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FOREST STEWARDSHIP SERIES 12

Fish and Fish Habitat

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Streams that flow through forested areas often contain some of the best fish habitat in California. However, people's activities in forests can reduce the quality of this habitat. To prevent unintended effects of human actions, it is important to know a little about fish and their needs.

Objectives

Understand salmonid habitat needs and how these depend on proper forest and land management to maintain water quality, stream channel habitat, and riparian vegetation.

Competencies

- *Learn the habitat requirements and biology of anadromous and resident salmonids, including salmon and trout.*
- *Recognize that water quality, channel features, channel substrate, and riparian vegetation are critical components of aquatic habitat for fish.*
- *Become familiar with the protection of aquatic habitat quality during forest management and other land uses through best management practices and the use of riparian buffer strips.*

Related Forest Stewardship Series Publications

- *Riparian Vegetation, ANR Publication 8240*
- *Forest Ecology, ANR Publication 8233*
- *Laws and Regulations Affecting Forests, Part I: Timber Harvesting, ANR Publication 8249*
- *Forest Streams, Publication 8239*
- *Forest Water Quality, ANR Publication 8241*
- *Technical and Financial Assistance, ANR Publication 8253*

UC PEER REVIEWED

This publication focuses on cold-water fish such as trout and salmon because they are most commonly associated with coastal and montane forests. These fish require aquatic habitats with year-round water temperatures below 68ºF (20ºC), high levels of dissolved oxygen, clear water, and a stony or gravelly substrate (streambed). They are common in small and large perennial streams, although they may spawn in intermittent streams. Cold-water fish are also found in larger lakes and ponds at higher elevations (fig. 1).

Warm-water fish can tolerate higher water temperatures of up to 80ºF (26ºC) or even more for short periods, as well as lower oxygen levels and muddy bottoms. Typical warm-water fish include bass, perch, and catfish. Warm-water fish are commonly found in ponds, lakes, and large streams. They are also found in places where cold-water fish would normally exist but where the existing temperature and water quality prevent their occurrence.

SALMONID BIOLOGY

Two general classes of salmonid fishes inhabit California's forest streams: year-round residents and anadromous residents. Year-round salmonids live in the stream for their entire life cycle. Anadromous salmonids spend much of their life cycle in the ocean but are hatched, reared, and return to spawn in fresh water streams. The four anadromous salmonid species in California are chinook salmon, coho salmon, steelhead trout, and coastal cutthroat trout. In recent years, chum salmon have also been found in California, even though their natural range was thought to be farther north.

Salmon life cycles are complicated and vary from species to species. In general, they have three important life stages: eggs, young fish (juveniles) that live in fresh water and then migrate to the sea, and adults. Adults migrate back from the ocean to their natal streams to spawn. These spawners deposit eggs and bury them in gravel nests called redds. The embryos incubate and hatch in the redd and emerge as "fry" after they have consumed

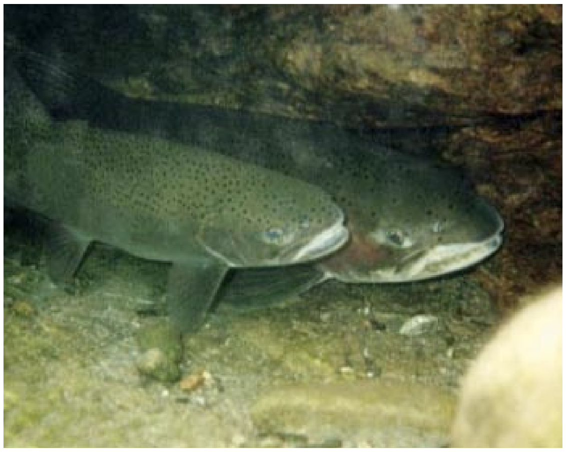

Figure 1. Steelhead trout in the Trinity River, below Lewiston Dam. The dam prevents access to miles of suitable spawning habitat upstream. *Photo:* Richard Harris.

their yolk supply. The timing of fry emergence is determined by water temperature during incubation. Normally, fry emerge in the spring, and, depending on the species and stock, the young fish can remain in fresh water streams or lakes 1 to 2 years before migrating to the ocean.

Coho salmon remain in their stream-rearing habitat for up to a year after emerging from the redd. They then spend 2 years in the ocean before returning to freshwater streams to spawn and die. Steelhead trout may stay in a stream for 1 to 3 years and then live in the ocean from 1 to 4 years. Up to half of all adults do not die after spawning; they return to the ocean and may spawn again. Young cutthroat trout spend up to 2 years in fresh water before migrating to the sea. Those found above migration barriers on coastal streams live out their lives in fresh water. Chinook salmon vary considerably in the length of fresh water rearing they require, a built-in flexibility that can limit the degree to which stream habitat or flow changes can impact this species.

In addition to the four species of anadromous salmonids described above, ten species and subspecies of native resident trout and four species of non-native resident trout are found in California (table 1). Although several of these fish (e.g., brook trout) can tolerate slightly warmer water conditions than the anadromous salmonids, they are all cold-water fish that require excellent water quality.

Resident salmonid adults spawn in fine gravel under conditions similar to those used by anadromous salmonids. Kokanee salmon and brook trout can spawn in streams or at lake margins. Many resident juvenile salmonids frequently live out their lives in the immediate vicinity of their birthplace; others may move downstream to larger streams or, like kokanee salmon, migrate to a lake environment.

AQUATIC HABITAT QUALITY

Salmonids require abundant insects or small fish as a food source, clean cold water, escape and hiding cover, and a gravelly channel substrate for spawning. Water quality, channel features, channel substrate, and riparian vegetation are all critical to maintaining quality aquatic habitat in streams. The health of the entire aquatic ecosystem is important to fish.

Water Quality

High dissolved oxygen content and cool water are critical to maintaining salmonids and the aquatic insects they feed on. Cold-water fish, amphibians, and insects can tolerate only relatively narrow ranges of temperature. Temperature also affects the amount of dissolved oxygen in the water, which in turn affects the ability of organisms to respire. Most aquatic creatures cannot live in water that has a low dissolved oxygen content. Low dissolved oxygen is often associated with stagnant water or water that has been enriched with nutrients or decaying organic matter.

Channel Substrate

Channel substrate refers to the rock or soil materials that make up a streambed. Salmonids must lay their eggs in a clean gravel stream bottom. The relatively large size of the gravel allows water to circulate and carry dissolved oxygen to the eggs. When the eggs hatch, the young fish hide from predators in the spaces between the gravel; if excessive fine sediment fills these spaces, the young fish are deprived of hiding places. Sedimentation can also smother insects that live in the channel bottoms and prevent

Table 1. Non-anadromous salmonid species in California

Species	Range	Biology	Subspecies
rainbow trout	Native non-anadromous form of steelhead trout. Most widespread and popular resident trout in California due to plantings.	Spawns in spring in cold streams (50°F, 10°C).	Coastal rainbow trout; Eagle Lake rainbow trout (capable of living in highly alkaline waters).
golden trout	Native; transplanted throughout California.	Adapted to high-elevation lakes and streams. Spawns in spring.	Volcano Creek golden trout; Little Kern River golden trout; Kern River golden trout.
cutthroat trout	Native non-anadromous form of cutthroat trout. Native to eastern side of the Sierra Nevada.	Spawns in spring in cold water.	Lahontan cutthroat trout (native to the Truckee, Walker, and Carson Rivers); Paiute cutthroat trout.
redband trout	Native; three remnant populations remain.	A close relative of the coastal rainbow trout.	McCloud River redband trout; Goose Lake redband trout; Warner Lake redband trout.
brown trout	Non-native but planted widely throughout the state.	Prolific fall spawner in high mountain lakes, reservoirs, and streams.	None.
brook trout	Non-native but planted widely throughout the state.	Spawns in fall and early winter. Tolerates warmer waters than rainbow trout.	None.
lake trout	Non-native; planted in Lake Tahoe.	Requires deep waters.	None.
kokanee salmon	Non-native; planted in Northern and Central California	Landlocked form of sockeye salmon.	None.
bull trout	Extinct in California.	A native species of char.	None.

water from carrying dissolved oxygen to eggs. The channel bottoms also provide a place for aquatic plants to root, including algae and plankton, which serve as food sources for insects and fish.

Channel Complexity

Channel complexity is the arrangement of bed forms in a stream. Generally, productive salmonid streams have equal proportions of fast water (riffles) and slow water (pools), slackwater side channel areas that provide refuge during high flows, and abundant shelter from predators and fast water (rocks, boulders, logs, and overhanging banks) (fig. 2).

The more diverse the spatial arrangement of material in the stream channel, the greater the diversity of the aquatic community and, generally, the better the habitat for salmonids.

- Rocks and large woody debris create pools and riffles in a stream.
- Riffles are areas of swifter flowing water where the surface is turbulent. The flowing water delivers insects for food, and the broken surface provides cover from predators. Riffles are also the “lungs” of a stream, where turbulent flow captures and incorporates oxygen from the atmosphere.
- Pools are formed where water falls over a boulder or log, scouring out a deep hole where juvenile and adult fish can hide.
- Logs, root wads, boulders, and protruding stream banks can cause backwater pools to form as water swirls around the obstacle. Juvenile steelhead are often found in low-gradient riffles, while juvenile coho salmon almost always live in pools formed by large wood.

Riparian Vegetation

Vegetation on, near, or overhanging the water provides plant materials that are consumed by aquatic animals. This riparian vegetation includes hardwood and softwood trees, shrubs, and even herbaceous vegetation. Plant roots stabilize banks, and the vegetative canopy shades the water, keeping temperatures low. Certain aquatic insects spend part of their life cycle in riparian vegetation; since adequate riparian vegetation is important to insects, it is also important to fish that eat these insects.

STATUS OF ANADROMOUS SALMONIDS

One of the major environmental issues in California is the status of anadromous salmonids. Anadromous salmonids have been declining in number in California and throughout the Pacific Northwest for several decades. Specific stocks of chinook, coho, and steelhead have been listed by the federal government (U.S. Fish and Wildlife Service or National Marine Fisheries Service) or the state government

Figure 2. Good salmonid habitat includes pools and fast-water riffles as well as a riparian canopy that provides shade, nutrients, insect habitat, and large woody debris. *Photo:* Richard Harris.

(California Department of Fish and Game) as threatened or endangered under applicable state or federal laws (table 2). Certain resident trout species, such as the Lahontan cutthroat trout, are also listed. Once a stock or species is listed as threatened or endangered, a recovery plan is developed and special measures must be taken to maintain the habitat quality for these fish.

Stocks of anadromous fish have declined due to a combination of human and natural influences. Human influences include urbanization, stream damming, water diversions, habitat modification, and fish harvest. Urbanization, agriculture, road construction and maintenance, and forestry have contributed excess sediment to streams, degrading the aquatic habitat. Stream clearing conducted years ago removed large woody debris from many stream channels, making the habitat less complex and less suitable to salmonids as well as other aquatic life.

Large and small dams have created complete or partial barriers to salmonid migration upstream and downstream. This has eliminated access by fish to many miles of spawning and rearing habitat. Harvest by commercial and recreational fishing and predation by exotic fish species have reduced the number of salmonids returning to natal streams to spawn. Hatchery operations have reduced genetic diversity among fish populations. Finally, fluctuations in climate and ocean conditions such as the El Niño effect can reduce ocean food supplies for salmonids and favor warm-ocean predators.

The California Forest Practices Act provides measures to protect against new direct impacts to fish habitat, water quality impacts, and depletion of large woody debris. However, many streams will not recover for decades from historical impacts, legacies from earlier management practices.

Table 2. Status of anadromous salmonids in California as of 2001

Species and location	Listing status	Location	Spawning	Population status
Sacramento winter run chinook salmon	California endangered 1989; Federal endangered 1994	Sacramento River and tributaries	spring and summer	stable as of 1999
Sacramento spring run chinook salmon	California threatened 1999; Federal threatened 1999	Butte, Chico, Big, Mill, and Deer Creeks	August–October	stable to declining as of 1999
Northern Coast coho salmon	Federal threatened 1997	North of San Francisco to Oregon border	October–January	unknown
Central Coast coho salmon	California endangered 1995; Federal threatened 1996 (south of San Francisco)	Humboldt County to Santa Cruz County	October–January	declining as of 1999
Northern Coast steelhead trout	Federal threatened 2000	Humboldt County to Mendocino County	Runs occur in winter, spring and summer	unknown
Central Coast steelhead trout	Federal threatened 1997	Russian River to Soquel Creek		
South/Central Coast steelhead trout	Federal threatened 1997	Pajaro River to Santa Maria River		
Southern Coast steelhead trout	Federal threatened 1997	Santa Maria River to Mexican border		
Central Valley steelhead trout	Federal threatened 1998	Sacramento and San Joaquin Rivers		

POTENTIAL IMPACTS OF FOREST MANAGEMENT ON SALMONIDS

Since a combination of factors has led to the decline in anadromous and some resident salmonid populations, action across a broad spectrum of society is needed to save these fish from further decline.

Forestland owners and managers play an important role in protecting and restoring salmonid habitat. Forest management, as well as urbanization and agriculture, can degrade salmonid habitat through direct impacts on water quality, channel complexity, channel substrate, and riparian vegetation. Road construction and culverts can create barriers to fish migration and can deliver excessive sediment to watercourses (fig. 3).

Reduction of riparian forest canopy can reduce stream shading, which may increase stream temperatures to a point lethal to fish. Management activities and point sources (such as legacy roads) that deliver excessive sediment to a stream may fill in spaces between particles of gravel on streambeds, reducing the oxygen supply to insects and young fish, which slows fish growth and increases mortality. Sedimentation can also change the physical form of stream channels and the habitats they provide, such as decreasing the number and depth of pools. Many activities, including stream clearing and fuel wood harvesting, can deplete a stream of its large woody debris.

Removal of riparian vegetation for any reason may adversely impact fish habitat. For example, removing plants whose roots strengthen the stream bank can lead to bank erosion and sedimentation. Also, runoff that is no longer filtered by streamside vegetation can cause more erosion and is likely to carry higher sediment loads directly into streams, increasing streamflow volume and sediment levels.

Anadromous trout and salmon may migrate many miles up and down streams during their lifetimes. Resident trout also move up and down streams to seek food, shelter, and spawning habitat. Culverts under roads can interfere with this migration, blocking passage by making fish jump too high, removing resting pools, and creating streamflow conditions that are too shallow or too fast.

Figure 3. Roads and stream crossings are the main sources of sediment that negatively impacts streams in California's forests. *Photo:* Courtesy Angela Wilson.

MAINTAINING AND RESTORING AQUATIC HABITAT

Avoiding impacts on aquatic habitat requires planning. Preventative measures should be taken both for streams occupied by salmonids and for watercourses upstream of salmonid habitat that influence downstream conditions.

Maintaining streamside management zones or riparian vegetation buffers are key strategies to protect aquatic habitat. Riparian buffers are required by any timber harvest plan (THP) in California and are advisable even for areas not subject to harvest. The California Forest Practices Act stipulates various streamside protection zones, depending on the type of stream. These streamside zones protect water quality by filtering runoff, stabilizing stream banks, contributing shade, and providing a source for large woody debris and other vegetative input to the stream. Managed properly, these zones can support essential habitat for a wide variety of terrestrial and aquatic plants and animals.

Best Management Practices (BMPs) are approved practices that minimize impacts from land uses. BMPs provide guidelines for proper construction and maintenance of roads as well as for retention and recruitment of streamside forest cover and future supplies of large woody debris. Specific BMPs, along with state and local rules, have greatly reduced impacts on a wide range of aquatic species in some watersheds. Improved practices have reduced erosion, improved water quality, and helped restore aquatic and wildlife habitat. For example, improved design and installation of culverts allows fish to pass more freely. The Forest Practices Act provides numerous BMPs to prevent or reduce the negative impacts of forest management on fish, such as excluding equipment from streamside zones and establishing standards for road and stream-crossing construction.

RESOURCES

The recognition that active restoration is needed if anadromous fish populations are to return to former levels has stimulated state and federal agencies to create a number of programs that share the costs for landowner restoration efforts. These agencies can also provide technical assistance on restoration planning. Efforts may include improvement of roads and stream crossings, elimination of barriers to migration, restoration of riparian areas, and enhancement of stream channel habitat. Contact your local Department of Fish and Game office for information on these programs. Other agencies and groups involved in restoration include the UC Cooperative Extension, U.S. Fish and Wildlife Service, Resource Conservation Districts, the Natural Resource Conservation Service, and local watershed councils.

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