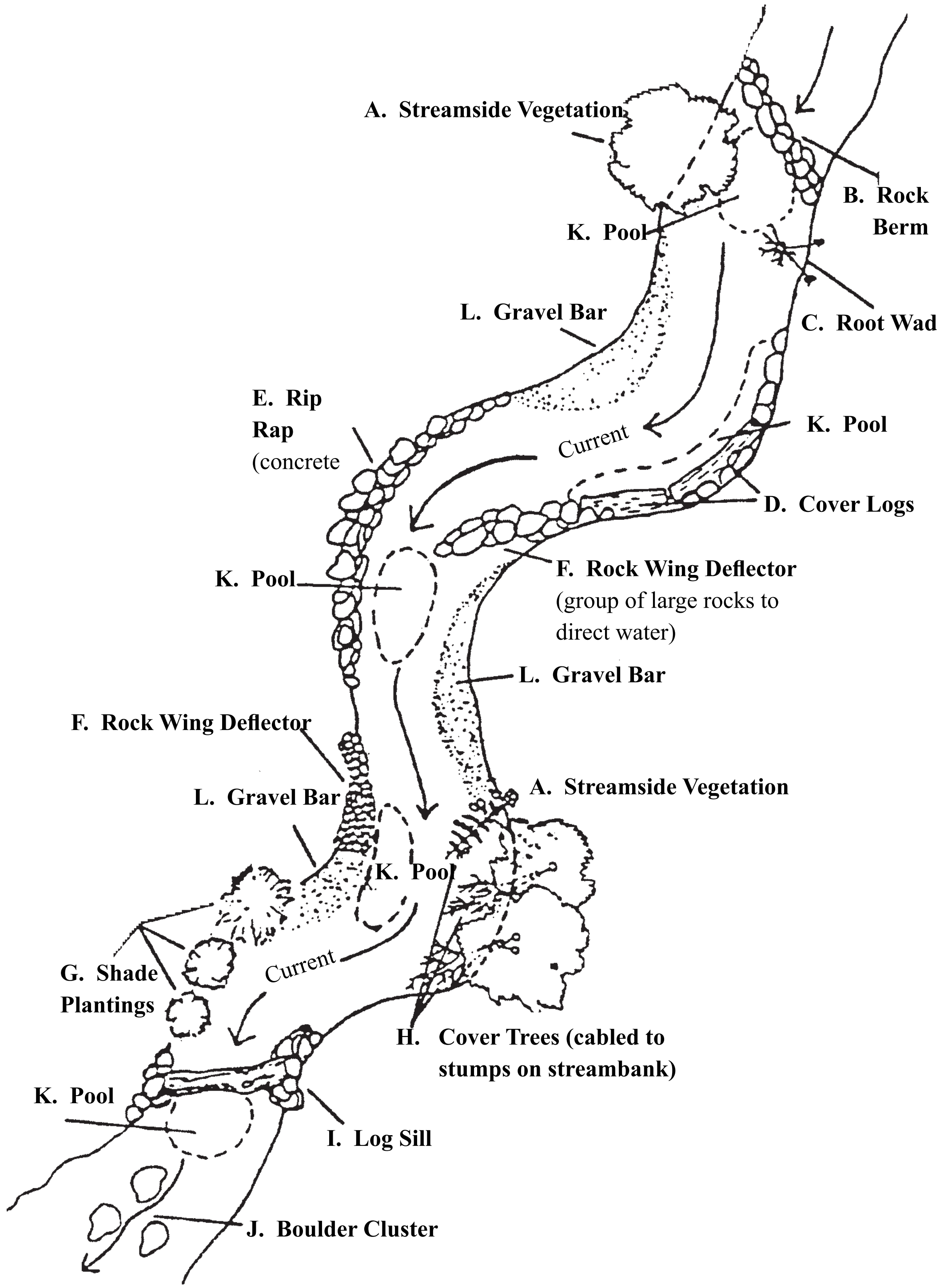
Figure 2

3. In Figure 2, what happens to aquatic insect larvae as the current enters a pool and slows down?

4. In Figure 2, where would salmon fry have the best chance of finding lunch? Why?

5. In Figure 2, where would salmon fry use the most energy catching food? Why?

The River from Above



Erosion: Water + Soil = Impact

Objectives
Students will (1) describe the process of erosion, (2) how sand, silt, or both affect water flow; and (3) identify how vegetation and human activities can affect sand, silt, or both in surface water.

Curricular Areas
Science, English Language Arts, and Social Studies

Method
Students create a model to simulate the affects of erosion in a stream. Students will add sand, silt and a combination of both to the system and note the results. Students will test the use of vegetation to help prevent erosion.

California Content Standards
GRADES 3-8

Science

3rd Life 3 c, d, e; Investigations 5 b, d, e
4th Life 3 b, c; Earth 5 a, b, c; Investigations 6 a, c, d
5th Earth Science 3 e; Investigations 6 h
6th Earth 2 a, b
7th Earth/Life 4 c; Investigations 7 c, e
8th Motion 1 a; Investigations 9 a

Social Studies

3rd 3.1
4th 4.1

English Language Arts

3rd Speaking 1.0
4th Speaking 1.0; 2.0
5th Writing 2.0; Speaking 1.0, 2.0
6th Writing 2.0; Speaking 2.0
7th Writing 2.0, Speaking 2.0

Materials
- Time to complete: (1) 50-minute class period

For each group of four students:
- Clear plastic 1-gallon container such as a storage box
- Pea-sized gravel to cover the bottom of the container
- Water (fill container to 1 inch from the top)
- 1 cup coarse sand
- 1 cup silt (silica powder, or fine dirt, from stream-edge)
- three straws per person
- brightly colored beads (pea-sized or larger)
- plastic tablecloth
- paper towels

For class observation experiment:
- 2 aluminum roasting pans, 3 inches deep
- soil for each container
- lawn sod or turf for one container
- 2 plastic tablecloths
- spray bottle or watering can
- 2 clear plastic containers to catch runoff water
- wooden blocks to elevate one end of aluminum pan
- scissors to cut drain in aluminum pan

Background
One material moving through the watershed is soil. Sediments (soil) enter water in two main forms:
1. Surface erosion sheds small amounts of particles into the water.
2. Mass erosion (e.g., landslides) dumps huge amounts of dirt into water.

Causes of surface erosion vary. They can include anglers walking trails to favorite fishing spots, or cattle trampling and consuming streamside vegetation that holds soil in place. Logging, mining, and road construction can also contribute to surface erosion. Mass erosion, such as mudslides or earth slumps, occurs more frequently on hillsides altered by human activity, such as clear-cut logging, road construction, or home building.

Soil being carried by water is a natural ongoing process. Erosion has occurred since water appeared on the planet. However, sedimentation may affect aquatic wildlife by altering nutrients, diminishing sunlight to plants, and altering stream energy and velocity. One important effect of sedimentation is to block the flow of water to organisms residing in bottom substrates. The flow of clean water is important in most aquatic environments because flowing water often carries dissolved oxygen that aquatic animals need for respiration. Depletion of oxygen in bodies of water affects organisms even at early stages of development. For instance, salmon lay their eggs in gravel that receives a flow of clean water, either from a stream or river, or from spring water percolating up from the lake bottom. As the water flows over the eggs, it delivers dissolved oxygen to them. If the eggs do not receive enough oxygen, they die. Silt and sand enter streams through erosion. Silt and sand act like concrete to block water movement, and thus diminish the amount of oxygen reaching the developing eggs. Once the erosion-causing activity is stopped, streams may cleanse themselves. (Depending on the extent of the problem, self-cleansing can take from 1 to 20 years.)

The major purpose of this activity is to show that aquatic wildlife and its habitat can be influenced by land-based activities in the surrounding watershed.

Procedure

Before class:

1. Set up a container with gravel and a small handful of colored beads covered by water as an example for students. Post a large sheet of paper on the wall for groups to record their results. A sample observation chart is at the conclusion of the activity.
2. For the second experiment, prepare two aluminum pans. Cut a drain into one side of each pan (see diagram). Bend the cut aluminum to form the drain. Fill pans; in one put a shallow layer of soil topped with lawn sod or turf. The second pan should have only soil (pack down the soil so that it is as firm as possible).

During class

1. Ask students if they can define erosion. When the rain falls and washes down the hills into the valleys, what happens to the soil? Where does this soil go? What happens when this soil goes into a river? Explain that the students will conduct an experiment and make inferences about the affect that sediment may have on the life in river.
2. Ask the students why oxygen is important to aquatic animals. How does a fish breathe? How does the oxygen get into the water? (You may review the riffles and pool information.) Remind students that increased turbidity due to sediment can interfere with sunlight transmission, fish respiration and plant photosynthesis.
3. Place students into groups of three or four. Ask each group to gather the supplies and set up its demonstration. Explain the three parts of the procedure (Steps 4, 5, and 6 below), and ask students to predict what will happen as each sediment type is added to the water.
4. Each person in the group should simultaneously blow bubbles into the water with a straw. Make sure the straw is at or near the bottom of the container so that the end is pushed into the layer of gravel. Have each group discuss the ease or difficulty in blowing bubbles and record the observations on the sheet on the wall. Remind students that the blowing of bubbles is meant to demonstrate how water moves in different situations.
5. Instruct the groups to add 1 cup of sand to the water and then to blow bubbles again. Be sure that the straw is pushed through the sand so that it reaches the gravel. The group then discusses the difficulty level and records its observations on the master sheet on the wall.
6. Now add 1 cup of silt to the water, allowing it to settle, and push the end of the straw into the layer of gravel and blow bubbles again. The group then discusses the difficulty level and records its observations on the master sheet on the wall.
7. Conduct a class discussion about the demonstration and results, and describe what these results might mean to aquatic organisms and their need for clean water. What happened to the colored beads? What if the beads were salmon eggs? Will the sediment affect the survival of the eggs? How do sand and silt get into the water? Which of these sources are human and which are natural? What can happen to fish and other

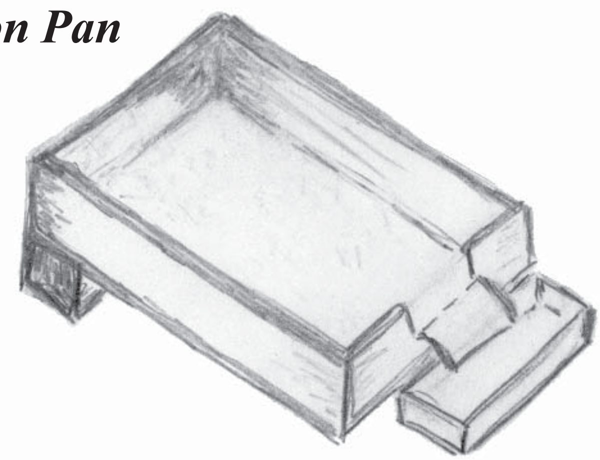
aquatic organisms if too much sediment gets into aquatic systems?

8. Is there someway to prevent sediment from entering the waterways? Have students brainstorm things that might reduce siltation. Would vegetation growing along riverbanks help? Explain that the next simple experiment will demonstrate the effect of vegetation on erosion.
9. Set up the class observation experiment. Place the pans on a plastic covered table and elevate the end opposite the drain. Below the pan drain place a clear plastic pan or jar to collect the water runoff. *Suggestion:* place a plastic sheet on the floor.
10. Now create a rainstorm. Use a spray bottle or watering can to simulate rain. Look at the water in each container. Is there a difference? What made the difference? Have students make inferences concerning vegetation and riparian areas. Is there something that can help minimize erosion when human activity disturbs the natural landscape?
11. Conclude the lesson by asking students to summarize facts they learned from both activities. Key points include:
    - gradual erosion is a part of natural dynamics,
    - human activities can accelerate the process,
    - excessive silt can have an impact upon plants and animals, and
    - vegetation can help minimize the erosion process.

Extension

1. Research and discuss ways to minimize the addition of sand or silt into natural aquatic systems.
2. Explore how people living in an urban area might help minimize siltation with water conservation.
3. Develop a plan for a riparian restoration

Erosion Pan



- Cut a 3” pan 1.5” to 2” deep and 3” to 4” wide.
- Bend the cut portion to form a drain to guide water into catch pan.
- Elevate the pan to facilitate the water run off.
- Collect runoff in a clear plastic container.

Erosion Observation Chart

Difficulty Levels	Group 1	Group 2	Group 3	Group 4
Clean Water				
Easy to blow				
Less easy to blow				
Hard to blow				
Sand in Water				
Easy to blow				
Less easy to blow				
Hard to blow				
Sand & Silt in Water				
Easy to blow				
Less easy to blow				
Hard to blow				

Stream Planning

Objectives
Students will: (1) identify human activities that negatively effect riparian ecosystems, (2) describe how the impacts of human activities could be minimized or eliminated and (3) describe a direct role that they could play in reducing human impacts.

Curricular Areas
Science, English, Language Arts, Social Studies, Art

California Content Standards
Grades 4-8

Science

3rd Life 3 a, b, c, d, e

4th Life 2 a, b, c; 3 a, b, c; Investigations 6 c

5th Earth 3 a, b, c, d, e; 4 a; Investigations 6 h

6th Earth 2 a, b; Ecology 5 b, c, d, e; Resources 6 b, c; Investigations 7 a, b

Social Studies

3rd 3.1

4th 4.1, 4.4, 4.5

English Language Arts

3rd Write 1.0; Listen/Speaking 1.0

4th Write 1.0; Listen/Speaking 1.0

5th Write 1.0; Listen/Speaking 1.0

6th Write 1.0; Listen/Speaking 1.0

7th Write 1.0; Listen/Speaking 1.0

Method
Students will become land developers and develop a section of land adjacent to a river. After the development is complete, students will observe the effect of the development process and explore possible solutions.

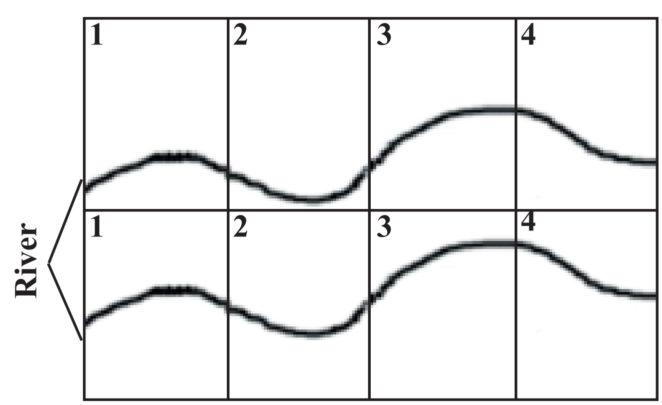
Materials
- Time to complete: (1) 50-minute class period
- 24 to 32 feet of white butcher paper
- Crayons or colored markers
- Copy of "Water We Going to Do" activity sheet, one per group

Background
When humans choose to live and conduct any activity near a river, they affect the ecosystem. Habitat disruption, polluted storm water runoff, water diversion, and riverbed alteration and siltation are among the possible consequences. Impacts to streams occur when the streamside is changed or the land within a watershed is modified.

The quality of water in a stream is a reflection of land uses and natural factors found in its watershed. If soil near a river naturally erodes, chances are the river has sediment and turbidity problems. If the land has stable vegetative cover, erosion is kept in check. When humans develop the land, they often break the sod, cut the forest, build cities, engage in mining, and many other activities that impact the watershed and water quality. Everyone bears responsibility for the health of a watershed and the waterway. Individual actions, both negative and positive, add up. Understanding a river's water quality and quantity involves observing the condition of the complete watershed.

Procedure
Before class:

Using blue markers, watercolor or tempera, draw and color a river on butcher paper (see illustration). River bank lines should be about 12 inches apart. Make a grid, divide the river in half lengthwise and divide widthwise so that each student will have a waterfront and land section. Number the sections on one side of the river in sequential order, placing



numbers in upper left-hand corners and repeat for the other side. Cut out the sections.

Part I

1. Inform students that they have been given a section of property along a river and one million dollars. They may develop their land any way they wish. Give each student a section of river. Explain that the blue is water and the blank space is the land they own. They can farm or ranch, build a resort, a housing development, a factory, or parks, plant a forest, or do mining – whatever they like.
2. Have the students draw their plans for their property. When drawings are complete have students look at the number on their section. Explain that each piece is actually a part of a puzzle. Starting with number one, have students assemble their pieces. To assemble the stream, pathway, and adjacent land area in proper order, the *ones* should face each other with the *twos* next to them and so forth. Post the sections on a wall (or walls, depending on the length of your river and your room).
3. Have students share their plans.

Part II

4. Up until now, the students have not been given any specific information about the river. Now, go back and give them some details. Draw in or label some natural features such as salmon spawning gravel beds, shallow water nursery areas for salmon fry, marshy habitat for waterfowl, a stand of trees for nesting herons, and so forth. To make the discussion more meaningful, place the natural features in a vulnerable place according to the students' plans for development. For example, place salmon spawning areas in a place that potentially would receive siltation from human activities or that people would be likely to stand on (for example, fishing or swimming areas). The heron nesting trees may be placed in an area with lots of human activity.
5. Now that the students know more about the river they have developed, ask them to identify all the potential problems that they can think of for the ecosystem. Divide the class into groups of three or four students. Provide each group with a copy of the "Water We Going to Do" student activity sheet. Have each group record all of the potential problems they can think of for the entire river corridor. Once the problems are recorded from the group, record possible solutions for each problem. Can some problems be solved completely or can they only be minimized?
6. Have the groups share their ideas. Make a class chart of problems and solutions.
7. Have students think of all the ways that they themselves could be part of the solution. What can they do to help solve or minimize each of the problems? Students working in their groups will complete the "Me" section. Have the groups share their ideas with the class.
   a. Which problems were easiest to solve? Which problems would take more effort?
   b. How would the students' plans for development have changed if they knew more about the river before they developed it? Who needs to be educated about river ecology? How might this occur? (Scientific studies, laws and regulations, public awareness, and volunteer efforts)
   c. Is there a river nearby that might have some of the problems the students identified? What can each student do to solve or minimize those problems? Are there any projects the students would like to work on to educate other people about how they can help?
   d. What is the significance of the statement, "everyone lives downstream?"

Extensions

Design a community that uses their best management practices and allows for minimum contributions of pollutants.

Evaluation

- Describe the effects that large quantities of the following things might have on an aquatic

Activity adapted with permission from *Some Things Fishy, A Teacher's Guide for the Feather River Fish Hatchery,* published by the CA Department of Water Resources, Office of Education.

Water We Going to Do?

Problem	Solution	Me

Aquatic Ecosystems

Objectives
Students will: (1) identify components of the ecosystem, (2) describe connections between elements of the ecosystem, (3) discuss hypothetical changes in the ecosystem and the effect of the change, (4) identify how energy flows through the aquatic ecosystem.

Curricular Areas
Science and Language Arts

California Content Standards
Grades 2-5

Science

2nd Life 2 c; Earth 3 c, e; Investigations 4 a, d
3rd Life 3 a, b, c, d; Investigations 5 b
4th Life 2 a, b, c; 3 a, b, c, d; Investigations 6 a, c, d
5th Earth Science 3 a, b, c, d, e
6th Earth Science 4 a; Ecology 5 a, b, c, d, e; Resources; 6 a, b, c; Investigations 7 a, d, e, h
7th Evolution 3 a, d, e

Social Sciences

2nd 2.4
3rd 3.1
4th 4.1, 4.5

English Language Arts

2nd Speaking 1.0
3rd Speaking 1.0
4th Speaking 1.0
5th Speaking 1.0
6th Speaking 1.0
7th Speaking 1.0

Method
Using a web activity, students will become a part of an aquatic ecosystem. They will explore the myriad of interactions within it and ultimately make hypothetical changes to test the idea of interdependence.

Materials
- Time to complete: (1) 50-minute class period
- 300 to 500 feet of twine or string
- Copy and cut apart the "Aquatic Ecosystem Cards." If possible, print the "guess who" answer on the backside of the card.

Background
Plants produce food (stored energy) from inorganic elements and are combined into a group called "producers." Plants use sunlight to provide energy for the chemical process, called photosynthesis, that takes place within their cells. The raw materials for this process are carbon dioxide and water. The oxygen that is produced is a waste product. The food energy they produce is stored in themselves.

The producers form the base or bottom of the food chain or food web. Animals that eat the producers or other animals are called "consumers." Consumers that eat only plants are called herbivores (from the Latin root meaning "grass-eating"). Animals that eat other animals are called carnivores (from Latin for "meat-eating"). Some animals eat both plants and animals and are called omnivores (Latin for "all"). The general term "predator" applies to an animal that eats another animal. The word "prey" refers to the animal that is eaten. A given animal might be a predator on one species and the prey for another.

At each stage of the food web there is a transfer of food energy, which is used for many different things. It may be used for growth, reproduction, waste, respiration, and some is stored as fat or oil. Consequently, each level of the food web above the level of the producer has less available food than the level below it.

Procedure
1. Read John Muir's quote: "When you try to change a single thing, you find it hitched to everything else in the universe."
2. Ask students to share their ideas about what Muir meant. Do the students agree?
3. Explain that in this activity, each student will become a part of a system that includes plants, people, animals, and their environment (an ecosystem).
4. Have students sit in a circle. Pass out the "Aquatic Ecosystem Cards" and ask them to hold them so that everyone in the circle can see them.
5. Stand in the center of the circle with the twine or string. Starting with the sun, have each student read the information on the card (a copy of the script is included if teacher or other strong reader needs to assist). Each student's part will end with a question for the class to discuss and answer. The

answer chosen will determine which student will read their information next. The student reading the information is responsible for making sure the class answers correctly (answer should be printed on the back of the card).

6. Make the web with the string, and follow the path of the students reading and answering questions. The reader holds on to the string as it is passed to the next reader. Continue to unwind the string until everyone is holding onto the string. The teacher may need to aid in the passing.
7. Once the web is complete, discuss the following questions (keep the web intact).

Questions:

1. Are components of this ecosystem connected?
2. Does the pattern created by the string remind you of something? (Connections in an ecosystem are complex, more like strands in a spider web than the links of a chain.)
3. What if? Questions:
   a) As plants and animals die in the ocean, they sink to deeper depths where they decompose and create nutrient-rich water. Winds blowing surface water away from the shore allow the colder, nutrient-rich water to rise from below. This cold-water upwelling brings important nutrients to the surface, causing plankton "blooms" or population increases. However, sometimes warm-water currents (e.g. El Niño) interfere with this cold-water upwelling. This means that nutrient-rich water is not available to the plankton. Let's say that our ecosystem is experiencing El Niño conditions. What will happen to our plankton? Who depends on plankton for food? (answer: krill) Who depends on krill for food? (answer: adult salmon in the ocean) If there is less food available for adult salmon in the ocean, all the life stages of the salmon will be affected. Raise your hand if you represent salmon at any stage. Just those people give two short, gentle tugs on the twine. Who felt it? How would you have been affected by the change in salmon?
   b) California often experiences times of lower rainfall. In these times of drought, there is less water available to an ecosystem. Let's say that our ecosystem is experiencing a drought. Raise your hand if you represent water in some form. Just those people give two short, gentle tugs on the twine. Who felt it? Is there anyone who was somehow not affected by the drought?
   c) Let's take a look at our policymakers. What would happen if they decided not to put any limits on when and how many salmon could be caught? What might happen to the number of salmon in the ocean? Remember, if there are fewer adult salmon, then there are fewer salmon at every life stage, so anyone who represents salmon gives two tugs on the twine. Who feels the effect? How?
   d) Now let's say that way up in the mountains, a forest is improperly logged. When the rains come, much soil and debris are washed into the stream. This sediment in the water eventually settles on the river bottom. If it settles on salmon or steelhead eggs, how would they be affected? How would this affect other parts of the ecosystem?
4. (Start rolling up the twine at this point or have the class put it down.) Does John Muir's quote apply to this ecosystem?
5. Are people a part of the ecosystem?
6. What negative effects could people have on the system?
7. How could negative effects be minimized?
8. What positive effects could people have?
9. Were all of the changes that we discussed caused by humans? Which ones were not? Can you think of other changes that might be caused by nature?

Evaluation

- Describe at least three connections between elements of that ecosystem.
- Describe a hypothetical change that could occur in the ecosystem and explain its effect.
- Discuss the roles that humans can play in that ecosystem.
- Describe how energy flows through an aquatic ecosystem and give an example.

Activity reprinted with permission from *Some Things Fishy, A Teacher's Guide for the Feather River Fish Hatchery,* published by the CA Department of Water Resources, Office of Education.

Master Script

I am the **sun**. Plants use my energy to make food, even simple water plants like...Guess who?

I am **algae**. In the water, I grow on the bottom, rocks, and other things, or float, depending on my kind. When I make food from the sun's energy, I use some to stay alive, but some is stored. I am eaten by tiny water animals called...Guess who?

I am a **water flea**. I use some of the energy I get from plants, such as algae, to live, but some I store. I am a source of food, and therefore energy for this small fish...Guess who?

I am a **perch**. I use the energy I get from eating water fleas and insects to swim and stay alive, but I store some of the energy in my muscles, body fat, and other body parts. When small, I am food and an energy source for this amphibian... Guess who?

I am a **bullfrog**. The energy I get from eating fish and other animals helps me to stay away from predators who might try to eat me for energy, such as this reptile...Guess who?

I am a **garter snake**. Although I am a predator, I am also prey. I could easily become food energy for this long-legged wading bird...Guess who?

I am a **great blue heron**. I feed along the edges of waterways by day, but at night I like to roost high up in a...Guess what?

I am a **cottonwood tree**. I am only found in areas where my roots can always get water. That is why I am so common along these waterways...Guess where?

I am a **river**. Water that flows along my path can be traced from high in the mountains all the way to the ocean. I am a highway for these fish that swim upriver to spawn (reproduce)...Guess who?

I am a **spawning salmon**. When I am an adult, I swim upriver until I reach a place to spawn. Female salmon spawn by laying eggs. Male salmon spawn by fertilizing the eggs so that they can become fish. Spawning is the end of my life cycle. Not long after I spawn, I become a...Guess what?

I am a **dead salmon**. When I swam upstream to spawn, I stopped eating and put all of my energy into reproducing. The condition of my body gradually worsened until I died. I still play a very important role. My decomposition adds nutrients to the stream. I become food for lots of plants and animals, such as this relative of a crab...Guess who?

I am a **crawdad**. I look like a small lobster and also feed on small fish, snails, and insects. I am food for this playful aquatic mammal...Guess what?

I am a **river otter.** I rely on crawdads as one source of food. One of the requirements for my habitat is that I have plenty of this...Guess what?

I am **unpolluted river water.** I carry lots of nutrients to plants and animals that live in and around me. I also have molecules of this gas dissolved in me...Guess what?

I am **oxygen**. Fish use their gills to take me out of the water, but I am also absorbed by these small, round living things that will eventually become a fish...Guess what?

I am **salmon eggs**. As my parents traveled upstream, they were followed by a fish that eats me for energy. Part of its name even sounds like an animal that would steal eggs...Guess who?

I am a **steelhead**. I am a rainbow trout and I spend part of my life in the ocean. I am a very popular sport fish for these humans who try to catch me for recreation...Guess who?

I am an **angler**. Some people call me a fisherman, but since women like to fish too, the word angler includes everybody. I make sure that I am a good sport by following special rules designed to protect the fish. Also, if I am over sixteen years old, I have to buy one of these permits that allow me to fish...Guess what?

I am a **fishing license**. Some of the money anglers pay for me is used to improve the places where fish spawn. One form of improvement of restoration involves adding these small rocks to a river or stream... Guess what?

I am **gravel**. Spawning salmon and steelhead look for a gravel bed in just the right place. Their eggs will have a safe place to develop until they hatch and become...Guess what?

I am **salmon or steelhead fry.** In two to five years, I will return to this gravel to spawn. If there is not enough spawning area in my home river, sometimes I develop in these human-made fish nurseries...Guess what?

I am a **fish hatchery**. I am often built along a river because one of these human-built structures blocks fish from traveling upstream to their former spawning beds...Guess what?

I am a **dam**. I was built to collect and store water for all kinds of uses. One group of people use the water stored behind me to grow their crops...Guess who?

I am a **farmer.** Although I depend on water from dams, the original source of that water is something I really depend on... Guess what?

I am **rain and snow**. I come from clouds that form as water evaporates from the earth. My biggest source of moisture is this huge body of water...Guess what?

I am the **ocean**. I am home to thousands of kinds of plants and animals. Some animals, such as salmon and steelhead, spend only part of their life living and feeding in my waters. In fact, this is where many adult salmon are caught by these people who make their living from fishing...Guess who?

I work in the **commercial fishing industry**. A group of people decide how long I can fish each year and how many fish I am allowed to catch...Guess who?

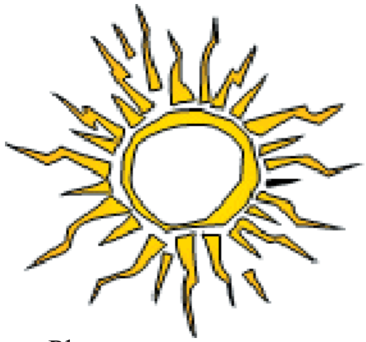
I am a **policymaker**. I consult with biologists when I write fishing regulations. The number of this large fish left in the ocean is affected by my decisions...Guess who?

I am an **adult salmon.** Policymakers' decisions do have an effect on our population size, but so does the amount of food available to us in the ocean. One of our major sources of food is this shrimp-like animal...Guess who?

I am **krill**. Although only about an inch long, I am the food for many ocean animals including many whales. My food is the soup of the sea...Guess who?

I am **plankton**. Animal plankton is called zooplankton, and plant plankton is called phytoplankton. Like other plants, phytoplankton depends on this energy source to make its own food...Guess who?

The **sun**. The END (and the BEGINNING).



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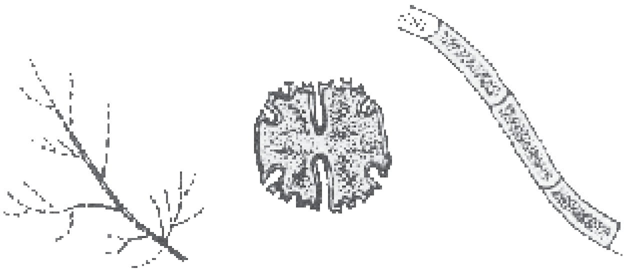

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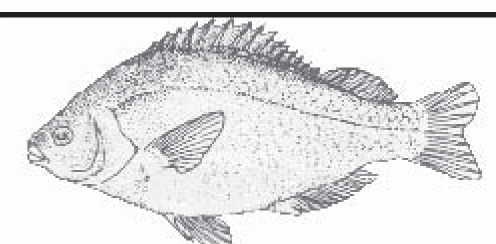
USFWS, TimothyKnepp



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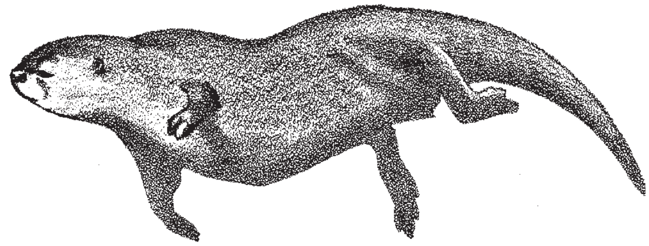
<td>
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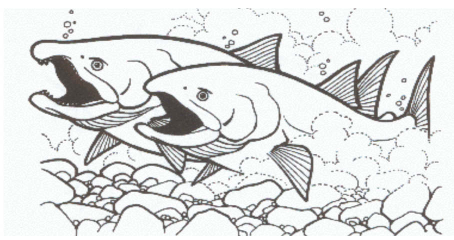
<td>
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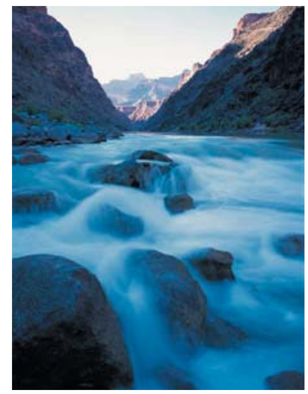</td>
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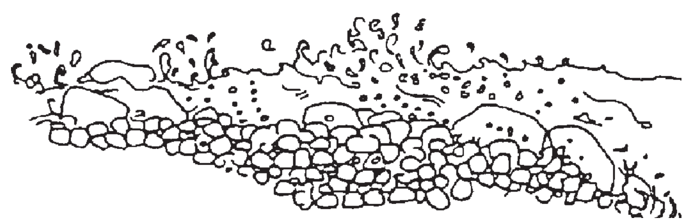
<td>
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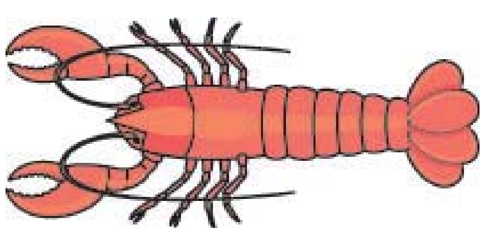
<td>
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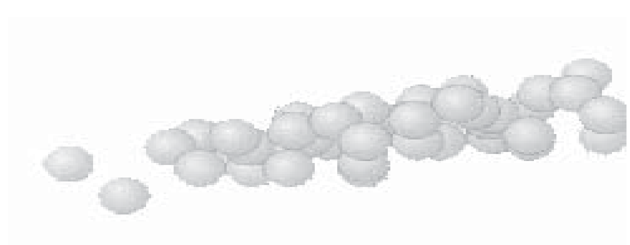
<td>
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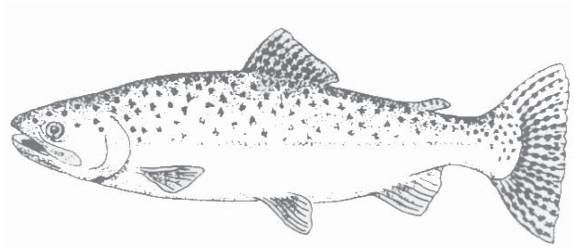

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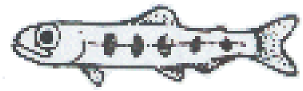

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USFWS, Paul Kerris

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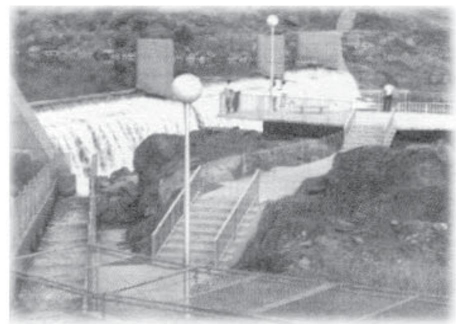

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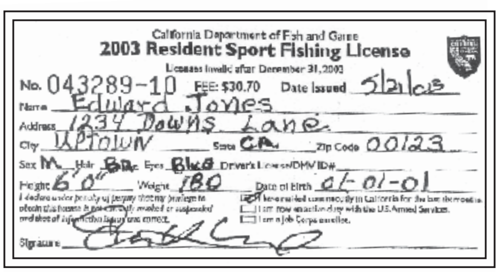

California Department of Fish and Game
2003 Resident Sport Fishing License
License invalid after December 31, 2003
No. 043289-10 FEE: $30.70 Date Issued 5/21/03
Name Edward Jones
Address 1234 Downs Lane
City Uptown State CA Zip Code 00123
Sex M Hair Br Eyes Blk Driver's License/DMV ID#
Height 6'0" Weight 180 Date of Birth 01-01-01
I am now on active duty with the U.S. Armed Services.
I am a Job Corps enrollee.
Signature

I am a **fishing license**. Some of the money anglers pay for me is used to improve the places where fish spawn. One form of improvement of restoration involves adding these small rocks to a river or stream... Guess what?

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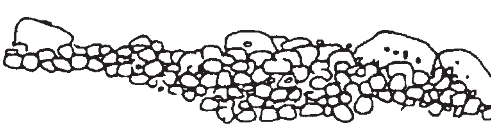

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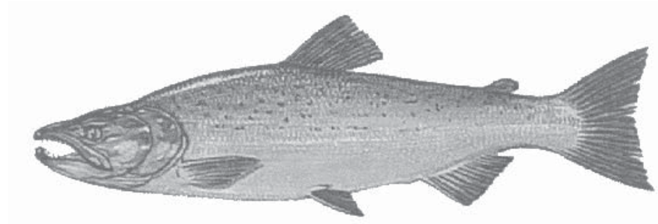

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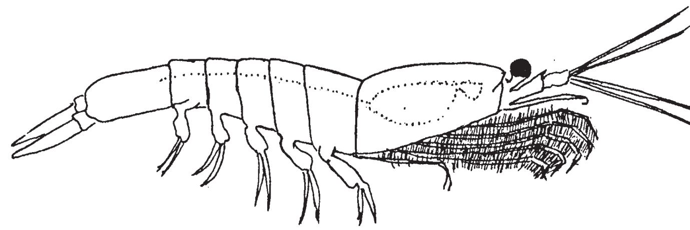

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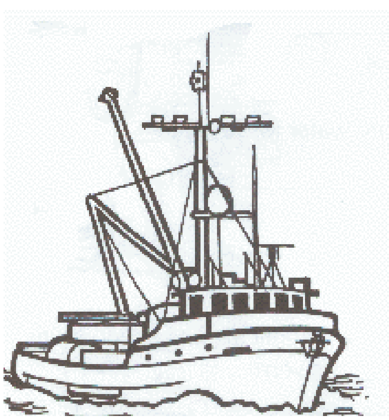

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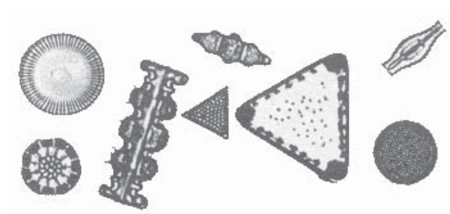

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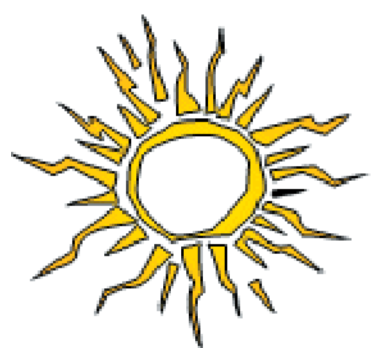


Aquatic Connections

Objectives
In this series of three interrelated activities students will: (1) explain how food availability is a limiting factor, (2) identify feeding relationships and the transfer of energy among plants and animals, and (3) discuss human activities which affect the food web in an aquatic environment.

Curricular Areas
Science (organizing, inferring, predicting, experimenting, communicating), Math (averaging, graphing), English Language Arts

California Content Standards
GRADES 3-8
Science
3rd Life 3 a, c, d; Investigations 5 a, c, d, e
4th Life 2 a, b, c; 3 a, b, c, d; Investigations 6 a, c, d, e
5th Life 2 f, g; Investigations 6 c, g, h
6th Earth 3 b; Ecology 5 a, b, c, d, e; Resources 6 a, b, c; Investigations 7 a, c, d, e
7th Living Systems 5 g; Investigations 7 c, e
Math
3rd Numbers 1.0, 2.0; Data 1.0; Reason 1.0, 2.0, 3.0
4th Numbers 1.0; Data 1.0, 2.0; Reason 1.0, 2.0, 3.0
5th Numbers 1.0; Data 1.0; Reason 1.0, 2.0, 3.0
6th Data 1.0, 2.0, 3.0; Reason 1.0, 2.0, 3.0
7th Data 1.0; Reason 1.0, 2.0, 3.0
English Language Arts
3rd Speaking 1.0
4th Speaking 1.0
5th Speaking 1.0
6th Speaking 1.0
7th Speaking 1.0

Method
The concept of food webs is communicated to students with a simulation of natural systems. Students will model animals in search of food. Three activities are used in this simulation; each activity builds on the experience from the previous one.

Materials
- Time to complete: (3) 50-minute class periods.

For each student:
- 10 markers, 15 for second game (poker chips, beans, pennies or other non-destructible small items)
- small plastic bag

For the teacher:
- 2 data sheets and a clipboard
- pencil

Background
In every ecosystem components are linked by the transfer of food energy called the food chain or food web, because it is not as simple as a straight chain. Plants or producers form the base or bottom of the food web. Animals that eat producers or other animals are called consumers. Consumers that eat plants are called herbivores (Latin meaning "grass-eating"). Animals that eat other animals are called carnivores (Latin meaning "meat-eating"). Some animals eat both plants and animals and are called omnivores (Latin meaning "all"). The general term "predator" applies to an animal that eats another animal. The word prey refers to the animal that is eaten. A given animal might be a predator on one species and the prey of another.

Energy is used at each stage of food transfer. Some is used for growth or is stored as fat or oil. Some is used for reproduction. Some is waste, such as undigested material lost in feces or the bodies of dead organisms. Much of the food that an animal eats is broken down in a process called respiration that takes place inside body cells.

Human activities may affect food chains in many ways. Pollution and habitat destruction cause obvious changes that are easy to see. However, more subtle changes may result from extensive harvesting or removal of specific levels of the food chain. When some fish are selectively removed, it may have a significant impact on other animals and on the plants in a watershed. Very careful planning is necessary to be able to either remove or add animals in a system without disturbing the ecological balance of the entire system.

Procedure

This activity has three parts, with each part building on the previous one. Teachers may choose to do one or all three parts. Each part will require one class period.

Before class (same for all parts):

1. Plan the location for the activity, including an alternate site in case of rain if you are planning to do it outside. This exercise works best in an open space.

Part I

Carrying Capacity - the relationship of food availability to the number of herbivores an area can support

2. Review terms *zooplankton* and *phytoplankton*. Zooplankton feed on the tiny phytoplankton that drift through the surface water in an aquatic environment. Explain that the students will be zooplankton searching for phytoplankton to eat. What happens when herbivores have to compete for food? Have students predict what might happen if they do not get enough to eat. Will they starve and die? Will they have any offspring?
3. In this exercise, the river has a limited number of phytoplankton and only a few zooplankton. The food supply will stay the same from one generation to the next. The beans or poker chips represent phytoplankton. To start, designate 2/3 of the class as zooplankton and give each student a plastic bag to collect phytoplankton. The rest of the class is reserved for the next generation.
4. Scatter 10 food items per student. Tell students to eat as much as they can without taking any away from another zooplankton. Begin the food search and let students pick up all the food. It will be over pretty fast.
5. Have everyone sit down. Did they all get the same amount of food? Some individuals are more efficient searchers than others. Record the results on a data sheet.
   - Herbivores with fewer than nine phytoplankton starve to death.
   - Some of the zooplankton did not get enough food to reproduce.
   - Those that have nine to eleven left one offspring.
   - Those with twelve or thirteen phytoplankton have two offspring.
   - More than thirteen leave three offspring.
6. Repeat the game.
7. After reproducing, the parents die, leaving behind the number of offspring indicated on the data sheet, which are the zooplankton of the next generation. Change the number of players to match the number of offspring.
8. Recruit from the reserve and allow substitutions for tired "zooplankton." Scatter the same number of food items as the first game regardless of whether the number of players went up or down. Assume the same number of phytoplankton will be produced.

The amount of food is limited.

9. Run the game again and calculate the results. Repeat. If possible, do four or five generations. You should find that as long as the food supply remains the same, approximately the same number of animals are produced in each generation.

During class:

10. Put the results of the simulation on the board. Have the students discuss what happened. Consider the following questions:
    - Did all the zooplankton get enough to eat? Even though there was food enough for everyone to survive, some were better at competing for food.
    - What happened to those that had more food? The best competitors had the most offspring.
11. Review the conclusions. Animals compete for food. Those that do not get enough to eat die, or are caught by predators because they are weak or diseased. Those that compete most successfully leave more offspring. If the limit to the number of herbivores in an area is the food supply, their number remains more or less the same from one reproductive period to the next if the food supply remains constant. This average number of animals is the *carrying capacity* for that habitat.

Part II

Predator-prey: the feeding relationships among animals that live in a river

1. In this part of the activity, the class is going to be the animals in a river. Have students name some animals that live in the river. Some answers might be big and little fish, frogs, crayfish, tiny zooplankton, insects, beavers and raccoons. Have pictures of river animals to show the class.
2. In the river, where does the food come from? From plants which use light to do photosynthesis. Some of these plants are tiny phytoplankton while others are rooted green plants that grow under the water or along the edge of the pond. Write the words *phytoplankton* and *green plants* at the bottom of the board.
3. Introduce the word *producers* for those things that make food. Who might eat these plants? The tiny animals called zooplankton eat phytoplankton as the students learned in the previous part. Many insects and the crayfish feed on plants as do the beavers. Write *insects*, *crayfish*, *beavers* and *zooplankton* above the plants on the board and draw an arrow up to them.
4. Explain you are drawing a diagram of the path food takes in the river. Those animals that eat plants are called *herbivores*.
5. Who eats the herbivores? (Answer: little fish and frogs as well as some bigger fish.) Add them to the next level along with an arrow. Animals that eat other animals are called *carnivores*. The animals that get eaten are called *prey*.
6. Finally, who eats the carnivores? (Answer: the big fish and the raccoon, or the *top carnivores*.) They do not just eat the level below them, they also eat the crayfish from the lower level.
7. Can the students see the *food web* or *food chain* forming as you draw the lines between the levels? (One way to illustrate the web is to pass out cards with the names of different animals and have the students pass a ball of yarn from the persons with the lowest levels of the food chain or web to those higher up.)

8. Now for the game, have students go to the activity location. In this game they will be animals in a river food chain feeding on each other.
9. The food plants or phytoplankton (poker chips or large white beans) are scattered over a wide area. In this game food is not limiting, thus there are more plants than the herbivores can eat.
10. 1/3 of the class will be zooplankton, crayfish and insects. Give them the same colored strip of cloth to wear and a plastic bag. They are all *herbivores*.
11. Scatter 20 food items for each herbivore. That means 20 times one third the number of students. These are the plants in the river. The herbivores need more food to live, and must get 10 pieces of plant food before the end of the game. If they do not get 10 pieces, they die of starvation.
12. Give another 1/3 of the class a second color armband and a plastic bag. They are the *carnivores*, such as frogs and small fish. To eat, they must tag a herbivore. The herbivore gives up his food bag and sits down if he has been "eaten" by the predator, and therefore is out of the game. The predators must collect 20 pieces of food from the herbivore food bags to be alive at the end of the game. They must stop eating when they have 20 pieces. If they do not get 20 pieces, they die of starvation.
13. The remaining students are the *top carnivores*. They get the third color of cloth and a plastic bag. They feed by tagging either the herbivores or the carnivores who must give up their bags and sit down when tagged because they have been "eaten." The top carnivores need 40 pieces of food to be alive at the end of the game. They should stop eating when they have passed 40 food items.
14. Caution the students about rowdy behavior and running into each other. Give them 5 minutes to find food then stop the game. Record the results.
15. Change the number of students in each level. Assign 1/2 of the class to be herbivores, 4 or 5 students to be top carnivores, and the remaining students will be carnivores. Repeat the game for 5 minutes. Stop and record the results.

During class:

16. Analyze what has happened for each playing of the game. Record the results on the board.
    - Do the students think either of these worked like a real river food chain?
    - What was the cause of death in most cases for the herbivores? For the carnivores?
    - In each game,were the proportions the same at the end as the beginning?
    - What levels of the food web do they think should have the most animals?
17. The proportions in the first game were intentionally wrong. They were chosen because they do not work. The students should be able to see the lack of balance. The top carnivores are going to eat all their prey. With none left to reproduce, the top carnivores will starve to death. If all the herbivores get eaten, they will not leave any offspring, and the rest of the levels will starve to death in the future. The second game should provide information and help students develop inferences about food levels. The numbers at each level should be more like a standard pyramid.
18. Discuss the conclusions. In order for the food web or chain to be realistic, the students must have some individuals from each level alive at the end of the model. These animals will be the ones that reproduce, making the next generation.

Part III

Human activities that change the feeding relationships, and thus the ecological balance, of a food web.

1. Explain that this is a continuation of the food chain experiments conduced in Parts I and II. The question for this part is, "What impact do humans have on the balance of a food chain?" Ask students to name some ways people might affect the animals in the river food chain. Ask students to identify the food web of the river model from the previous game. Draw the food web on the board as students name the

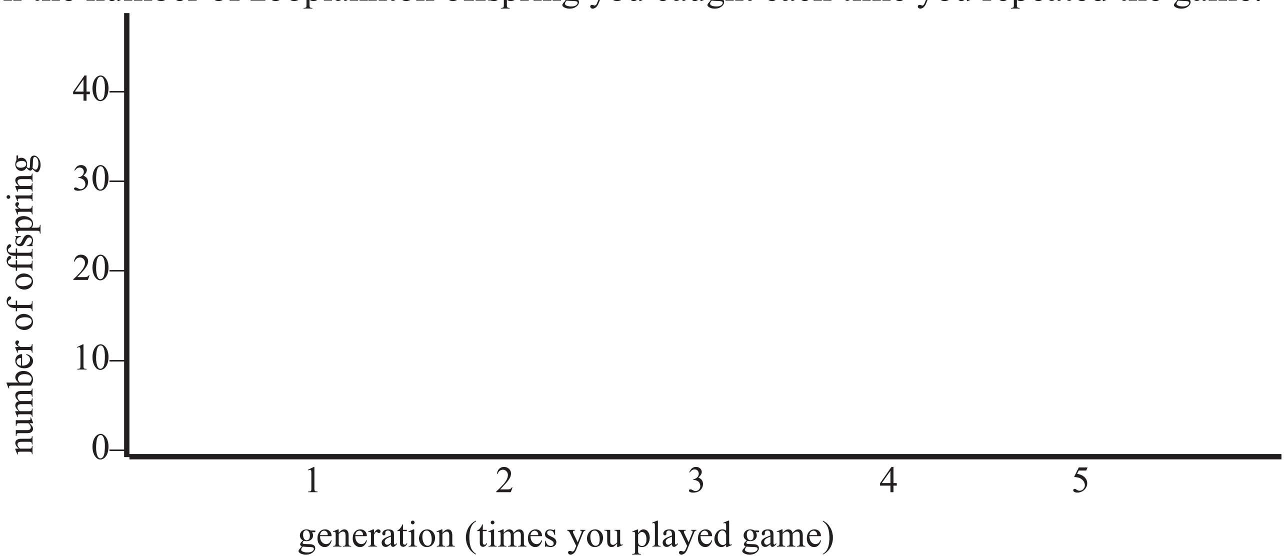
Activity adapted from *Living in Water Activity Guide* food chain section, written by Dr. Valerie Chase for National Aquarium of Baltimore, Baltimore, Maryland 21202.

Aquatic Connections Worksheet

Part I

	# at beginning	# starved	# with 1 offspring	# with 2 offspring	# with 3 offspring
Round 1					
Round 2					
Round 3					
Round 4					

Graph the number of zooplankton offspring you caught each time you repeated the game.



Calculate the average number of offspring in the population by adding the numbers from each generation together and then dividing by the number of generations you had.

Part II

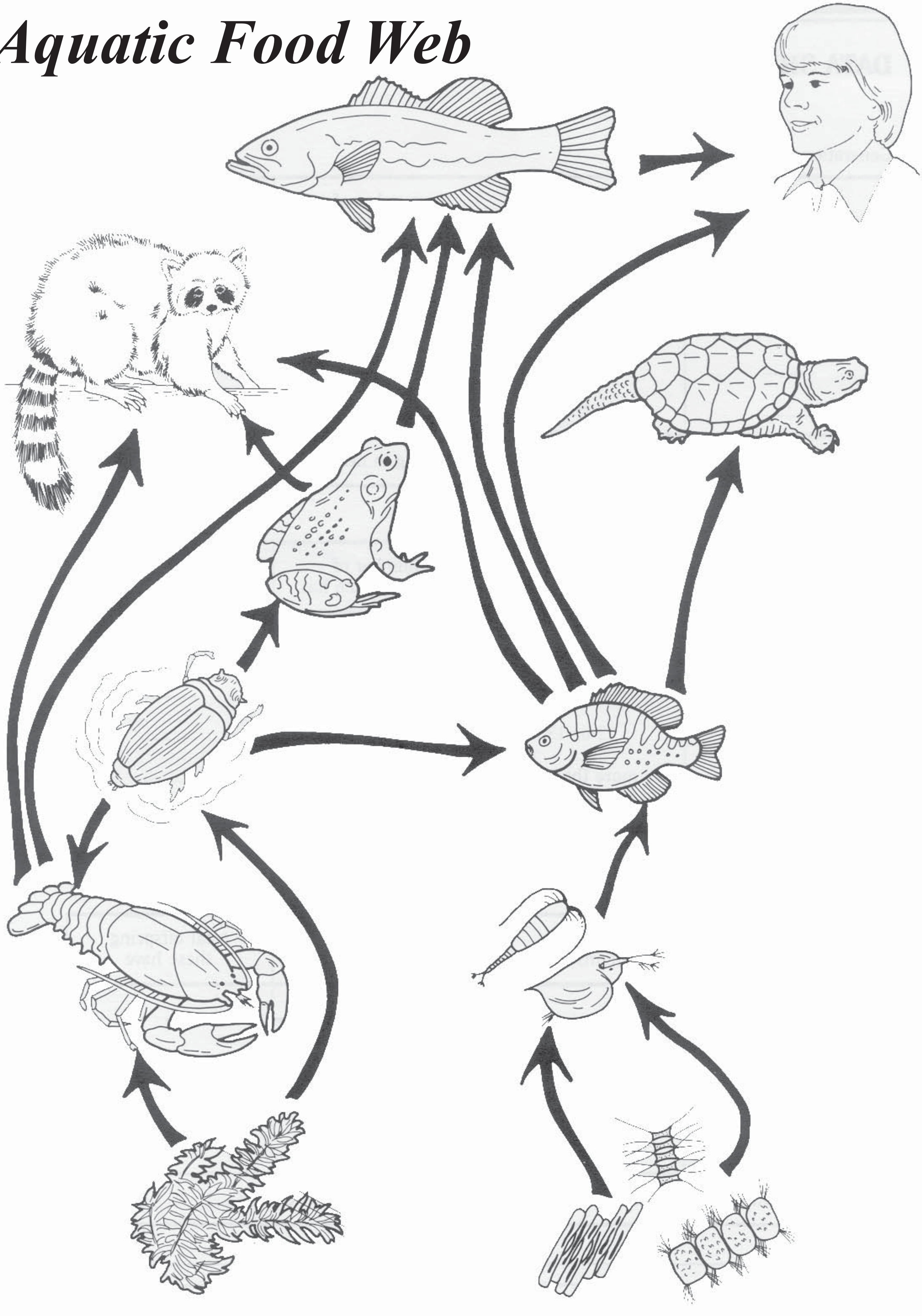
FIRST RUN

feeding level	# live at beginning	# eaten	# that starved	# alive at end
herbivores				
carnivores				
top carnivores				

SECOND RUN

feeding level	# live at beginning	# eaten	# that starved	# alive at end
herbivores				
carnivores				
top carnivores				

Aquatic Food Web



Designing Hatcheries with Genes in Mind

Objectives

Students will: (1) describe the importance of genetic diversity; (2) understand that hatcheries must implement practices to maintain as much diversity as possible; (3) understand why salmon and steelhead runs become threatened, endangered, and extinct; (4) understand traits that allow fish to survive and reproduce.

Curricular Areas

Science, Language Arts

California Content Standards

GRADES 5-8

Science

6th: Ecology 5 e; Investigation 7 a, d, e

7th: Genetics 2 b, c, d; Evolution 3 a, e; Living Systems 5 d; Investigation 7 c, e

English Language Arts

6th Speaking 1.0, 2.0

7th Speaking 1.0, 2.0

Method

Students will analyze the simulated gene make-up of a group of salmon and discuss hatchery operations and decisions as they relate to genetic diversity.

Materials

- Time: allow (1) 50-minute class period
- Large clear jar or bowl
- Pony beads, eight different colors
- *Designing Hatcheries* information
- *Hatchery Operations Problems* worksheet
- *Hachery Cards* for clues

Background

Diversity is essential to the survival of a species. There are three kinds of biological diversity: diversity found in an individual, diversity within a species or a given population, and diversity within an ecosystem. The ability of an individual to survive changes in the environment comes from the extent of genetic diversity the individual has, thus giving it the ability to adapt to those variations. Diversity within a population means that there are enough organisms to continue producing a variety of genetic combinations within the group. The third type of diversity, biodiversity, deals with the ecosystem. A diverse ecosystem provides a variety of food sources for those living there, which allows for a higher survival rate.

In the world of "survival of the fittest," an organism must have the genetic resources that allow it to survive the immediate changes in its environment, and that allow the species to adapt to long-term changes around it. The only way to ensure this will happen is to make sure that the genetic choices in the population are large enough to have the greatest variety of attributes passed along to individuals to the next generation. The best way to ensure a large and healthy population with enough gene choices is to have sufficient habitat to support it.

Hatchery practices are crucial in maintaining the genetic diversity of a salmon run. There are nine salmon and steelhead hatcheries in California. Of these, three are state owned, four are federally owned and two are privately owned. The California Department of Fish and Game operates all but Coleman Hatchery, which is operated by the U.S. Fish and Wildlife Service. All but one of the hatcheries serves as mitigation effort for lost spawning habitat. Each hatchery has production outputs or quotas of salmonids that they must return to the river in either smolt or yearling size. Due to the variations in each river system, the hatcheries are operated according to their unique fisheries. This ensures the success of each salmon run.

Since salmon and steelhead hatcheries are located right on the river systems, it is not necessary for hatchery staff to capture brood stock. Instead, the fish come to the hatchery. Each pan of eggs taken contains eggs from at least two females, and milt from two males. This practice is to encourage the mixing of the genetic pool.

This activity presents students with several dilemmas regarding operating a hatchery on a stream with wild fish present. While it has very general coverage of the issue of how to provide sport and commercial fisheries and protection of wild fish populations, at the same time, it should give students some insight into the factors that must be considered in hatchery operations.

Procedure

1. Have each student read the student sheet *Designing Hatcheries*.
2. Review the terms *genetic diversity* and *genetic traits*. Have students name a few genetic traits.
3. Divide the class into groups of two to four students. Give each group a copy of the *Hatchery Operation Problems.* Explain that each group of students will receive a small amount of colored beads. These beads represent the genes available in their salmon. Place all the beads in a glass jar, bowl, or plastic bag and mix the colors and give each group about a tablespoon full of beads. Explain that genes are distributed randomly in this activity just as in a real situation.
   a. Have students match their genes to the gene key and circle the colors or genes on the "Key to Genetic Traits" on the worksheet.
   b. Have students list the genetic characteristics of their salmon.
   c. Have students list genetic characteristics that are missing.
   d. How does the genetic make-up of their salmon affect its chances of survival?
   e. Have groups share their genetic make-up of each salmon. Is there genetic diversity within the salmon populations? Is there enough diversity to ensure a survival of some of the populations?
4. The key to the survival of salmon is to have the genetic resources, which cause adaptation to immediate changes in the environment, and allows the species to adapt to long-term change. This adaptation allows salmon to have a better chance of survival in their home stream than in any other.
5. Each group will now consider a hatchery operation problem and propose a solution for the problem.
6. Groups will be given a set of *Hatchery Cards*. These cards are to be divided equally between members of the group.
7. The group will use the clue cards to help formulate their answer to the problem. Once the decision is agreed upon by the group, they prepare an oral presentation for the class. This presentation will state the hatchery operation problem, the decision of the group, and a justification for that decision.
8. After each group presentation, have students review the clue cards and discuss the possibility of other decisions. Generally, the decisions should resemble the following:
   a. <u>Decision 1</u>: It is likely that fish from another stream have a different "library" of genes. These genes enable them to live just fine in their home streams but not in your stream. To ensure the success of your hatchery, you need to use fish from the stream you are trying to improve, because those fish have the best chance of survival in that particular place.
   b. <u>Decision 2</u>: Using fish from only a part of the run greatly limits the size of your gene "library." For instance, if you took fish from only the first part of the run, the resulting fish from your hatchery would be more likely to spawn early. This means that the *entire* population would be effected by a spell of flooding that occurred during spawning time. It would be far better to get fish from the entire run, which would conserve all the genes carried in the population. This would lengthen the spawning time and make it likely that some of the fish would spawn after the flood.
   c. <u>Decision 3</u>: Biologists estimate that in most situations, you would need at least 100 pairs of spawning salmon to maintain adequate genetic diversity in your hatchery fish population. More is better, so if you can take 300 pairs from your stream and still leave plenty of wild spawners to spawn in the stream, you should do it.

d. Decision 4: Increasing the spawning and rearing habitat makes room for more fish, both hatchery and wild, and therefore reduces competition. However, if the riparian and upland areas of the stream are being used poorly, your habitat improvements may not be successful.

e. Decision 5: Most habitats are "seeded," or full, and there is little room for more fish. The number of hatchery fish released has to be carefully watched to reduce disruption to wild fish. However, you could create more rearing areas in the stream to make room, making it possible to release your hatchery fish in sites not used by wild fish.

f. Decision 6: If your objective is to have more adults returning for anglers to catch, acclimate them to return to areas not used by wild fish. This reduces the chance that the hatchery fish will spawn with wild fish, and protect the wild fish gene pool. But, if you want the returning fish to spawn and be part of the (wild) stream-spawned-and-reared population, you want the adults to return to the natural spawning areas. This is a one-time operation that "jump starts" the population so that it will be self-sustaining in future generations.

g. Decision 7: You could close the trout fishery while the juvenile salmon are migrating to the ocean; this would prevent trout anglers from catching them by mistake. To protect returning adults, you could allow catch-and-release only for wild fish, marking (fin-clipping) the

Activity adapted from *The Fish Hatchery Next Door...* distributed by the Oregon Department of Fish and Wildlife.

Young Salmon Fry

Designing Hatcheries

Today there are about 20,000 different kinds, or species, of fish. These fish (and all living things) look and act the way they do because of traits they inherited from their parents. These traits developed over millions of years and many generations. Traits, such as the ability to grow a strong tail fin to propel the fish, a slime layer that helps the fish glide through the water, or a coloring that makes the fish difficult to find (camouflage), are easy to observe. But, some traits are not so obvious. The urge to migrate up a river to spawn, the ability to defend a feeding territory with great vigor, the drive to emerge from an egg in the gravel to the stream above, and resistance to disease are also inherited traits that help fish survive. These traits are passed along from generation to generation via structures called 'genes," which are contained in the sperm and eggs of the parents.

If all fish in a stream had the same genes, they would all react to a change in the environment in the same way. For instance, if a stream suffered a very low water year, and none of the fish had the combination of genes (the traits) to withstand a low-oxygen, warm-water environment, all of them would die. Luckily, fish in a stream do not have exactly the same genes. Over millions of years of spawning, wild fish populations built up a wide variety of genes, resulting in each fish with a slightly different makeup. Some of the fish in the stream probably would survive, because they inherited the ability to live in a warm-water, low-oxygen environment. These fish would be the basis of rebuilding a fish population in the stream. Some of these remaining fish would also have the inherited ability to survive in a cold-water, oxygen-rich environment, which would be important if the stream returned to its original condition.

This illustrates why every individual gene in a population is important, especially in a changing environment. The greater the differences in genetic makeup between members of the population, the greater the chances that some of the fish can survive environmental changes. It is like having a great library full of books (traits). If you threw away all the books that you didn't need at the time, you might be sorry later when you needed them again for some different information. In the case of fish, it is best to keep as many different genes as possible in the population. Biologists call this "genetic diversity." The goal is to have populations of fish (and all living things) with as much genetic diversity as possible. This is why wild fish are so valuable—because they have developed the most genetic diversity.

Suppose you had a situation in a stream where salmon spawning and rearing habitat was in short supply. Since wild salmon (the ones with the greatest diversity) depend on good habitat, wild salmon populations would be in short supply. So you decide to grow some salmon yourself and supplement the wild fish population with your own hatchery fish. Sounds like a good idea.... right? On the surface, raising a few fish to put into the stream seems fairly simple, and in

Hatchery Operation Problems

Key to Genetic Traits

Black	Tail Strength	Orange	Vigor (defending feeding territory)
White	Slime Production	Red	Drive to emerge from egg
Yellow	Camouflage	Green	Resistance to disease
Purple	Urge to return to spawn		

Each group must have one problem. The group should formulate a decision, use the clue cards for help, and prepare an oral presentation of the problem and the decision.

1. A run of salmon from a river system 100 miles to the south is particularly healthy and large. Does this sound like the place to collect males and females to provide eggs and sperm for your hatchery?
2. The run of salmon you want to use for your hatchery begins showing up on their natural spawning grounds in late October and continues until about the early part of January, with peak numbers during late November and early December. Circle the time period in which you would spawn fish for your hatchery:
   October 1-15-30 November 1-15-30
   December 1-15-30 January 1-15-30
3. Decide how many male and female fish you will need to provide adequate genetic diversity for the fish you will raise in your hatchery. You decide to spawn (circle one):
   10 pairs 25 pairs 50 pairs 100 pairs 300 pairs
4. You will be operating a hatchery on a stream or river. Would you need to also increase the spawning and rearing habitat in the stream?
5. You need to decide how many fish to release each year from your hatchery. Would you release as many as your hatchery can handle, or limit the number of fish you release each year?
6. Now you have to think about what will happen when your hatchery fish return to spawn. Would you acclimate your hatchery fish so that they would return to the areas used by wild fish for spawning, or acclimate them to return to areas not used by wild fish in your stream for spawning?
7. The stream your hatchery is located on has certain fishing regulations. What regulations would protect the wild and hatchery salmon as they migrate to the ocean and return to spawn?

Hatchery Cards

Fish are highly adapted to their home streams. Therefore, they have a better chance of survival in that stream than in any other.	The survival of a fish caught by an angler and later released depends on the careful treatment of the fish while playing it on the line and dislodging the hook. The least amount of handling is best.
Even fish from adjacent watersheds or river basins have different "libraries" of genes, which enable them to survive better in their own streams.	If you only collected fish for your hatchery from the early part of the run, the resulting offspring would likely all spawn early when they return as adults. Therefore, the entire population would probably be vulnerable to a spell of bad weather and flooding that may occure during spawning
When collecting eggs and sperm, you can get the greatest genetic diversity in your fish population by using the most fish possible.	One-hundred pairs of salmon are generally considered to be the minimum number needed to provide adequate genetic diversity to pass on to the next generation.
Using fish from various parts of a run would give you the largest genetic diversity in the offspring.	The number of fish collected from a stream to use as hatchery brood stock is dependent on the number of wild fish available in the stream. The key is to leave enough in the stream to insure there will be enough to sustain the genetic diversity of the next generation of wild fish.
Hatchery fry released into a stream where wild fry are living will compete with the wild fish for both food and space.	Increasing the habitat for spawning and rearing in stream makes room for more fish, both hatchery and wild.

Hatchery Cards

Creating better habitat in streams helps the wild fish population grow.	Habitat improvement projects in streams can be ineffective if riparian and upland areas of the stream are being poorly treated.
Most stream habitats are seeded, or full, and there is little room for more fish.	Smolts, or juvenile salmon, are usually released in the spring to migrate to the ocean. They are very similar to trout in appearance at this time.
All natural ecosystems have a limit on how many living things they can support, including streams. This is called the stream's "carrying capacity."	Many streams are closed to trout angling until late spring in order to protect salmon and steelhead smolts from being caught by trout anglers.
Hatcheries whose objective is to increase the number of returning adult fish for anglers can acclimate their fish to return to spawning areas not used by wild fish. This allows the wild fish population to reproduce naturally.	"Catch and release fishing," where some fish must be returned unharmed to the stream, protects wild fish while allowing hatchery fish to be caught.
Hatcheries whose objective is to produce returning adults that spawn and become part of the stream-spawned-and-reared population acclimate their fish to return to the stream spawning areas. This is a one-time operation, because the hatchery just wants to "jump start" a population so it will be self-sustaining in the future	Hatchery fish can be marked by clipping the adipose or other fins at the hatchery before they are released. This enables both biologists and anglers to identify the fish.

Assess Your Impact
No Action is an Action!

Objectives
Students will (1) monitor their water use, (2) identify, develop, and practice responsible water conservation behavior, (3) identify non-point source pollution and the effects on water quality, humans and wildlife, (4) identify personal choices that will help conserve water and reduce non-point source pollution.

Curriculum Areas
Science, Social Studies and Lanuage Arts

California Content Standards
Science

K Physical Science 1; Life Science 2; Earth Science 3
1st Life Science 2 a, c, e
2nd Life Science 2 c; Earth Science 3 e
3rd Life Science 3 a, c d
4th Life Science 2, 3 a, b
5th Earth Science 3 a, b, c, d, e
6th Earth Science 2 a, b; Ecology 5 b, e; Resources 6 b, c
7th Evolution 3e; Earth Science 4 a, c
8th Physical Science 3 b, c; Chemistry 6 a, b, c

Language Arts

K-2 water use only; 3-8 both activities

K-2 Listen/Speak 1.0
3rd Reading 1.0; Writing 1.0; Written/Oral 1.0; Listen/Speak 1.0
4th Reading 1.0, 2.0; Writing 1.0, 2.0; Written/Oral 1.0; Listen/Speak 1.0
5th Reading 1.0, 2.0; Writing 1.0, 2.0, Listen 1.0, 2.0
6th Reading 1.0; Writing 1.0, 2.0; Written/Oral 1.0; Listening 1.0, 2.5
7th Writing 1.0, 2.0; Written/Oral 1.0; Listening 1.0; Speaking 2.3, 2.4
8th Written/Oral 1.0; Speaking 2.3, 2.4

History/Social Studies

K K.4
1st 1.1, 1.2, 1.5
2nd 2.1, 2.2
3rd 3.1, 3.4, 3.5
4th 4.1, 4.4, 4.5
5th 5.7, 5.8

Method
Students will gather data to explore water use, sources of non point source pollution. Students will identify actions they can take to reduce non-point source pollution and conserve water.

Materials
- Water-Use Worksheet and *Wise Water-Use Tips*
- *Non-point Source Pollutants* and *Safe Substitutes to Reduce Non-point Source Pollution* Handouts
- Map of the local community

Background
Water use is such an automatic and habitual daily activity that we often do not understand the consequences of using water. Each time we draw water from its natural setting or modify the natural journey of water, we are likely to have an impact on salmon, other wildlife, and habitats. For example, dams block the salmon on their way back to their natal stream, and draining wetlands removes water from natural wildlife nurseries. Once water is diverted from its natural path and is used by humans, it is often contaminated or polluted. Contamination entering the water cycle can have damaging consequences for people, wildlife, and the environment.

Land-based pollution can either be from a "point source" or a "non-point source." Point source pollution starts from a specific place such as an oil refinery. Non-point source pollution is contaminated runoff starting from an indefinite or undefined place, often a variety of places. The soot, dust, oil, animal wastes, litter, sand, salt, pesticides and other chemicals that constitute non-point source pollution often come from everyday activities such as fertilizing lawns, walking pets, changing motor oil, and driving. With each rainfall, pollutants from these activities are washed from lawns and streets into storm drains that often lead directly to nearby bodies of water such as streams, rivers, and oceans.

Humans have water use choices. We can make decisions to use water respectfully and carefully while conserving water as a part of daily life. Water conservation reduces or prevents destruction of natural habitats by lessening the need for dams and other interventions. It also reduces the depletion of underground water stores that supply water for riparian and other habitats. Water conservation may also decrease wastewater discharges into sensitive environments such as estuaries.

In addition to conservation, we can be careful to prevent potential toxins like pesticides, detergent, fertilizers, motor oils, aerosols, cleaning fluids and powders, caustic acids, fuels and their byproducts from entering the water-cycle. We can affect both the quantity and quality of available water through personal and public conservation practices.

Procedure

Before class:

Copy student handouts:

- *Water-Use Worksheet* and *Wise Water Use Tips*
- *Non-point Source Pollutants* Handout
- *Safe Substitutes to Reduce Non-point Source Pollution* Handout

During class:

Part I Water Conservation

1. Introduce a brief class discussion of water and its use. All life depends on water to survive. Wherever we live, we do things each day that affect water, and influence the well-being of salmon, other wildlife, and people. Did the students know there is a fixed amount of water on Earth and its atmosphere? Of this only 0.003 percent is clean, fresh water that is usable.
   - Ironically, the Earth is covered with water (71%) yet, only a small percent is available for use by humans and wildlife. Discuss sources of water.
   - 97% of the water contains salt (oceans, seas or salt water lakes or rivers).
   - Water forms the ice caps and glaciers. A small amount of water is unavailable because it is too far underground, polluted, trapped in soil, etc.
   - Freshwater lakes, rivers and ground water provide the available water for human, salmon and other wildlife use.
2. Since our water is limited, is it important for humans to conserve water, use it wisely, and protect its quality?
   - Distribute the Water-Use Worksheet and ask students to keep track of how much water is used in their homes for seven days, from Saturday to Friday.
   - Students may post the worksheet on their refrigerator. Family member may help by putting a mark in the section designated after each water use.
   - The miscellaneous section is for special uses not listed (filling a fish tank, bathing the dog).
   - Students should bring their results on Monday.
3. On Monday, make a master chart that summarizes the total household use for the class.

   - Brainstorm ways to conserve water.
   - Challenge each student to reduce use and invite families to join.
   - On Friday, hand out another Water-Use Worksheet and a copy of the *Wise Water-Use Tips*. Have students monitor use for another seven-day period (Saturday to Friday) while using the wise water use tips.
   - Have students bring in their results on Monday and tabulate. Compare week 1 with week 2. Was there a significant reduction in water use?
4. Lead a discussion on what was easy to change and what was harder.

Part II Non-point Source Water Pollution

1. Remind students that wise conservation practices are only one part of water stewardship. Humans make choices about the amount of water they use and what they put down the drain. Keeping water free of pollutants is important for humans, plants, and wildlife. Ask students what they know about non-point source pollution. Have they heard the term? Do they know what it means? What are some examples? (Answer: Non-point source pollution is contaminated runoff originating from an indefinite or undefined place, or more often a variety of places).

2. Ask students what types of non-point source pollution might be originating from their school and their community. Write their answers on the board.
3. Pass out the *Non-point Source Pollutants* and *Safe Substitutes to Reduce Non-point Source Pollution* handouts. Go over the information as a group.
4. Ask students to think about possible sources of non-point source pollution in the community. Pass out copies of a community map. Ask students to locate possible sources of non-point source pollution and see where it may go. Does it empty into a waterway? Examples could include:

<u>Schools</u>

- Playgrounds, ball fields (trash, fertilizers, pesticides)
- Sewage system, including restrooms, cafeteria, and science classes (trash, excess nutrients, detergents, chemicals, pathogens)
- Parking lot (trash, heavy metals, dripping oil)
- Sidewalks and outdoor hallways (trash)

<u>Community</u>

- Farmland (sediments, excess nutrients, fertilizers, pesticides)
- Construction sites (trash, sediments)
- Residential areas (trash, fertilizers, pesticides, detergents from car washing)
- Parking lots (trash, heavy metals, dripping oil)
- Parks (trash, fertilizers, pesticides, animal waste)

5. Brainstorm about actions students and their parents or caregivers can take to reduce pollutants entering the watershed. Examples:
   - Put your trash in garbage cans (Storm drains carrying litter empty into local waterways).
   - Dispose of chemicals at approved household hazardous waste collection sites. Do not dump them on the ground or down storm drains.
   - Walk pets on grassy areas, and pick up after your pets to prevent pet waste from entering the storm water system.
   - Keep cars well maintained and free of leaks. Recycle used motor oil.
   - Compost yard waste, and don't dispose of leaves or grass clippings in your storm drain. Landscape your yard to prevent water runoff.
   - Never exceed manufacturers' recommendations for use of chemical products.
   - Use as few pesticides as possible. Use "natural" approaches to pest control and organic gardening techniques.
6. Consider ways for students to help reduce non-point source pollution at its source, beginning at home, extending to their school, and out in the community. Most of the activities would likely be done by adults; however, students would need to advocate these suggestions. Brainstorm with students how they can approach adults in a helpful manner. Possible activity suggestions:
   - Use maps and information from this activity to create a non-point source pollution display for the school and community.
   - Make a list of pollutants your school is generating (detergents, pesticides, fertilizers), discuss with school staff non-point source pollution, and suggest alternative products.
   - Conduct a storm drain stenciling activity around your school to alert people about the hazards of non-point source pollution. Contact your local public works department to find out about their stenciling program.
   - Write to local or state representatives to find out what measures are being taken (or considered) to reduce non-point source pollution.

Extension

1. Consider other stewardship actions such as:
   - Planting trees at home, at the school, or in your community.
   - Plant native trees, shrubs or grasses in a riparian area.
   - Participate in a river or beach clean-up day
2. Have a class discussion on the process of problem solving.
   - Define the problem
   - Brainstorm solutions
   - Analyze the suggestions
   - Evaluate and select the best solution
   - Apply the process to water conservation and water pollution problems and create an action

Activity information adapted from *Waves, Weltands and Watersheds,* copywright 2003 by the California Coastal Commission (415) 909-5400 www.coastforyou.org

How Much Water Does Our Household

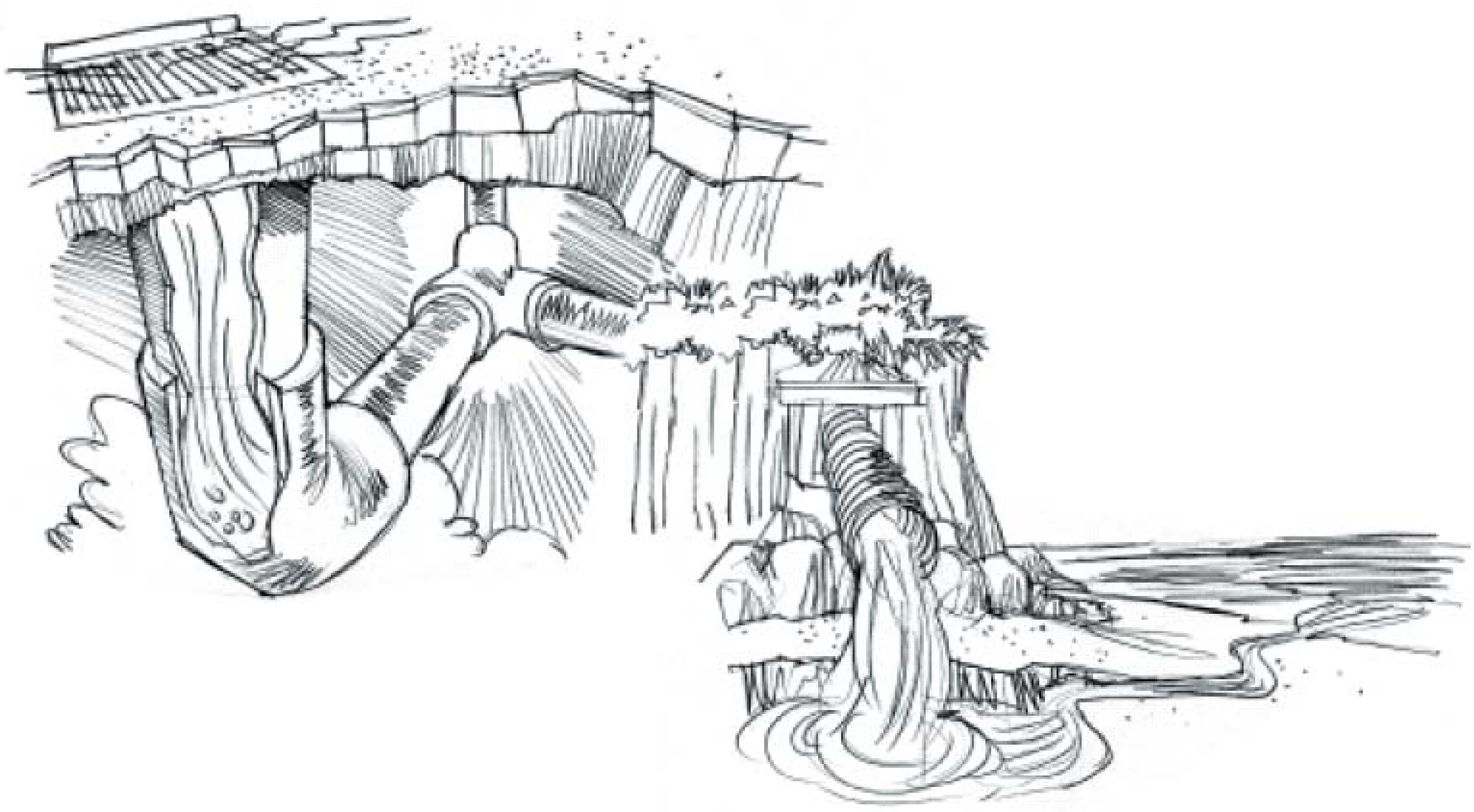
Use	**Gallons per use**	**Number of times** (tally)	**Total Gallons**
Flushing toilet	3 1.6 with Low Flow		
Brushing teeth	3 with water running 1 with water off		
Shower ___ minutes	5 gal/min with old shower head 2.5 gal/min with new shower head		
Taking a bath	40 if full		
Washing dishes	10		
Washing clothes	40		
Watering lawn	40		
Washing car	40 0 (carwash recycles water)		
Other:	estimate ____		
Other:	estimate ____		
Other:	estimate ____		

Wise Water Use Tips

Shower: Rinse yourself off, and then turn off water while you lather up. Turn it back on to rinse off. This will reduce the number of minutes the shower is on. A new shower head may be installed. New shower heads made in the U.S.A. will use a maximum of 2.5 gallons/minute.
Brushing teeth: Turn on the water to wet the brush then turn it off until brushing is complete and you are ready to rinse. This uses less than 1 gallon.
Washing Clothes: Wash only full loads; this will reduce the number of loads needed.
Washing Dishes: Only run the dishwasher with a full load; this reduces the number of loads.
Bathtub: Fill the bath only halfway, this saves 20 gallons.
Toilet: Toilets made after 1992 us an average of 1.6 gallons/ flush. For older toilets place a plastic bottle filled with water in the tank. This reduces the amount of water used for each flush by the amount of water in the bottle.
Washing a car: Use a carwash that recycles water. This saves 40 gallons and reduces water pollution.
Watering your garden: Water once per week, deeply in the early morning (reduces evaporation). Use a bucket in the kitchen and bath for water when waiting for water to warm up. Use this water for plants. Encourage the planting of native and drought-tolerant plants, because they need less watering.
Cleaning house: Use a broom instead of a hose to clean the driveway or patio. Save water, get exercise!

Non-point Source Pollutants

Debris (plastics, glass, metals, woods)	Runoff from roads, landfills, and parking lots into storm drains, sewer systems, beach and boating activities	Can harm aquatic life by entanglement or ingestion
Sediments	Construction sites, agricultural lands, logging areas	Clouds water, decreases plant productivity, suffocates bottom-dwelling organisms
Excess nutrients (fertilizers, animal wastes, sewage, yard waste)	Livestock, gardens, lawns, sewage treatment systems, runoff from streets	Prompts phytoplankton or algal blooms, causes eutrophication (depleted oxygen), and odor
Acids, salts, heavy metals	Runoff from roads, landfills, and parking lots, roadway snow, dumping sites	Toxic to aquatic life and can be taken up by organisms and bioaccumulate in their tissues
Organic chemicals (pesticides, oil, detergents)	Forests and farmland, antifouling boat paints, home lawns, golf courses, sewage treatment systems, street runoff	Chronic and toxic effects on wildlife and humans, possibly carcinogenic
Pathogens (coliform bacteria)		



Safe Substitutes to Reduce Non-point Source Pollution

At Home

Air Fresheners
- For sink disposal odors, grind up used lemons.
- For surface odors on utensils and chopping blocks, add a few drops of white vinegar to soapy water.

Deodorizers
- For carpets, mix 1 part borax with 2 parts cornmeal; spread liberally and vacuum after an hour.
- Sprinkle baking soda in the bottom of cat boxes and garbage cans.

Dish Detergents
- Use mild, biodegradable, vegetable oil-based soap or detergent.
- For dishwashers, choose a detergent with the lowest phosphate content.

Disinfectants
- For disinfecting tasks, use ½ cup borax in 1 gallon hot water.

Drain openers
- Pour boiling water down the drain once a week.
- For clogs, add a handful of baking soda and ½ cup white vinegar to your drain, cover tightly and let sit 15 minutes while carbon dioxide bubbles work on clog. Finish with 2 quarts boiling water, and follow with a plunger.

Floor cleaners
- For plain wood floors, use a damp mop with mild vegetable oil soap and dry immediately.
- For painted or varnished wood floors, combine 1 teaspoon of washing soda with 1 gallon of hot water. Rinse and dry immediately.
- For vinyl floors, combine ¼ cup white vinegar and ¼ cup washing soda with 1 gallon of warm water, and mop.
- For scuff marks on linoleum, scrub with toothpaste.

Furniture polish
- For finished wood, clean with mild vegetable oil soap.
- For unvarnished wood, polish with almond, walnut, or olive oil; be sure to remove excess oil.
- Revitalize old furniture with linseed oil.

Glass cleaner
- Combine 1 quart water with ¼ cup white vinegar.

Laundry detergent
- Avoid products containing phosphates and fabric softeners.

Bathrooms
- Combine 1/2 cup borax in 1 gallon of water for cleaning and disinfecting toilets.
- Clean toilets frequently with baking soda.
- Tub and sink cleaners: Use baking soda or a nonchlorinating scouring powder.

For the Garden

Garden fertilizers
- Use organic materials such as compost, either from your own compost pile or purchased from the store.

Garden weed and fungus control
- Use less-toxic soap solutions for weed killers.
- For fungus, use less-toxic sulfur-based fungicides.
- To control powdery mildew on roses, spray both sides of rose leaves (in the morning, weekly) with a mixture of 2 tablespoons mild liquid soap, 2/3 teaspoon baking soda, and 1 gallon water.

Pest Control
- For outdoor ants, place boric acid in problem areas.
- For indoor ants and roaches, caulk entry points. Apply boric acid dust in cracks and insect walkways. Be sure it's inaccessible to children and pets (it's a mild poison to mammals).
- For garden aphids and mites, mix 1 tablespoon of liquid soap and 1 cup of vegetable oil. Add 1 teaspoon of mixture to a cup of water and spray. (Oil may harm vegetable plants in the cabbage family.)
- For caterpillars in the garden, apply products containing Bacillus thuringiensis to the leaves when caterpillars are eating.
- For mosquitoes in the yard, burn citronella candles.

Source: Take Me Shopping: A Consumers Guide to Safer Alternatives for Household Hazardous Products. Published by the Santa Clara County Hazardous Waste Management Program.

Watch out for these toxic ingredients!

Degreasers: trichloroethylene (TCE), toluene, methylene chloride. **Disinfectants**: phenylphenol, phenol chlorobenzene, diethylene glycol. **Drain cleaners**: sodium hydroxide, potassium hydroxide, hydrochloric acid. **Dry cleaning fluids**: TCE, perchloroethylene (PERC), 1,1,1-trichloroethane (TCA), naptha. **Gasoline**: benzene, paradichlorobenzene. **Oven cleaners**: methylene chloride, xylene, toluene, methyl ethyl ketone chloride, nitrobenzene. **Spot removers or cleaning fluids**: carbon tetrachloride, 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), perchloroethylene (tetrachloroethylene, PERC). **Toilet bowl deodorizers**: paradichlorobenzene. **Upholstery cleaners**: TCE. Wood preservatives: pentachlorophenols (PCPs), arsenic.

Legends and Stories

Objectives
Students will (1) explore oral tradition through story, (2) use facts, knowledge and understanding of natural resources to creatively shape a solution to a natural resource problem.

Curricular Areas
Science, History, and Language Arts

California Content Standards
Science
3rd Life Science 3 a, b, c, d, e
4th Life Science 2 a, b, c, 3a, b, c, d; Earth Science 5 c
5th Life Science 2 a, b, c, d, e, f, g; Earth Science 3, d, e
6th Ecology 5 a, b, c, d, e; Resources 6b
7th Evolution 3 a, e; Earth 4 e, g

Social Studies
3rd 3.1, 3.2, 3.3
4th 4.2, 4.4
5th 5.1, 5.4

Language Arts
3rd Reading 1.0, 2.0, 3.0; Writing 1.0, 2.0; Written/Oral 1.0; Listen/Speak 1.0, 2.0
4th Reading 1.0, 2.0, 3.0; Writing 1.0, 2.0; Written/Oral 1.0; Listen/Speak 1.0, 2.0
5th Reading 1.0, 2.0, 3.0; Writing 1.0, 2.0; Written/Oral 1.0; Listen/Speak 1.0, 2.0
6th Reading 1.0, 2.0, 3.0; Writing 1.0, 2.0; Written/Oral; 1.0; Listen/Speak 1.0, 2.0
7th Reading 1.0, 2.0, 3.0; Writing 1.0, 2.0; Written/Oral 1.0; Listen/Speak 1.0, 2.0
8th Reading 1.0, 2.0, 3.0; Writing 1.0, 2.0, 3.0; Written/Oral 1.0; Listen/Speak 1.0, 2.0

Method
Students will create a story about the future using what they have learned about watersheds and salmon. They will develop this story into a "Readers' Theater" format.

Materials
- Microphone and recorder (or simulated ones)
- Stools for the readers
- Copies of the *Readers' Theater* example
- Copy of *The Creation*

Background
Before the coming of European settlers, there were many different Indian tribes in California. In contrast to the Great Plains and the Southwestern Desert, Native Americans densly populated the areas in this part of the continent because of the abundance of natural resources. California tribes were grouped in larger units by language and culture. The type of environment in which each group lived generally determined cultural grouping. The cultural group of the Valley Nisenan (the Central Valley) was of the Penutian language group. They were part of the Maidu tribe and occupied territory in Central California from the high Sierra to the valley plain. Native groupings followed large waterways. For example, the Nisenan built their villages on the Notoman or East Water (American River). They lived in the valley bordered

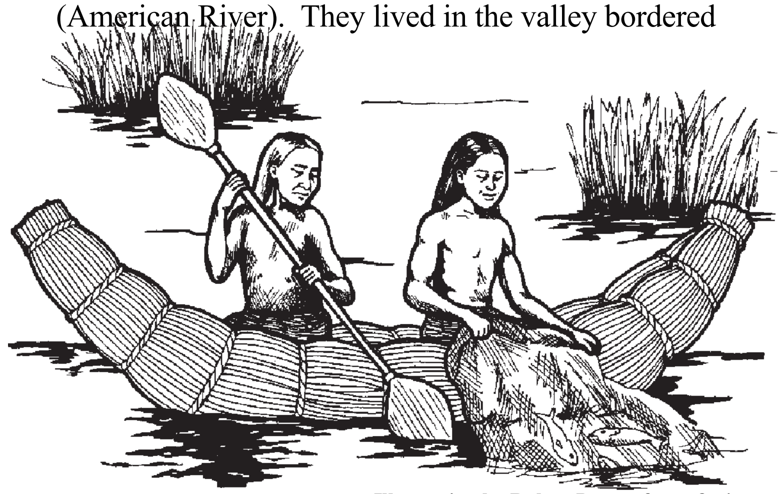


Illustration by Robyn Patton from *Ooti, A Child of the Nisenan.*

by the Sacramento, Bear and American Rivers. The Interior Miwok group occupied the land of the southern portion of the Sacramento Valley and northern portion of the San Joaquin Valley.

The land of the Great Valley was one of the richest habitats in California with its rivers, vast areas of grassland, fair quantities of variable woodland, and chaparral. The woodland provided deer, vegetables and the staple acorns; the grasslands provided antelope; the rivers provided salmon, and other fish and the large gallery forests along the riparian corridors provided more acorns. Fishing was important. Salmon, sturgeon and lampreys were taken, primarily in net, and often in conjunction with reed rafts or boats made of tules. The fish were usually roasted and eaten. However, much of the salmon was dried and stored to used throughout the year.

For tribes in the northwestern part of California, the rivers were especially important. Many northwestern tribes considered the rivers central to their existence. Salmon was a large portion of the diet of the peoples of the Klamath and Trinity rivers. As a consequence, ceremonies to ensure the bounty of the salmon were of great importance. These tribes' life cycles, religions and wars focused on the rivers, particularly the salmon of those rivers. The tribes of the central valley were provided with the abundance of game, fish, and plants with seasonal variations. Although salmon was a very important food, there is no documentation of salmon ceremonies for the Nisenan people.

Procedure

1. Native American story telling was important in passing oral tradition from one generation to the next. Stories were told by the shaman (spiritual doctor). He called upon the spirits for good crops and hunts. The shaman used animal people as story characters. One of the favorite characters is Coyote, the greatest of the animal people. Coyote is known as the trickster. He can be good or mischievous.
2. To help students learn about the Native American style of story telling, read *The Creation* story.
3. Next, introduce the students to the concept of a Readers' Theater. In Readers' Theater, students are assigned reading parts from a written script. The parts are read rather than memorized. Students sit on stools or stand in front of the class to do this. A microphone can be used as if the story is being broadcast over the radio. Explain that students will be writing their own original Readers' Theater script.
4. To help students understand a Readers' Theater, have them participate in one by using the following example. The class might want to include sound effects and possibly record the reading.
5. Ask students to create an original story about the American River, how it became polluted, and the health of the watershed to be restored. Ask students to use what they have learned about salmon and watersheds to guide their imagination.
   - The story can involve spirits, animals or plants, natural or human-made objects, or ordinary people. Encourage students to use their creative talents.
   - Once the story line is developed, students should write it for the Readers' Theater, using a narrator and any characters they wish.
6. Hold a Readers' Theater.

Extension

1. Have students make masks or other props to

Reader’s Theater
Why the Salmon Return Each Year

Characters:

Narrator
Raven
The Fog Princess
Raven’s Friend

Narrator: Raven liked to eat fish. But, in order to eat fish he must first catch them. On this day, Raven is fishing in his canoe with this friend, Gitsanuk.

Raven: Look at this, Gitsanuk. Another Bullhead! More bones to choke on! With all the water in this stream, one would hope for better fish.

Gitsanuk: Look Raven! The fog approaches quickly. We should head for shore.

Raven: It is too late. I can not see to guide the canoe. The fog surrounds us.

Fog Princess: Do not be afraid. I will see you safely to shore.

Raven: Who are you? How did you get in our canoe?

Fog Princess: Give me your hat.

Narrator: Raven and Gitsanuk watched in amazement as the Fog Princess (for that is who she was) gathered all the fog in Raven’s hat. When the fog was all contained, the sun shone again and Raven beached the canoe safely.

Raven: You have saved us with your magical powers. There is no one as good or beautiful as you. Will you stay with us and be my wife?

Fog Princess: Yes, Raven. I will be your wife and my wedding gift to you shall be a new fish so delicious that you have never tasted another like it. Gitsanuk, bring a bucket of water. Now watch as I dip my fingers into it.

Gitsanuk: Look, a golden fish. I shall build a fire.

Raven: Yes, we must cook it at once.

Gitsanuk: See how well the new fish roasts. The smell is truly wonderful.

Raven: And the taste is more wonderful still. Wife bring us more of these fish.

Fog Princess: Your hunger is now cared for. I can not produce that which is not needed.

Raven: I said I want more fish! Unless you produce them at once, I shall be angry at you!

Narrator: Just then, where the day had been still, a wind rose and shook the leaves from the trees. Raven and Gitsanuk were soon so covered with leaves that they could not see. Then, as quickly as it had begun, the wind stopped and the leaves floated to the ground. When Raven looked up, he saw that the Fog Princess had gone.

Gitsanuk: Raven, look to sea. The fog disappears there and the Princess with it. There, she is gone! Your selfishness has cost you dearly.

Narrator: And Raven hung his head in shame. But as we know, a wonderful thing did happen! Even today, the salmon return to the Indians’ streams once each year and it is said that the Fog Princess brings them… just enough each year to keep the tribe from hunger.

Activity and Readers’ Theater Story adapted from the Oregon Department of Fish and Wildlife Activity Guide, *The Fish Hatchery Next Door*.

The Creation

In the beginning there was no sun, no moon, no stars. All was dark, and everywhere there was only water. A raft came floating on the water. It came from the north, and in it were only two persons--Turtle and Peheipe, the clown. The stream flowed very rapidly. Then, from the sky a rope of feathers, called Pokelma, was let down, and down it came Earth Maker. When he reached the end of the rope, he tied it to the bow of the raft and stepped in. His face was covered and was never seen, but his body shone like the sun.

At last Turtle said, “Where do you come from ?” And Earth Maker answered, “I come from above.” Then Turtle said, “Brother, can you make for me some good dry land, so that I may sometimes come up out of the water?” Then he asked another time, “Are there going to be any people in the world?” Earth Maker thought awhile , and then said, “Yes.” Turtle asked, “How long before you are going to make people?” Earth Maker replied, “I don’t know. You want to have some dry land. Well how am I going to get any earth to make it?” Turtle answered, “If you will tie a rock around my left arm, I’ll dive for some.” Earth Maker did as Turtle asked, and then reaching around, took the end of a rope from somewhere, and tied it to Turtle. When Earth Maker came to the raft, there was no rope there, he just reached out and found one. Turtle said, “If the rope is not long enough, I’ll jerk it once, and you must haul me up; if it is long enough, I’ll give two jerks, and then you must pull me up quickly, as I shall have all the earth that I can carry.” Just as Turtle went over the side of the boat, Peheipe began to shout loudly, wondering what would happen to him.

Turtle was gone a long time. He was gone six years, and when he came up he was covered with green slime, he had been down so long. When he reached the top of the water, the only earth he had was a very little under his nails, the rest had washed away. Earth Maker took with his right hand a stone knife from under his left armpit and carefully scraped the earth out from under Turtle’s nails. He put the earth in the palm of his hand and rolled it about until it was round. It was as large as a small pebble. He laid it on the stern of the raft. By and by he went to look at it. It had grown so that it could not be spanned by the arms. The fourth time he looked, it was as big as the world, the raft was aground, and all around were mountains as far as he could see. The raft came ashore at Todoiko, and the place can be seen today.

This is the story as remembered and told by a Maidu

Story reprinted from *Ooti, A Child of the Nisenan,* published by The American River Natural Association, second edition 2000.

The River Valley Journal

Objectives
This is a summation activity for students to use information and knowledge they gained from previous lessons. Students will, (1) identify a diversity of issues related to salmon and its habitat; and (2) develop their own opinions concerning some issues involving salmon and its habitat.

Curricular Areas
Language Arts, Science, Art, and Social Studies

California Content Standards
GRADES 3-8

English/Language Arts

3rd Reading 2.0; Writing 1.0, 2.0; Written/Oral 1.0
4th Reading 2.0; Writing 1.0, 2.0; Written/Oral 1.0
5th Reading 2.0; Writing 1.0, 2.0; Written/Oral 1.0
6th Reading 2.0; Writing 1.0, 2.0; Written/Oral 1.0
7th Reading 2.0; Writing 1.0, 2.0; Written/Oral 1.0
8th Reading 2.0; Writing 1.0, 2.0; Written/Oral 1.0

Social Studies

3rd 3.1, 3.3, 3.5
4th 4.1, 4.4

Science

3rd Life 3 a, b, c, d, e; Investigations 5 e
4th Life 2 a, b, 3 a, b, c, d; Earth 5 c
5th Life 2 a, b, c, d; Earth 3 e; Investigations 6 i
6th Ecology 5 a, b, c, e; Resources 6 b; Investigations 7 d
7th Genetics 2 a, b, c; Evolution 3 a, d, e; Physical Science 6 b, c, e, f

Method
Students, as a class, write and produce a newspaper that features Chinook salmon and American River information and issues.

Materials
- Time to complete: (3) 50-minute class periods
- Student work from previous lessons
- Research or library resources for historical and native peoples information
- Art materials
- Camera and film or donated photos
- Sample neighborhood newspapers

Background
The production of a newspaper requires an array of skills including design capabilities, composition, research and decision-making. This activity provides an opportunity for the class to work cooperatively in the production of a newspaper. Students may research historical events, explore current issues, express their recommendations about salmon and their habitats, as well as use materials from previous lessons.

Procedure
1. Using an actual neighborhood newspaper as a model, discuss the various parts of a newspaper. Help the students recognize that a paper contains many different sections; in addition to news stories, there are comics, sports, editorials, food, entertainment, business, advertisements, weather, obituaries, and much more.
2. Explain that the class will work together to create a "Salmon Edition" of the *River Valley Journal*. Some students will work in a team while others will work individually. Have the class decide on the articles that will be included and compile a list. Review previous lessons for materials to include. Remind the class that the paper should have both satirical and serious articles. For example:
   - Cartoon: "Adaptable Ada: A Fish for All Habitats" (Fashion a Fish creation)
   - "Fish Race to Spawning Beds" (sports)
   - Food section: "Fine dining at the River Bend"
   - Book review: *The Life and Times of a*

49'er...“Miners changed the course of the waterways, and washed away mountains with hydraulic mining...”
- Editorial: “The need for water conservation”
- Kids page: “Create a Salmon Life Cycle” maze, word search, or cross word puzzle
- Use an interview from the “Fishy Facts” activity

3. Have the students choose an area of interest and begin researching and writing their stories. Encourage sharing and collaborating with others as they work. Keep students on task and make sure written information is accurate even for the humor and satire articles.
4. For the production part of the newspaper, use either a computer with newspaper template software, or have students hand-write their articles using a specified column format (3 ½ or 4 inches wide will work).
5. The artwork can be photos, illustrations or computer graphics. Help students with the use of equipment, computers, software, cameras, etc.
6. Once the newspaper is complete, copies can be made for the class and perhaps for distribution throughout the community.
7. Summarize this activity with a discussion of each article or feature. How does this newspaper demonstrate what students have learned about salmon and their habitat?

Extension

1. Instead of a newspaper, do a TV news talk show using a video camera.
2. Do an exhibit for a community event

Salmon Jeopardy

Objective
This activity will assess student comprehension of information regarding fish anatomy, the salmon life cycle, salmonid species, the food web and watersheds.

Curricular Areas
Language Arts, Science

California Content Standards
GRADES 3-8

English/Language Arts

3rd Listening/Speaking 1.0
4th Listening/Speaking 1.0
5th Listening/Speaking 1.0
6th Listening/Speaking 1.0
7th Listening/Speaking 1.0
8th Listening/Speaking 1.0

Science

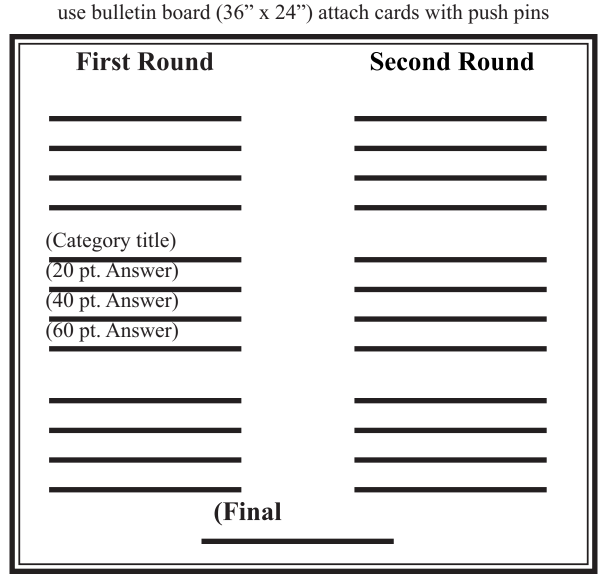
3rd Life Science 3 a, b, c, d, e
4th Life Science 2 a, b, 3 b; Earth 5 c
5th Life Science 2 a, b; Earth 3 d
6th Earth 2 a, b; Ecology 5 a, b; Resources 6 b
7th Genetics 2 a; Evolution a, e

Method
Students, in teams, will play a game of jeopardy to demonstrate the knowledge that they gained in prior lessons.

Materials
- Time to complete: (1) 50-minute class period
- Create game board (see illustration)
- (6) category cards
- (6) 20 point cards (answer on reverse)
- (6) 40 point cards (answer on reverse)
- (6) 60 point cards (answer on reverse)
- Final Jeopardy card
- Noise-maker and an index card per team

Procedure
1. Ask if everyone is familiar with the TV Jeopardy Game. Explain that the classroom version will have a few modifications. The class will be divided into 3 or 4 teams. Each team must work together when giving an answer in the form of a question.
2. There will be two regular rounds of 10 minutes each. The points in each category will remain the same in both rounds; the first answer is worth 20 points, the second answer is worth 40 points, and the third answer is worth 60 points.
3. The teacher starts the game by choosing and reading an answer card. The team to ring-in first has the opportunity to give the answer in the form of a question. Give the team a few seconds to discuss and agree on an answer. One person must give the group's answer (whoever is in control of the ringer must then pass on the responsibility).
4. If the team was correct, they score the points. If they are wrong, the points are subtracted from the team's total score. Ask if another team wants to answer. They must ring-in, discuss, and then answer in the form of a question. If correct, they receive the points; if they are incorrect, the points are subtracted from the team's total score.
5. The team who answers correctly chooses the next category and point value to be read. Complete as many as possible in the 10 minute round.
6. Start a second 10 minute round. Proceed the same as the first round.

use bulletin board (36" x 24") attach cards with push pins



JeopardyJeopardyJeopardyJeopardyJeopardyJeopardyJeopardyJeopardy

FIRST ROUND

Life Cycle

20 points	Where salmon grow to be mature adults	What is the ocean?
40 points	Salmon laying their eggs	What is to spawn?
60 points	Salmon hatchlings (just born)	What are alevins?

Anatomy

20 points	What fish use to breathe	What are gills?
40 points	These help fish to move in water	What are fins?
60 points	The sense used by salmon to find its home stream	What is smell?

Threats

20 points	A large brown furry animal that eats salmon	What is a bear?
40 points	A man made structure that holds back water	What is a dam?
60 points	Carried by water runoff into rivers	What is soil (or silt)?

SECOND ROUND

Family

20 points	Members of the salmonidae family	What is salmon and trout?
40 points	Name given to fish born in fresh water who migrate to the ocean then return to fresh water to spawn.	What are anadromous Fish? What is a steelhead?
60 points	A salmonid that is not a salmon but is anadromous	

Food Web What is a predator?

20 points	Animals that hunt other animals for food	What is a food chain?
40 points	The name for an order of plants eaten by an animal that is then eaten by another animal	What are producers?
60 points	A name given to plants, the group that forms the bottom of the food chain	

Watershed What is a watershed?

20 points	The land and the waterways that drain the land	What is the Sacramento
40 points	The large watershed where we live	River Watershed?

FINAL JEOPARDY

One of the five species of Pacific salmon: also known as king salmon. — What is Chinook?

Appendices

Bio in the Region *Pacific Salmon–A Unique Nutrient Cycle*

(This article is written by Gail Hickman Davis, primarily from excerpts of: Pacific Salmon Carcasses: Essential Contributions of Nutrients and Energy for Aquatic and Terrestrial Ecosystems by C. Jeff Cederholm, Matt D. Kunze, Takeshi Murota, and Atuhiro Sibatani; Fisheries, the Journal of the American Fisheries Society, Vol. 24, No. 10, October 1999.)

Pacific salmon and other salmonids (those fish in the genus Oncorhynchus) have evolved several unique adaptations to survive and exploit resources in a wide range of aquatic environments.

The most significant of these adaptations is that the fish spend most of their lives in the ocean and migrate upstream to freshwater to breed. This behavior is called anadromy, hence the salmonids are described as anadromous. They are also semelparous, which means they die after spawning once. Many species have adopted these behaviors, including chinook, chum, pink, sockeye, coho, masu, and amago. Anadromous trout such as cutthroat and steelhead repeatedly spawn (iteroparity) to varying degrees, depending on individual runs.

Since most species of Oncorhynchus are semelparous, a healthy spawning run will produce a large number of carcasses after the fish have spawned. Scientists have long observed that these carcasses play an important role in providing food for terrestrial consumers, as Russian expeditioner V.K. Arseniev observed around 1906 along one of the rivers emptying into the Sea of Japan:

> *For cleaning up these swarms of fish nature sent sanitary officials in the form of bears, pigs, foxes, badgers, raccoon, dogs, crows...and jays. The dead fish were taken by the birds as a rule, while the mammals tried to catch the living ones.*

Pacific salmon have long been considered an important conveyor of significant nutrients from the northern Pacific Ocean back to land. This represents a unique way to move nutrients upstream. This subject has attracted attention from scientists and economists throughout the Pacific Rim. Consider Japan's Edo era (1603-1867), when people believed that a streamside forest could provide fish with numerous benefits such as cover, nutrients, and food. This belief remained in the minds of people living near waterfronts or forests after the Meiji Restoration (1868). When the first forest act of Japan was introduced, at the beginning of the twentieth century, it contained an article ordering conservation of uo-tsuki-rin, literally "fish-attracting forest."

The movement of marine nutrients inland can be considered in the context of the Native American culture in the Pacific Northwest. Many Native American tribes in the Columbia River basin traveled long distances to partake in the catch and consumption of salmon, and in doing so distributed their excrement over this vast watershed and beyond. Some tribes of the upper Columbia were known even to cross the Continental Divide to trade dried fish with tribes of the upper Missouri River basin, thus providing another way to transfer marine-derived nutrients to the surrounding land mass.

Since salmon adults spend long periods feeding in the ocean and generally do not feed once they enter freshwater to spawn, the nutrients they release are almost entirely of marine origin. This process represents a major link among marine, freshwater, and terrestrial ecosystems.

The Research

The fate and utilization of nutrients provided by decomposing salmon carcasses may depend on numerous variables, including species (spawning densities and location in the watershed preferred for spawning), in-stream physical structure (retention of organic debris or otherwise), water flow levels, consumption by aquatic and terrestrial wildlife, and the conditions of the riparian ecosystem such as the amount of light that limits primary productivity.

Most studies show that primary production (production by photosynthesis) in lakes and streams is increased by nutrients released by salmon carcasses. Some studies in Alaska showed that salmon carcasses contributed nitrogen and phosphorus compounds to lakes and their tributaries. This probably enhanced the supply of phytoplankton and zooplankton available for young sockeye salmon.

Another study showed that adult salmon excretion and gamete (eggs and sperm) release prior to death also contributed substantial amounts of nitrogen (approximately 30% of the total) into the ecosystem.

There are three main pathways by which nutrients released from salmon carcasses get into the upstream ecosystem.

a. Primary production–producers are mainly green plants which use light energy from the sun to convert carbon dioxide (absorbed from air or water) and water to the sugar glucose. Oxygen is released as a by-product. This chemical conversion is photosynthesis. Plants are able to manufacture all the complex molecules that make up their bodies from the glucose they produce plus a few additional mineral nutrients. Some of these mineral nutrients come from salmon carcasses. Producers range in diversity from microscopic, single-celled algae to plants and large trees.
b. Microfauna on the streambed gravel–the small animals (some microscopic) that live on and among the gravel eat dissolved bits of the rotting carcasses.
c. Direct consumption of eggs, fry and carcasses

Contributions of marine nutrients from salmon eggs could be significant in many stream systems since an average of only 10%-30% of eggs deposited by a female will survive to emerge as fry. Many birds, fish, aquatic insects, and mammals will readily consume salmon eggs.

Eagle numbers decrease when there are high stream flows that wash salmon carcasses away. Many studies have shown a correlation between spawning salmon and where eagles go and how successful eagles are at reproducing.

It has been found that the timing of reproduction in female mink of Chichagof Island, Alaska, shifted to coincide with the availability of salmon carcasses. Annual runs of coho, chinook, and pink salmon provide female mink with unlimited food supplies, which help them meet their nutritional needs during lactation. Spawning salmon provide young animals with an abundance of food, giving them a selective advantage for survival.

Many of the energy requirements for hibernation in some bears are met by consuming salmon carcasses. This is because salmon are more nutrient-dense than virtually any other food source available to bears along the Pacific Northwest coast. Salmon contributed 33%-90% of the metabolized carbon and nitrogen in grizzly bears in the Columbia River basin the Pacific Northwest prior to 1931. Coastal Alaskan brown bears obtain virtually all of their carbon and nitrogen from salmon (85%-100%).

The animals using salmon carcasses within a riparian ecosystem each feed on various parts of the carcass. Twenty-two species of mammals and birds were observed or known to consume salmon carcasses in seven streams of the Olympic Peninsula, Washington. Large carnivores, such as bears or eagles, will first kill live salmon or retrieve carcasses from pools and then carry the carcass to the adjacent bank to be wholly or partially consumed. Smaller animals and scavengers then concentrate on the remainder of the carcass until just bone matter remains. Some small mammals may even use bone material from carcasses deposited on stream banks.

Bears, and other large mammals and birds, can transport carcasses a great distance from streambanks and often will not consume carcasses in the same location. The number of carcasses transported from a stream channel to riparian forest can constitute a large percentage of the stream's total salmon run. It was estimated that 3,611 carcasses, or 63% of an entire run, were moved to a riparian ecosystem by three to eight black bears in a stream in Gwaii Haanas, British Columbia. This allows for random distribution of the salmon-derived nutrients and the decaying carcass, and could have a fertilizing effect on riparian vegetation. Fertilization could occur either through the direct deposition of a carcass or through fecal matter of animals that have consumed carcasses.

Anadromous salmon and their carcasses clearly have significant roles in providing food and nutritional resources to numerous terrestrial animals. The presence and availability of salmon during fall and winter may be of significant importance to many animals since other food sources are limited at that time. Therefore, the ecologically significant connections between anadromous salmon and terrestrial wildlife merits increased attention in fish and wildlife management, ecosystern-based management plans and ecological research.

To ensure effective recycling of nutrients from the ocean back to land, the major vector of this process–wild anadromous salmonids–must recover from its current status. Identifying and securing channels for recycling inorganic nutrients are important components of biological diversity maintenance, at least in the North Pacific. The key to sustaining the human economy also may fie in these material cycles to some degree since our economy relies heavily on healthy ecosystems to sustain food production and other resources. Therefore, the importance of the nutrient feedback system of anadromous Pacific salmon illustrates the need for continued research and corresponding management to protect and recover native salmonid populations before the system collapses entirely.

"Whenever we try to pick out anything by itself, we find it

Glossary

adapted or adaptation: an adaptation is a characteristic that was inherited and cannot be changed in an individual; adaptations have a genetic basis and are passed on to offspring.
adipose fin: small fleshy fin on the back between the tail and the dorsal fin. Removed when the fish is tagged.
alga (-ae plural): a photosynthetic organism which lacks the structures of higher plants, such as roots or seeds; may be single-celled or may be large multicelled organisms such as seaweeds.
alevin: fry that still has the yolk sac attached.
anadromous: fish that live as adults in the ocean, but swim up into rivers and streams to lay their eggs.
angler: a person who fishes.
aquatic: growing, living or frequenting water. In this curriculum aquatic includes both fresh and salt water.
benthos (ic): of or on the bottom of a body of water.
buck: male salmon or trout.
carnivore: animal that eats other living animals which it catches, as opposed to a scavenger which consumes dead animals.
catadromous: animals that live in fresh water and move to the ocean to spawn.
Chinook: one of five species of Pacific salmon; also known as king salmon.
circuli: concentric rings on fish scales; used to tell age of fish.
classification (-ying): a systematic arrangement into groups or categories on the basis of characteristics shared.
cold-blooded: term used to describe animals whose internal temperature is determined by that of its environment; may be quite warm on a hot day; also called ectotherms. Plants function as ectothermic organisms.
consumer: an organism that does not do photosynthesis and must feed on other organisms.
dissolved oxygen: oxygen molecules mixed in solution with water.
ecological balance: the relatively stable conditions found in natural, undisturbed communities over time.
eyed egg: first noticeable stage of egg development.
erode (-sion): gradual wearing away; in this case water is the agent that causes the wearing away.
estuary: region where salt and fresh water mix in a partially enclosed body of water; generally at a river mouth or in lagoons behind barrier beaches.
fertilization: the process of joining egg and sperm.
fingerling: a young fish about the size of a person's finger.
food web (chain): the sequence of organisms in a community which produce food and consume it; the path that food (materials and stored energy) takes through a group of organisms.
fresh water: water with a salinity of less than 0.5 parts per thousand; no taste of salt.
fry: general term for young fish.
fungus: parasitic organism that can appear as a patchy, white growth on the skin.
gills: organs that allow fish to absorb oxygen from water.
green: a fish that is not ready to spawn.
grilse: two-year-old salmon returning to spawn; males are known as jacks, females as jills.
habitat: the arrangement of food, water, shelter, and space suitable to a specific animal's needs. It is the physical and biological environment in which an animal completes its life cycle.
hatchery: a place for spawning fish artificially and raising the young fish.
hen: female salmon or trout.
herbivore: animal that eats plants or algae (photosynthetic organisms).
jack: male grilse.

jill: female grilse.
ladder: a series of steplike waterfalls constructed to allow fish to swim over high barriers (for example, dams and river banks) .
lateral line: row of sensory pores that form a lengthwise line on the side of a fish. It senses water movements and electrical impulses.
migrate: to move periodically or seasonally from one region to another.
migration: movement of animals from one area to another; frequently done on a seasonal basis between specific areas.
milt: sperm.
non-point source pollution: contaminated runoff originating from an indefinite or undefined place, or more often a variety of places
photosynthesis: chemical process that takes place inside cells in which light energy is used to make carbohydrates from carbon dioxide and water; oxygen is a waste product of this reaction; takes place in plants including algae, such as seaweeds and phytoplankton.
phytoplankton: small, generally microscopic aquatic organisms that are photosynthetic and drift with the currents; generally single-celled; includes many kinds of organisms called algae
planting: relocating hatchery fish to a natural environment.
point source pollution: pollution that is released from a specific known source that has an exact location.
predator: animal that hunts and eats other animals.
prey: organism that is eaten by a predator.
producers: organisms that make food; in this curriculum primary producers, generally photosynthetic organisms, are simply called producers.
redd: gravel nest dug by a female salmon for the purpose of laying her eggs.
respiration: chemical process that takes place in the cells of plants and animals in which carbohydrates are broken down and energy is released which can be used by the cells to do work; most common form involves the use of oxygen and the release of the waste products carbon dioxide and water.
ripe: a fish that is ready to spawn.
roe: fish eggs.
salt water: ocean or sea water; salinity of 35 parts per thousand.
skein: membranous packet inside the female in which eggs develop.
smolt: stage of development during which the young fish go through physical changes that prepare them for the transition to salt water.
spawn: the release of eggs for fertilization in the water.
spawning: process of reproduction in fish.
spawning colors: outward color changes on fish noting readiness to spawn.
steelhead: Rainbow trout that migrate to the ocean.
swim bladder: gas filled organ found in most bony fish which is inflated or deflated to adjust the buoyancy of the fish and changes its position in the water.
tagging: marking an individual fish so scientists can tell it from any other.
trolling: the fishing technique of dragging a line through the water behind a slow-moving boat.
turbid: prevents the passage of light; cloudy or opaque.
viscosity: resistance to flow.
weir: artificial barrier that prevents fish from swimming upstream but still allows water to flow downstream.
yolk sac: attached food supply for newly hatched fry.
zooplankton: generally small to microscopic aquatic animals, larvae or eggs that are not strong swimmers and drift with currents; may be a temporary resident of zooplankton or may be a permanent member.

Resources

Salmon Non-fiction Books

Come Back, Salmon: How A Group of Dedicated Kids Adopted Pigeon Creek and Brought It Back to Life. Molly Cone, Sidnee Wheelwright (Illustrator).

Discovering Salmon by Nancy Field, Sally Machlis (Contributor): Workbook and activities, order at: www.heritagehouse.ca/summaries/discoveringsalmon.htm

Field Guide to the Pacific Salmon. Adopt-A-Stream Foundation, Robert Steelquist.

Life Cycle of a Salmon. Angela Royston.

Observing Nature: Salmon. Stephen Savage, Colin Newman (Illustrator).

Pacific Salmon: Alaska's Story. Alaska Department of Fish and Game.

Pacific Salmon: Life Histories. G. Groot, et al.

Reaching Home: Pacific Salmon, Pacific People. Tom Jay (Photographer), and Brad Matsen.

Salmon. John M. Baxter.

Salmon. Sylvia M. James, Paul Bachem (Illustrator).

Salmon Nation : People and Fish at the Edge. Elizabeth Woody (Editor), et al.

Salmon Stream. Carol Reed-Jones.

The Salmon. Sabrina Crewe, Colin Newman (Illustrator). (Explanation of salmon life cycle.)

Salmon Fiction Books

A Salmon for Simon. Betty Waterton, Ann Blades (Illustrator).

Down to the Sea: The Story of a Little Salmon and His Neighborhood. Jay Nicholas (illustrator).

Magic School Bus Goes Upstream : A Book About Salmon Migration. Joanna Cole, Bruce Degen (Illustrator)

Salmon Summer. Bruce McMillan (Illustrator).

Related Non-fiction Books

California Rivers and Streams. Dr. Jeffery Mount.

Creek Critters, A Guide to Common Aquatic Vertebrates and Invertebrates of Central California. This book is a great identification guide. Order from: Livermore Area Recreation & Park District, 71 Trevamo Rd., Livermore, CA 94550. Attn: Ranger Supervisor, phone (925) 373-5770.

First Fish, First People: Salmon Tales of the North Pacific Rim. Judith Roche, Meg McHutchison, editors.

Freshwater Gamerish of North America. Dick Stemberg.

Totem Salmon : Life Lessons from Another Species. Freeman House.

Related Fiction Books

A River Dream. Allen Say.

Devil's Bridge. Cynthia DeFelice.

The Fish Princess. Irene N. Watts, Steve Mennie (Illustrator).

My Father's Boat. Sherry Garland TedRand (Illustrator).

A Swim through the Sea. Kristin Joy Pratt.

Salmon Media

"Cyber Learning Collection": Task Force is a two volume, comprehensive CD-ROM series that investigates salmon ecology and the conflict over salmon restoration at http://www.cyberlearn.com

"Find Your Way": http://www.pbs.org/wgbh/nova/hokkaido/migration.html

The Pacific Salmon and Steelhead Coloring Book U.S. Fish and Wildlife Service. Contact Viola Taylor violataylor@mail.fws.gov

"The Salmon and the Stream" audio tape. Journeys Home. Living River, 16636 74h Ave, NE, Bothel, WA 98011.

"Salmonids in the Classroom," Department of Fisheries and Oceans, British Columbia: http://salmonid.sd73.bc.ca/site.html

"Salmon in the Classroom": www.fish.washington.edu/sic/index.html

"The Salmon Page": www.riverdale.k12.or.us/salmon.htm

Related Media

"Chinook Salmon": http://students.washington.edu/manu19b/UWchinook.html

"eNasco": online catalogue for educational materials at http://www.nascofa.com/prod/Home

"Fly & Field": Trey Combs, author of steelhead books, good local/regional fishing info available at American Fly Fish (Watt & Fair Oaks): http://www.flyfield.com/clipart.htm, http://www.graphsearch.com, www.chartingnature.com

Gyotaku: many sites, ask mamma.com

Glacier Chiller: http://www.glaciercorp.com/index2.html.

"Nature Watch": The ultimate resource for indoor and outdoor educators at 9811 Owensmouth Ave #2, Chatsworth CA 91311, 800/228-5816, 800/229-5814 FAX info@nature-watch.com, www.nature-watch.com

Salmon Videos

Bringing Back the Salmon: Bypassing Dams to Restore Snake River Salmon. National Wildlife Federation 2000. The current threats facing the lower Snake River salmon: how dams kill salmon, recovery methods that, so far, have failed, and explains why dam removal is the best chance these salmon have to survive. 15 minutes.

Journey of the Kings. Northwest Power Planning Council. Depicts the plight of Columbia River Salmon and the regional program designed to protect them. The camera soars over and dives into some of the Northwests most breathtaking environments as it follows the migrating salmon from their freshwater streams to the Pacific Ocean and back again. 26 minutes. 503/230-4171. http://www.bpa.gov/Corporate/KR/ed/page6.htm

Last Chance for the Pacific Salmon. Terra Video 1995. An in-depth look at crises and solutions. 60 minutes. (800) 333-4350.

Life Cycle of the Salmon. Oregon Sea Grant 1999. ORESU-V-99-002. The story of salmons IM cycle with remarkable images that reveal the salmon's world, often from their underwater point of view. A clear, informative narration makes the video suitable for viewers of all ages. 5:30 minutes. (800) 375-9360. http://seagrant.orst.edu/sgpubs/multimedia.html

Nature: Miracle of the Scarlet Salmon. WNET, Time Life Video 1988 #WX052. Award winning film documents the four year life cycle of the gallant and determined sockeye salmon. 60 minutes. (800) 336-1917 ext. 100.

Return of the Salmon: Restoring the Fish to Rivers and Watersheds: Oregon Sea Grant 1995. ORESU-V-95-001. Informative overview of the causes of salmon decline, importance of watersheds in restoration, and actions of watershed groups. 33 minutes. MO 375-9360.

http://seagrant.orst.edu/sgpubs/multimedia.html

Salmon and Steelhead on the Edge. Katherine Domeny Associates 1988. A provocative documentary that traces the decline of California's fisheries and argues recovery is possible. 29 minutes. P.O. Box 2100 Davis, CA 95617-2100.

Salmon Project Video Series. Digital Studios 1996. Teaches students in grades 7-12 to develop critical thinking skills about the preservation and use of natural resources, using the decline of the Pacific salmon as a case study. (800) 499-3322. http//www.cyberlearn.com/

Salmon: Why Bother? Oregon Sea Grant 1999. ORESU-V-99-001. Why do people care that many salmon runs in the Northwest are on the verge of extinction? Six diverse Oregonians give their own views about why they're involved - in various ways - in helping restore salmon and their watersheds. 12 minutes. (800) 375-9360. http://seagrant.orst.edu/sgpubs/multimedia.html

The Days of Salmon Traps and Pirates. John Sabella & Associates 1995. Tall tales from tire fishing grounds of yesteryear. 30 minutes. (206) 632-6272.

The Great Age of Salmon. John SabeUa & Associates 1994. History of the Northwest and Alaskan salmon industry and the Pacific American Fisheries Company. 30 minutes. (206) 632-6272.

The Magic School Bus Goes Upstream. Scholastic #308 1997. The salmon bus won't stop. Using its sense of taste and smell, it swims the long joumey to a shallow freshwater stream miles away. 30 minutes. TV.

Wild Salmon Forever. Sierra Club, 1996. 22 minutes. (510) 654-7847. http://www.sierraclub.org/store/

Related Videos

Eyewitness: Fish. BBC Wildvision, 1994. Fish guides us on a dazzling voyage of discovery through the waters of the world to investigate the myths and facts about these exotic creatures. 30 minutes. www.amazon.com

Farmers of the Sea. VHS Video. J. R. Larison, L. Weimer, and J. E. Lannan. Oregon Sea Grant, 1984. 57 minutes. (800) 375-9360. https://admtn.ucsadm.orst.edu/marketplace/web/

In Our Hand. CA Department of Fish and Game, 2003. Video of Nimbus Fish Hatchery. 10 minutes.

Unconquering the Last Frontier. Robert Lundahl and Associates 2000. Documentary film that chronicles the historic saga of the damming and widening of Washington's Elwha River. (415) 543-3155. http://www.evolutionfilm.com

Up the Down Stream. California Department of Water Resources. Feather River Fish Hatchery. 12 minutes. (916) 653-4893.

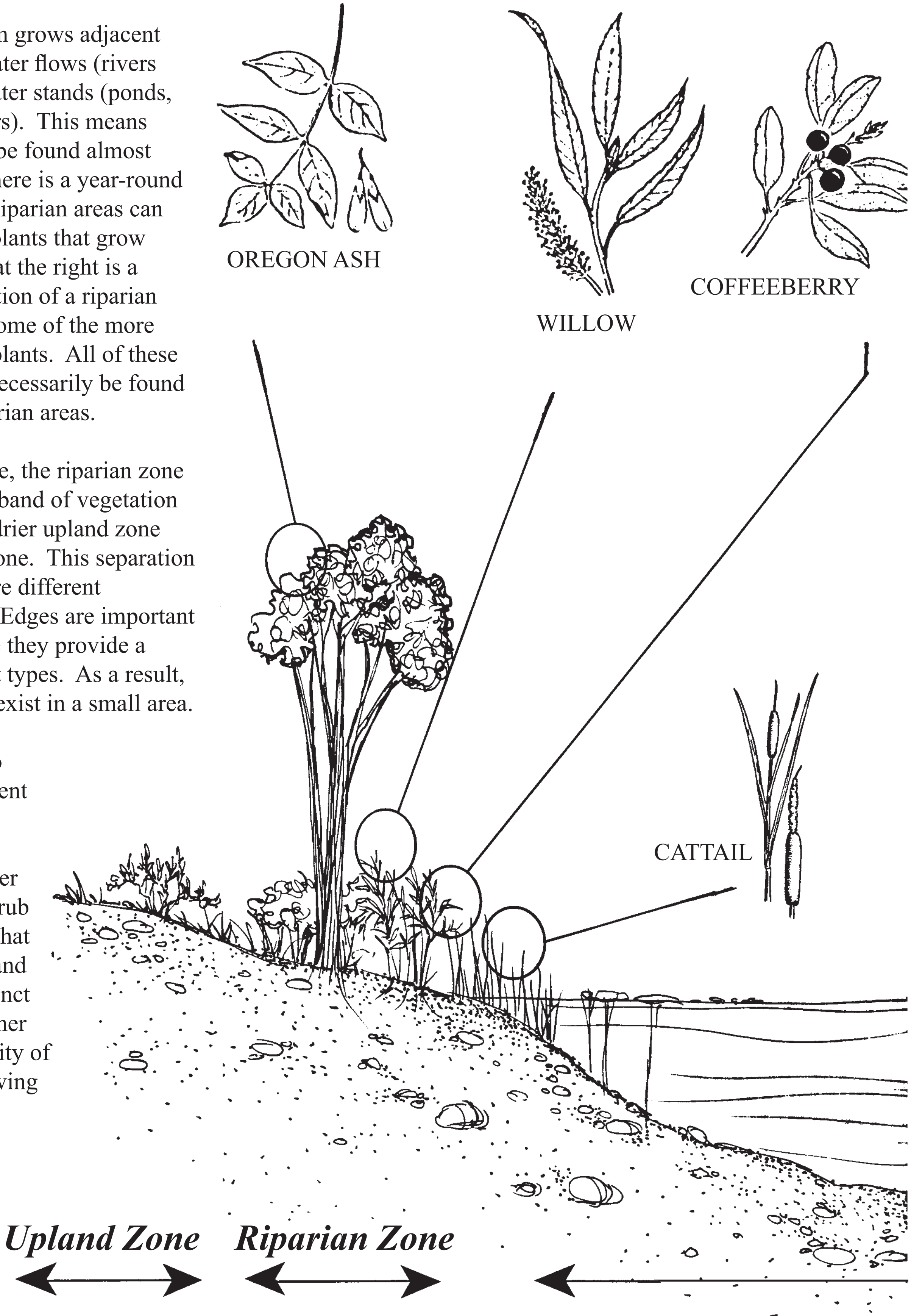
A Visit to the Feather River Hatchery. California Department of Water Resources. A young girl talks to her classmates about her trip to the fish

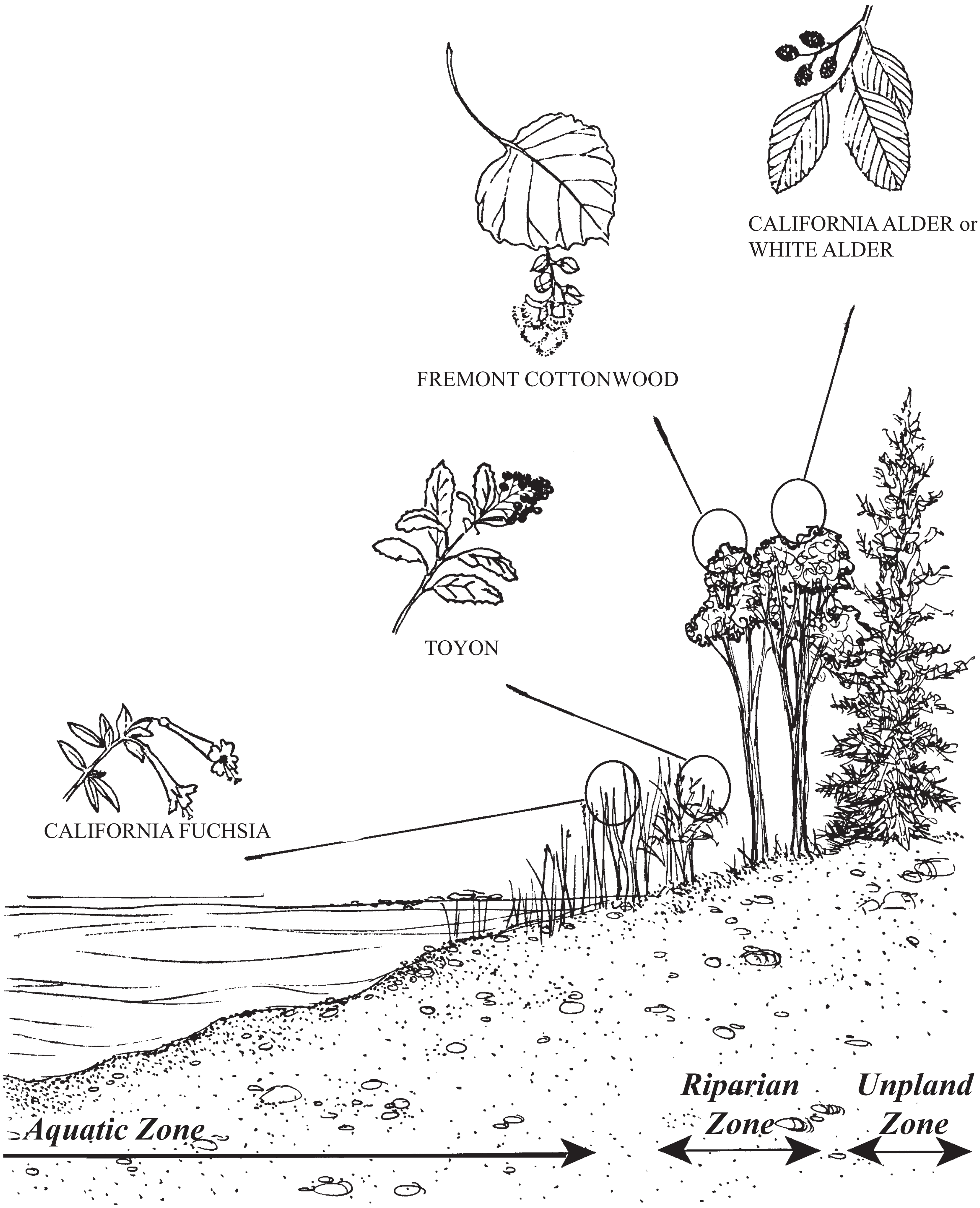
Common Plants of a Riparian Zone

Riparian vegetation grows adjacent to places where water flows (rivers and streams) or water stands (ponds, lakes and reservoirs). This means riparian areas can be found almost anywhere where there is a year-round source of water. Riparian areas can be recognized by plants that grow there . The scene at the right is a general representation of a riparian area. Shown are some of the more common riparian plants. All of these plants would not necessarily be found together in all riparian areas.

Viewed from above, the riparian zone is a narrow, dense band of vegetation that separates the drier upland zone from the aquatic zone. This separation creates edges where different ecosystems meet. Edges are important to wildlife because they provide a diversity of habitat types. As a result, more animals can exist in a small area.

Riparian areas also have several different vertical layers; tall cottonwood trees create a canopy over the thick willowshrub level and beneath that are grasses, forbs and cattail. These distinct vertical layers further increase the diversity of habitat types, allowing




CALIFORNIA ALDER or
WHITE ALDER
FREMONT COTTONWOOD
TOYON
CALIFORNIA FUCHSIA
Aquatic Zone
Riparian
Zone
Unpland
Zone

Where Water Meets the Land...the Riparian Zone

Riparian areas are important places for wildlife. Riparian areas provide animals with food, water and shelter. Riparian areas are important to people, too. They help keep water clean, protect land from erosion and are peaceful places to visit.

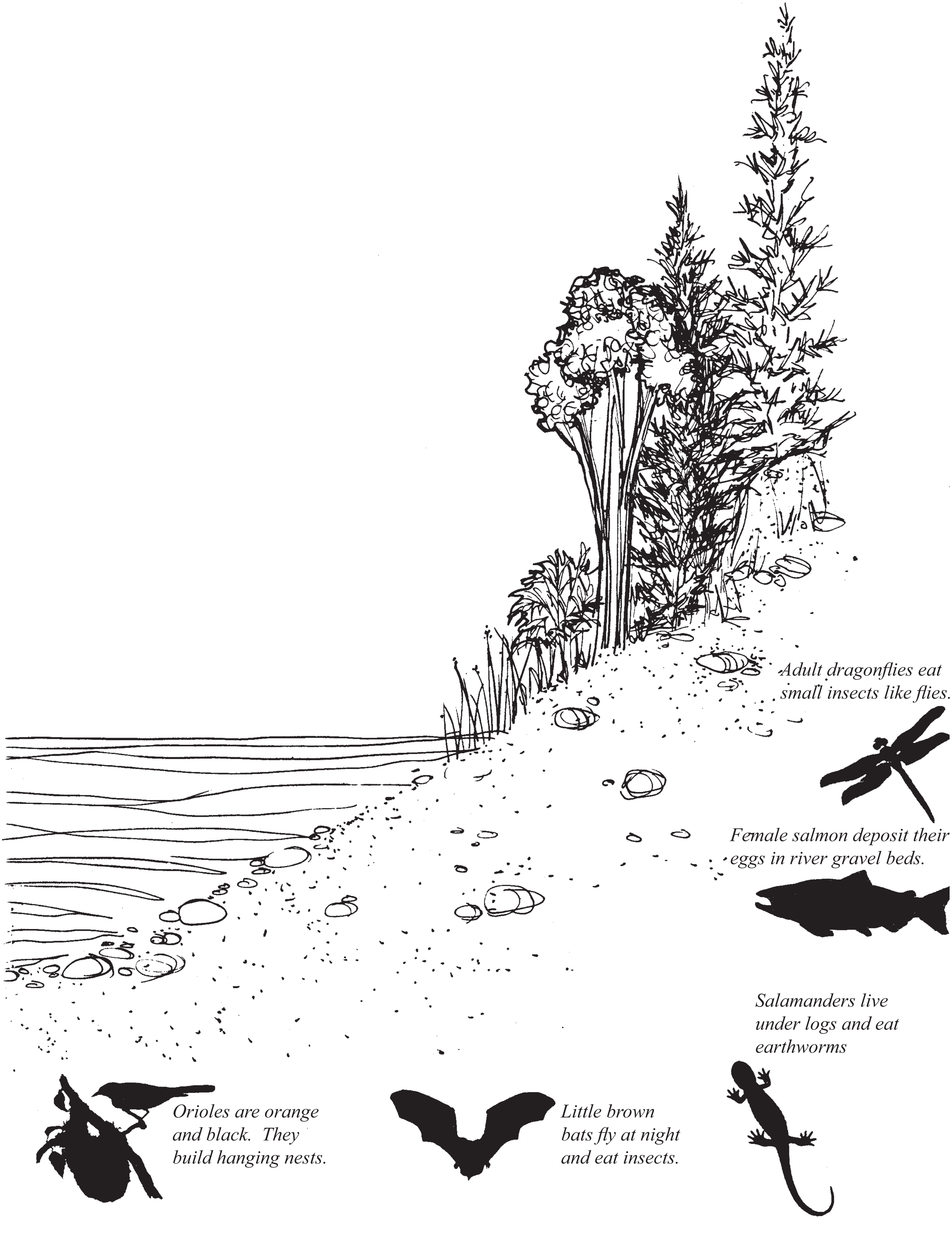
Look at the animals on this page. They need a place to live. Help them find a home. Draw a line from the animal to the place where it may be found.

Kingfishers dive from trees into the water to catch fish.

Mayflies can fly as adults. They live underwater as a nymph.

Garter snakes swim well. They eat frogs and other small animals.

Great blue herons are big wading birds. They catch fish.



Adult dragonflies eat small insects like flies.
Female salmon deposit their eggs in river gravel beds.
Salamanders live under logs and eat earthworms
Orioles are orange and black. They build hanging nests.
Little brown bats fly at night and eat insects.

Grade Level Index

Grade Level
X targeted
0 useful

Activity	Page	Pre-K-2	3-5	6-8
Fishy Facts			X	X
ECE Fishy Facts		X		
Fashion a Fish		0	X	0
Light Vision			X	X
Variations of a Theme			X	X
Finger Fish		X		
The Salmon Story		X	0	
The Great Anadromous Fish Game			0	X
Hooks and Ladders			X	0
ECE Hooks and Ladders		X	0	
Homing Insticts			X	X
Watershed Model			X	0
Home Wet Home			0	X
Erosion			X	0
Stream Planning			0	X
Aquatic Ecosystems			X	
Aquatic Connections		0	0	X
Designing Hatcheries				X
Assess Impact		0	X	X
Legends and Stories			X	0
River Valley Journal			X	X
Salmon Jeopardy			X	X

Student Assessment

Please copy the assessment sheet and have each student answer what they can before you begin activities. **Assure your students that this is not a test.** It is a survey to record their knowledge.

When you finish the salmon units, have students complete the assessment again. Score the assessments (this may be done by students or the instructor) and record the scores on assessment sheets.

Discuss the correct answers with the students. Emphasize how much they learned from the activities. The assessment is a record of the knowledge they have gained.

Return assessment sheets (both pre and post) with any suggestions or comments you have about the Activity Guide. The assessments will help us justify the Sports Fish Restoration Funding Grant that supports this program.

Return pre & post assessments to:

Bobbie Winn
Department of Fish & Game
1416 Ninth Street, Room 117
Sacramento, CA 95814

Answers

K-2

1. 1-Spawners, 2-Egg, 3-Alevins (or sac-fry), 4-Fry, 5-Smolt, 6-Adult (see *Salmon and Steelhead Life Cycle*, Unit 2)
2. (See *Fish Adapted to Life in the Water*, Unit 1)
3. 5
4. Bear, angler, otter, eagle
5. Fry should by in fresh water and adult in ocean.

3-5

1. spawning
2. salmon or salmonid
3. erosion
4. ocean to fresh water
5. oxygen
6. b. watersheds
7. c. dam
8. a.,b.c.d. (all of the choices)
9. A food chain is the sequence of organisms in a community which produce food and consume it. It is the path food takes from plants to animals and shows the transfer of energy from plants to other organisms.
10. The answer should include the six life stages (egg, alevin, fry, smolt, adult and spawner) and that salmon hatch in fresh water, migrate to the ocean and return to fresh water to spawn.

6-8

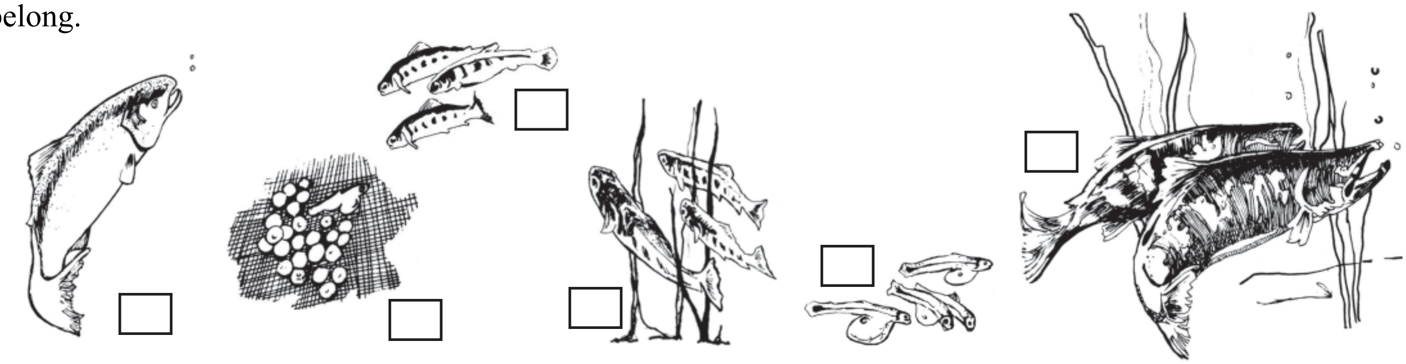
1. spawning
2. salmon or salmonid
3. erosion
4. ocean to fresh water
5. oxygen
6. watershed
7. Answers may include: loss of habitat, dams, removal of gravel, chemicals and pesticides in the water, pumps to remove water, removal of vegetation.
8. Genetic diversity enables an individual organism of adapt to variations or changes in the environment. Hatchery practices: use a large number of spawning pairs, use fish from the entire run, and monitor the number of hatchery fish released to avoid impacting the habitat for wild salmon, use fish from the stream being improved.
9. Food webs are made up of food chains and show how organisms within an ecosystem are interrelated. Food webs represent the transfer of energy from one organism to another, usually as one eats the other and show the transfer of energy from plants to animals. Examples of food webs will vary.
10. Answers will vary but should include the human handling of solid waste, toxic chemicals, water; practices used in agriculture, logging, industry, for recreation, for land development, and the introduction of non-native species.

Grade___________ Number of correct answers________

Salmon

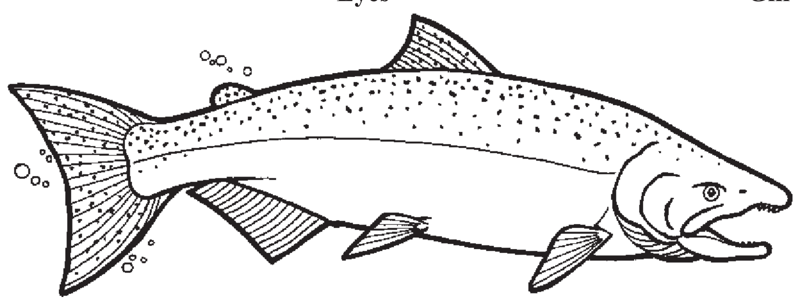
Pre & Post Student Assessment: Kindergarten through 2nd grade

1. Put the life cycle stages in order: Place a number next to each stage to show the order in which they belong.



2. Parts of a fish: Draw a line from the word to the area where it is found on the fish:

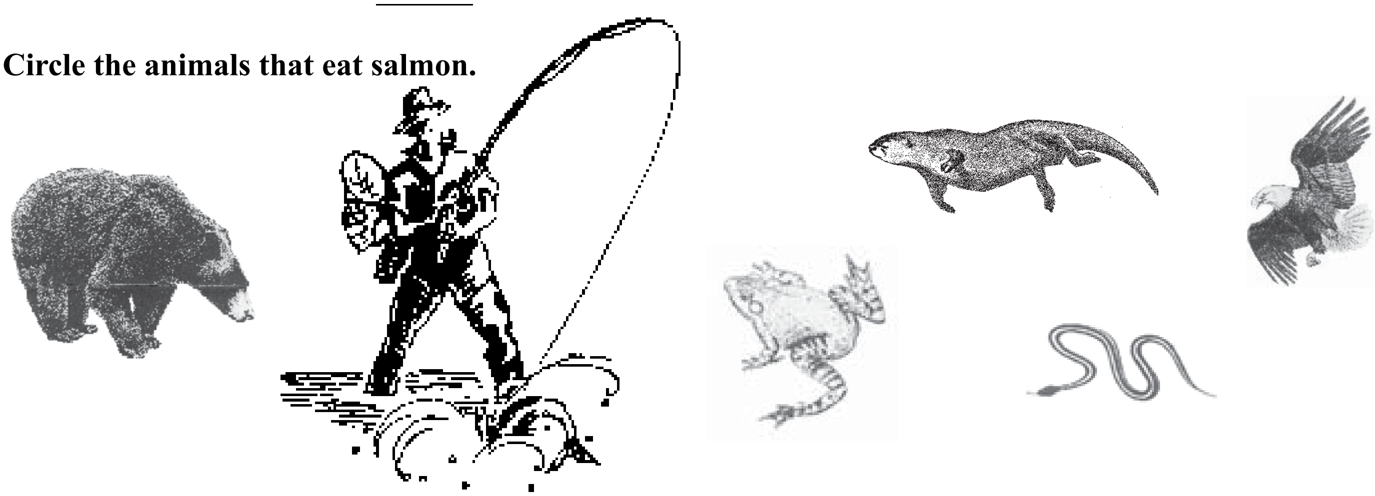
Fins (6) **Eyes** **Gill**



Head **Lateral Line** **Mouth** **Nostrils**

3. Fill in the blank: There are ______kinds of Pacific Salmon.

4. Circle the animals that eat salmon.



Grade___________ Number of correct answers________

Salmon

Pre & Post Student Assessment: 3rd through 5th grade

Fill in the blanks with the correct word or words to complete the sentence.

1. Female Salmon releasing eggs for fertilization is called ___________________________.

2. Steelhead and salmon are part of the ______________________________ family.

3. The roots of plants help prevent _________________________ along a river bank.

4. Anadromous fish migrate from the ________________ to __________ __________ to spawn.

5. Gills are organs that allow fish to absorb______________________ from water.

Make your choice: circle the correct answer, there may be more then one correct answer.

6. The land and the waterways that drain the land are called?
   a. rivers
   b. watersheds
   c. erosion
   d. canyons
7. A man made structure that holds back water, used for flood control or water storage is called?
   a. a pond
   b. a lake
   c. a dam
   d. a bridge
8. Which of the following animals eat salmon?
   a. humans
   b. bears
   c. bass
   d. seals

Short answer: use the back of this paper for your answers.

9. Write a description of a food chain and give a example of a 3 or 4 part food chain.

10. Write a paragraph about the life cycle of the salmon. (use the back of this page)

Grade___________ Number of correct answers________

Salmon

Pre & Post Student Assessment: 6^{th} through 8^{th} grade

Fill in the blanks with the correct word or words to complete the sentence.

1. Female Salmon releasing eggs for fertilization is called ___________.

2. Steelhead and salmon are part of the _________ family.

3. The roots of plants help prevent _________ along a river bank.

4. Anadromous fish migrate from the _______ to ______ ______ to spawn.

5. Gills are organs that allow fish to absorb___________ from water.

6. The land and the waterways that drain the land are called a ___________.

Short answer: use the back of this paper for your answers.

7. Why is the Chinook salmon in trouble? Name four reasons.

8. Explain genetic diversity, why is it important? What hatchery practices help maintain genetic diversity?

9. Write a description of a food web and provide an example.

10. Name three actions that humans can do to help and three actions humans can do to harm salmon.