U.S. Department of the Interior
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Natural Resource Information Division

Pacific Salmon (Part I)

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In North America, five Pacific salmon species occur from California to Alaska (Table on next page). All are important commercial food fishes and some are popular game fishes. Many are raised in commercial hatcheries and have become available year-round in food markets. In the wild, the persistence of salmon is at risk from many threats, notably excessive harvest and land-use such as agriculture, grazing, logging, urbanization, channelization, and roads, which introduce pollutants and silt and alter stream hydrology and aquatic habitat. Other sources of threat are hydroelectric dams, water allocations, exotic species, and—in the opinion of some--hatchery supplementation.

General Biology

Ocean-going Salmon

The Pacific salmon are cold water fishes that thrive best in water that is no warmer than 70°F. They belong to the Salmoninae subfamily (Insert) of fine-scaled fishes with well developed teeth and coarse stubby gill rakers. Biologically, they are primitive fishes as evidenced by primitive air bladders, the lack of spines in their fins, and the position of the pelvic fins far back on the body. In more advanced fish families like, for example, the sunfishes (Family Centrarchidae), the fins are characterized by pronounced spines and the pelvic fins are far forward on the body. Also unlike more advanced fish families, salmon have a small to medium-size adipose fin on the dorsal surface of the body above the anal fin (Figure on page 3). Related species of the salmon existed more than 100 million years ago.

Kingdom Animalia- Animal Kingdom
Phylum Chordata - Chordates
Subphylum Vertebrata - Vertebrates
Class Osteichthyes – Bony fishes
Order Salmoniformes - Salmon Order
Family Salmonidae –Salmon Family
Subfamily Salmoninae – salmons
Genus *Oncorhynchus*

The life cycle of the salmon is most interesting and again very primitive. All Pacific salmon species were originally anadromous, that is, they spawn in fresh water streams where the eggs hatch and the young remain for less than 1 year to 3 years (Table on next page). The young fishes then migrate to the open ocean where they remain for 1-7 years and grow to their mature lengths. To reproduce, all sea-running salmon return to the stream were they themselves were spawned--the *cradle stream*. Some species, particularly the chum salmon (*Oncorhynchus keta*), spawn near saltwater. Others travel long distances to the headwaters of streams. The longest known spawning trip was more than 2, 400 miles by a chinook salmon (*O. tschawytscha*) from the Bering Sea to Lake Teslin in Canada.

Salmon that return from the ocean to spawn are more brightly colored than their conspecifics in the ocean. The colors are species-specific and range from greens and browns to lavender and dark red. The jaws of returning males elongate and become hooked at the tips (Figure on page 3). Males develop long fierce-looking canine teeth and can no longer close their mouths. The eyes of both sexes are set deep in their sockets and the fins are frayed. Returning male sockeye and pink salmon also develop a distinct hump.

At the spawning site, the female prepares a nest called *redd* in the gravel. She fans the redd with her tail to let the current wash away silt and fine particles. Nests can be as large as 10 feet long and 3-4 feet wide. As soon as a female deposits her eggs into the redd, one or two males spread milt over them. The female immediately prepares another redd above the first redd. While she is digging the new redd, she lightly covers the fertilized eggs with gravel in the nest behind her. Before she exhausts her supply of eggs, the female may have made several redds. A large female may lay as many as 5,000 eggs or 800 eggs per pound of fish in a single spawning season. The females and the males may defend their redds.

When the females have laid their eggs and the males deposited their sperm, they seek refuge in pools and die within a few days. The strategy of reproducing only once in a lifetime is called *semelparity*.

Table. Characteristics of Pacific salmon species (*Oncorhynchus* spp.)

Characteristic	Pink salmon *O. gorbuscha*	Sockeye[a] salmon *O. nerka*	Chinook[b] salmon ***O. tschawytscha***	Chum salmon *O. keta*	Coho[c] salmon *O. kisutch*
Average (maximum) weight (lb)	3-5 (10)	8	<30 (<100)	12 (>30)	6-12 (30)
Maximum length (ft)	8	2	5	>3	2
Food	plankton, crustaceans	plankton	fishes, crustaceans, squid	crustaceans	fishes, crustaceans, squid
Age at migration to ocean	<1	during first year	during first year	<1	1-3, usually 2
Maturation (n^{th} yr)	2	3-7, usually 4	3-7, usually 4-5	3-6, usually 4	3-4, usually 3
Coloration in the ocean	silvery with bluish backs, caudal and adipose fins covered with black spots, spots on caudal fin are coarsely oblong	bluish above, silvery below; no spots	dusky or bluish above, silvery below. back and dorsal and caudal fins usually profusely covered with spots; dark mouth with white teeth	dusky above and light below; fins more or less blackish	bluish above, silvery below; few spots on back, dorsal fins, and base of caudal fin

[a] a land-locked form of the sockey salmon is called kokanee
[b] also called king salmon
[c] also called silver salmon

Salmon eggs usually hatch in about 2 months. The fry stay in the protective gravel until the yolk sac is completely absorbed. Then the young fishes squirm free and move into the stream where they feed on immature and adult aquatic insects. Fingerlings, except those of the pink salmon, have dark parr markings on their sides. The shape and position of the parr markings are species-specific.

Land-locked Salmon

Members of some of the ocean-running species have become land-locked. They live and reproduce successfully without going to the ocean. For example, the coho salmon was introduced into the Great Lakes as a replacement for the lake trout (*Salvelinus namaycush*). The kokanee is a landlocked form of the sockeye salmon in some lakes of British Columbia, Washington, Idaho, and Oregon.

Depletion and Restoration of Salmon Stocks

Before Euro-American settlement, each anadromous salmonid species in the Pacific Northwest and California consisted of many spawning populations, sometimes called *stocks* that were either geographically or temporally segregated. Each population had specific morphological and physiological characteristics that were adaptations to its particular environment.

In recent decades, Pacific salmon stocks have drastically declined from poor resource stewardship, blockage of movement by dams, and degradation of aquatic communities. One hundred of the approximately former 400 stocks on the West Coast are already extinct. Another 200 stocks are considered at risk. Several stocks have been placed on the federal list of threatened or endangered species, and more listings are imminent.

Historically, the restoration of Pacific salmon was focused on maintaining production in freshwater through hatcheries; modifying specific stream habitats with fences, log weirs, and other physical structures; providing minimum stream flows; and reducing harvest rates to increase spawning escapements. Another recent approach is *supplementation*, which is the use of artificial propagation to maintain or increase natural production while maintaining the long-term fitness of the target population and keeping the ecological and genetic effects on nontarget populations within specified biological limits. Attempts to reverse the decline of salmon stocks are made by numerous entities from California to Alaska.

Salmon in the National Park System

The relatively undisturbed habitats of national parks in the western United States could function as refugia for salmon and be vital for the conservation and recovery of these fishes. In fact, all

parks in the Columbia River Basin and coastal watersheds strive to conserve and restore healthy aquatic, riparian, and associated upland communities.

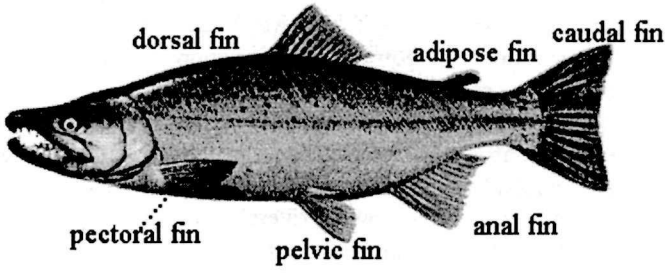
Point Reyes National Seashore and Golden Gate National Recreation Area

Point Reyes National Seashore and Golden Gate National Recreation Area, California, established a coho salmon and steelehead (*Oncorhynchus mykiss*; a seagoing trout) restoration center. The center staff and partner organizations inventory and monitor these species and prescribe restoration and watershed enhancements. The center is next to Lagunitas and Olema creeks, in which 10% of the remnant population of coho salmon in central California spawn (about 500 spawners). Staff is optimistic that habitat improvement with cooperation from adjacent landowners and local agencies can return salmon to at least near historic levels. Cooperation from volunteers and organizations interested in fisheries restoration in watershed enhancement has been significant

Olympic National Park

In Washington, the removal of two hydroelectric dams (Elwah River Ecosystem and Fisheries Restoration Act, P. L. 102-495) is proposed. Associated restoration has already been beneficial to streams in the area. The National Park Service is assisting with the recovery of Dungeness River pink salmon for outplanting in the Elwah River. When restored, salmon are expected to naturally stray from the Elwah River and support restoration of salmon in other streams.

Olympic National Park is also the site of research into water quality and other environmental effects on Lake Ozette sockeye salmon and other salmonids in the Ozette drainage. Park staff is conducting an inventory and assessment of the status of salmonid populations, monitoring recreational fisheries, and evaluating park regulation of these fisheries, including an experimental catch-and-release regulation. The development of a database with



information about salmon and steelhead stocks in Olympic National Park is being initiated. Information about the history of salmon and data about spawning escapements, catch, hatchery plants in adjoining waters, and estimated production will be entered into the base. The information will be used for analyses of survivorship trends of park stocks, identification of potential factors in current escapement and production levels, determination of current level and adequacy of federal, state, and tribal monitoring, and identification of stocks that are not being monitored.

Because a park facility seems to be having adverse effects on the Soleduck summer stock of coho salmon, the park is conducting a study to identify the adverse effects and possible mitigation. The park in cooperation with the Washington Department of Fish and Wildlife and the Quileute Tribe is developing escape for this stock of salmon. Information that is gathered for this purpose includes life history patterns, timing of the spawning and distribution in the watershed, number of spawners, and available rearing habitat during low water flow in summer.

Redwood National Park

Large-scale rehabilitation of the Redwood Creek watershed is underway in Redwood National Park. Abandoned and failing logging roads and stream crossings are being removed, the areas are being revegetated, and erosion of existing roads is being controlled. These measures are expected to reduce sedimentation from previously logged lands that is deleterious to salmonids in Redwood Creek and its tributaries. Placement of large in-stream wood structures, removal or modification of unnatural fish barriers, and modification of existing flood control levees are also significantly improving fish habitat. Annual surveys in summer and winter are conducted to provide information on the status of salmon and steelhead. More than a decade of monitoring juvenile salmonids in summer and fall in the Redwood Creek estuary verified the prominent role of estuaries in the life cycle of chinook salmon and steelheads and the importance of small coastal estuaries in degraded watersheds. Other measures that will benefit salmon are restoration of the estuary, prioritization of road removal by failure risk, monitoring of suspended sediment, and review of timber harvest.

North Cascade National Park Complex

The National Park Service and the Washington Department of Fish and Wildlife are sharing the cost of developing and evaluating the effectiveness of channels for spawning salmon along the Skagit River. The channels contain groundwater and existing swales and were designed to restore spawning and rearing habitat that was lost from hydropower development in Ross Lake National Recreation Area.

Park staff also participates in several interagency committees for the restoration of salmon in the Skagit River watershed: the Baker River Committee for the restoration of sockeye and other

salmonid species in the Baker River drainage; the Skagit River Chinook Work Group for the development and implementation of strategies to reverse the decline of chinook in the Skagit River watershed; and the Skagit River Watershed Committee for the determination of priorities for habitat restoration in the Skagit River watershed. Park staff also acts as consultant in FERC relicensing of hydropower facilities that affect park salmon populations and monitors salmonid populations and habitat in the park.

Coulee Dam National Recreation Area
Prior to impoundment, the Columbia River supported large numbers of anadromous fish species such as chinook salmon, sockeye salmon, and steelhead trout. The National Park Service has worked with the Washington Department of Fish and Wildlife and the Colville and Spokane tribes to develop and initiate mitigation of the loss of these anadromous fishes. A kokanee hatchery and a rearing facility support the resident fishery in Lake Roosevelt by annually producing thousands of kokanee for release. The National Park Service also monitors the effects of reservoir drawdowns on the resident fishery and participates in local and systemwide fisheries recovery.

The Pacific Salmon Treaty

The 1985 Canada-United States Pacific Salmon Treaty was negotiated to ensure conservation and equitable harvest of salmon stocks. Representatives of the two countries meet annually to review the fishery of the past year and to negotiate fishing regimes for future years.

The main implementing body of the treaty is the Pacific Salmon Commission, which consists of two national sections. Each nation has a commissioner. Legislation of the United States stipulates that the U.S. section must have one member from Alaska and one member from either Oregon or Washington, one representative of treaty tribes, and one non-voting federal official. The Canadian section is led by the federal Department of Fisheries and Oceans and includes representatives from First Nations, recreational and commercial fisheries, and the British Columbia provincial government. The treaty also established several scientific and technical committees that provide the commission with essential data on the salmon stocks and fisheries.

The two principles of the treaty are conservation and equity. Conservation prevents overfishing and provides optimum production. Equity provides each country with fishery benefits that are equivalent to the production of salmon from its own rivers, i.e., balanced interceptions of salmon by the two countries.

The treaty improved the conservation and management of Pacific salmon. For example, migration routes of the fishes, interception patterns, and interception estimates are now better known. Sockeye stocks in the Fraser River in British Columbia have increased. The rebuilding of wild chinook stock in the lower Georgia Strait is attributed to fishery restrictions by Canada. Closing of the net fishery at southern Vancouver Island reduced interceptions of coho salmon from U. S. origin. Enhancement (from hatcheries, incubation boxes, and spawning channels) of sockeye salmon from the transboundary rivers increased returns to Canadian and Alaskan fisheries.

Conservation of chinook and coho salmon is not yet fully achieved. Canada contends that the United States has not matched Canadian reductions of the harvest to sustainable levels. Canada wants Americans to catch fewer sockeye salmon bound for the Fraser River in British Columbia. The United States wants Canadians to reduce their catch of coho salmon off Vancouver Island, so that more of those salmon make their way into the Puget Sound and other American waters.

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