

Culture of Salmon

History

Different methods are used for aquaculture production of salmon. The three major techniques are salmon ranching, land-based tank operations, and net-pen rearing. At salmon ranch hatcheries, adult fish are spawned, the eggs are hatched, and the young are reared in tanks to increase their size and chances of survival in the wild. The salmon smolts are then released and grow to market size while at liberty in the ocean. After maturing at sea, the salmon return to the hatchery, where they are harvested. If at least three to five percent of the released salmon return to be harvested, a private salmon ranch may be profitable. However, it is not uncommon for 98 to 99 percent of the salmon to be lost to natural and fishing mortality before they can return to the hatchery.

Land-based tank operations maintain all of the fish at the facility until harvest. Fish are kept in tanks made of concrete, fiberglass, or other materials. Round tanks are often in the range of 30 to 40 feet in diameter. Water is pumped through the tanks to maintain good water quality, and growth comes from manufactured feed provided by the aquaculturist.

Net pen facilities use young fish produced in hatcheries, which are then placed into pens where they are fed until grown to market size. The pens are made from flexible netting material suspended from floats and are generally a few hundred square feet at the surface. Pens are often linked together to form large units of up to many acres. The net-pens are usually placed in sheltered salt-water areas where protection from ocean storms is provided and good water quality is maintained by natural currents.

Salmon have been produced in California by both private and public hatcheries. While the history of private trout production in California is strong and dates back to the 1800s, private commercial production of salmon in California has been intermittent and never very substantial. The beginning of recent interest in commercial salmon production was the authorization by the California Legislature in 1968 for the first (and only) private salmon ranching operation. In 1979, the legislature authorized the operation's move to its current site on Davenport Landing Creek (Santa Cruz County), where the operation has been inactive for several years.

In California, land-based tank operations were tried in the 1980s and 1990s, and accounted for some limited private aquaculture production of salmon. Most commercially produced salmon were from tank-rearing operations located in northern California, where cold water suitable for salmon culture is more readily found. Fish were grown to market size in tanks using either fresh or salt water. Steelhead trout (*Oncorhynchus mykiss*) were produced from domestic brood stock maintained by California aqua-

culturists, whereas coho salmon (*Oncorhynchus kisutch*) and Atlantic salmon (*Salmo salar*) eggs or fingerlings were imported from out of state to California farms. Salmon culture has not been a major component of the state's private aquaculture sectors and never contributed as much as five percent to the total value of the industry's production.

Conversely, public salmon hatchery operations play a key role in the management of California's natural resources. Hatcheries are built and operated to supplement natural salmon resources or to mitigate for the loss of natural production that occurs when water and power generation projects eliminate salmon spawning habitat. Thus, hatcheries help provide for the multiple beneficial use of the state's water resources. Public hatcheries produce approximately 40 million fish each year and are critical to maintaining the state's sport and commercial salmon fisheries. Over ninety percent of California's salmon harvest comes from south of Point Arena, where hatchery-produced fish generally make up over half of the catch.

Public hatchery production of salmon in California dates back to 1872 with the establishment of Baird Hatchery on the McCloud River in the upper Sacramento River drainage. Several other salmon hatcheries and egg taking stations also began operations in the late 1800s and early 1900s. Baird originally operated as an independent hatchery, then as an egg collecting station for salmon and trout reared at Mount Shasta Hatchery (then called Sisson Hatchery). After the construction of Shasta Dam, Mount Shasta Hatchery and the upper Sacramento spawning grounds were separated from the lower Sacramento River and the Pacific Ocean. Coleman National Fish Hatchery was built in 1942 to mitigate for those losses. It replaced many of the early hatcheries, including most of the salmon operations at Mount Shasta. Coleman Hatchery is on Battle Creek, a tributary of the Sacramento River at Anderson (south of Redding). It is the only federally operated fish hatchery in California.

Today there are seven California Department of Fish and Game-operated salmon mitigation hatcheries and two state-operated salmon restoration and enhancement hatcheries. All nine of these state-operated hatcheries have been built since 1955. The mitigation hatcheries are located on central valley and north coast rivers downstream from dams constructed for water or power development.

| Hatchery | Location |
|-------------------------------------|---|
| Iron Gate | On the Klamath River below Copco Lake |
| Trinity..... | On the Trinity River below Clair Engle Lake |
| Feather River | Below Lake Oroville |
| Mokelumne River Fish Installation | Below Camanche Reservoir |
| Nimbus..... | On the American River below Folsom Lake |
| Van Arsdale Fisheries Station | On the Eel River below Van Arsdale Reservoir |
| Warm Springs | On a tributary to the Russian River below Lake Sonoma |

The DFG's two restoration and enhancement hatcheries are the Mad River Hatchery near Eureka and the Merced River Fish Installation below Lake McClure. There is also a non-profit salmon and steelhead enhancement hatchery in California on the Smith River. The Rowdy Creek Fish Hatchery is located in the town of Smith River and began in 1967 as a Kiwanis Club project. It operates under an individual category in the California Fish and Game Code.

In addition, public or privately funded nonprofit salmon restoration and enhancement projects use a variety of habitat improvement, artificial spawning, and rearing techniques to improve runs of wild fish or to contribute additional fish to the fishery. Most are located on coastal streams in northern and central California. Saltwater pen-rearing operations have been located at Tiburon, Port San Luis, and Ventura. In 1998-1999, a total of twelve projects planted an average of 30,000 fish per project.

Status

Currently, there is no private for-profit aquaculture production of salmon in California. Nationally, and internationally, net pen rearing of salmon has proven to be the most successful method of private aquaculture production of salmon for the seafood market. The only net-pen rearing of salmon in California has been some small sport fishing salmon enhancement projects. Commercial net-pen rearing is not prohibited, in part because no suitable sites have been identified or developed which do not conflict with other established uses.

Every private aquaculture operation in California is required to register with the Department of Fish and Game. Before approving an application for registration, the department must determine that each facility will

not cause significant negative impacts on adjacent native fish and wildlife. Private salmon culture may be permitted throughout California where negative impacts will not result, except that commercial salmon farming is prohibited from the Smith River watershed.

The lone California commercial salmon ranching project (Davenport Landing) is required to operate under an annual permit from the Fish and Game Commission. Commission authority to issue the salmon ranching permit is granted by the California Legislature. The legislature reviews the authorization periodically and in 1995 extended authority to issue the permit to January 1, 2001. While the project does not have a current permit, it historically has been authorized to ranch chinook salmon, coho, and steelhead.

State and federal hatcheries produce chinook and coho salmon and steelhead using the same production techniques as other salmon ranching operations. Returning adults are artificially spawned and the offspring are reared to smolt or yearling size before they are released at the hatchery (or at other freshwater sites) to migrate to the ocean where they grow to adults. Chinook salmon return to be spawned, usually three or four years after release. Coho generally spend one year in freshwater and return from the ocean to spawn as three-year olds. Hatchery steelhead spend one or two seasons in fresh water and one to three seasons in the ocean and can repeat spawn after release.

Public hatchery production remains relatively constant; therefore, years of low natural production result in harvests with a larger proportion of hatchery fish. Depending upon the success of each year's natural production, Department of Fish and Game biologists estimate that hatchery-produced fish generally contribute from 50 to 60 percent of California's sport and commercial salmon harvests.

Most of the public hatchery production of salmon in California is intended to mitigate for the loss of habitat caused by construction of dams for water and power development. The concept of providing mitigation for losses to fish and wildlife caused by the building of a government project was originally established by the U.S. Congress when it enacted the Fish and Wildlife Coordination Act of 1934. The need to replace the natural fishery resources eliminated by these projects continues to have high priority with the people of California.

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Weighing and spawning of Chinook salmon at Rowdy Creek Hatchery, a community-run hatchery near Crescent City.
Credit: CA Sea Grant Extension Program