5 Pacific Salmon, Salmonidae

Salmon processing plant circa 1934. Photo credit: Department archives.

Salmon are among California's most valued natural resources. They provide a source of highly nutritious food for the general population and are an important source of income for the commercial salmon industry. Recreational anglers value them for their excellent sporting qualities and Native Americans celebrate them in many aspects of their culture. Salmon play a key role and occupy a unique niche within the State's highly diverse marine and inland ecosystems. They are considered a top predator but also contribute to the sustenance of other aquatic and terrestrial animals. In addition, their carcasses enrich the nutrient base of their natal (birth) streams after spawning is complete. Like other anadromous species (live part of their life in fresh water and part in salt water), their survival depends on the quantity and quality of freshwater spawning and rearing habitat available to them. The destruction of that habitat over the past two centuries has resulted in the biological extinction or extirpation of many naturally spawning populations of salmon. These same habitat issues threaten the viability of Chinook populations today. In the following, we provide a brief overview of the importance and role of salmon in the management of California's living marine fishery resources.

History of the Salmon Fisheries

Of the five species of Pacific salmon found on the Pacific coast, Chinook, *Oncorhynchus tshawytscha*, and coho, *O. kisutch*, are the species most frequently encountered in California fisheries. Small numbers of pink salmon, *O. gorbuscha*, are caught on occasion, primarily in odd-numbered years. Chum salmon, *O. keta*, and sockeye salmon, *O. nerka*, are rarely seen in California waters.

Salmon fisheries existed in California long before European settlers made their first appearance in the state circa 1775. Native Americans may have harvested over 8.5 million pounds (3855 metric tons) of salmon annually. In northern coastal areas, native peoples subsisted primarily on salmon. Salmon not only formed the bulk of their diet - a family might eat up to 2000 pounds (900 kilograms) a year - but was also used as barter

with other tribes. Salmon was consumed fresh or dried and smoked for later use throughout the year. The fish were of such significance to these early fishermen that ceremonies and rituals honoring their existence and importance were created. Traditional fishing methods included gill and dip nets, fishing spears, and communal fish dams.

Commercial salmon fishing in California began in the early 1850s, coinciding with the massive inflow of miners into the gold country. By 1860, gill net salmon fisheries were well established in the San Francisco Bay area (primarily Suisun Bay and San Pablo Bay) and in the lower Sacramento and San Joaquin rivers. The gill net fishery gradually spread to include coastal rivers north of San Francisco, although the Sacramento-San Joaquin fishery remained the largest. Growth of this fishery was enhanced by the canning industry.

The first salmon cannery on the West Coast started operations on the Sacramento River in 1864. By 1880, there were 20 canneries operating in the Sacramento and San Joaquin rivers and increased fishing effort provided them with an ample supply of salmon. The fishery reached its peak in 1882 when about 12 million pounds (5440 metric tons) were landed and processed. Shortly thereafter, the fishery collapsed due to a sudden decline in salmon stocks caused by the pollution and degradation of rivers from mining, agriculture, and timber operations, combined with an increase in fishing pressure. By 1919, the last inland cannery had shut its doors and one by one, California rivers were closed to commercial fishing. State legislation closed the Mad River fishery in 1919, the Eel River fishery in 1922, and fisheries (including tribal) on the Smith and Klamath rivers in 1933. In 1957, the last remaining commercial river fishery closed in the Sacramento-San Joaquin basin.

The ocean troll commercial salmon fishery began in Monterey Bay during the 1880s. These early fishermen trolled for salmon using small sailboats that supported two hand rods, one on each side of the boat with a single hook and leader attached to each line. Circa 1908, several Sacramento-San Joaquin fishermen transported their powered gill net boats to Monterey Bay and began trolling for salmon. These boats were a great improvement over the sailboats, but were still small compared to current standards. The fishery quickly grew to approximately 200 boats and by 1916, had expanded north off the coasts of San Francisco, Fort Bragg, Eureka, and Crescent City.

During the 1920s and 1930s, a typical salmon troller fished four to nine lines that each carried five or more hooks with up to 30 pounds (13.6 kilograms) of lead attached to keep the line at the proper depth. In 1935, about 600 trollers were active in the fishery. Pulling weights, lines, and salmon by hand onto a moving boat was a backbreaking job. Power gurdies were soon developed to pull the lines and, by the mid 1940s, were used by most of the professional salmon trollers.

A significant increase in fishing effort occurred after World War II, in conjunction with improved transportation and a rebound in salmon populations. By 1947, the commercial fleet had nearly doubled to 1100 vessels and was continuing to grow. The

fleet peaked at almost 5000 vessels in 1978 and included many summer fishermen who held other jobs during most of the year. Although some of these part time participants were serious about commercial fishing and had adequate ocean going boats, most used small sport-type boats that could be conveniently towed on a trailer. In 1983, a limited entry program was established in California and the number of active participants has steadily declined since its inception. During the last decade, the number of salmon vessels participating in the fishery has averaged less than 600 boats a year.

Salmon trollers today still use the basic fishing techniques developed during the 1940s, including powered gurdies and trolling four to six main lines (Figure 5-1). Today's vessels, however, are also equipped with various electronic devices that greatly aid in finding and staying on the fish. Radio communications are possible among several vessels simultaneously over large distances. Highly sensitive sonar equipment aids the troller in finding the salmon or bait and in pinpointing the depth at which to position lures. Precise vessel positioning is made possible through the use of global positioning systems. It is easy today to replicate a troll path or "tack" within a few feet of a previous or suggested path. Collectively, these instruments have significantly improved the efficiency of the modern troller compared to 75 years ago.

Figure 5-1. Commercial salmon troller. Photo credit: J Phillips, CDFW.

Estimates of commercial salmon catches are available in one form or another for years as early as 1874. In 1929, the California Department of Fish and Wildlife (Department) began officially reporting state commercial landings by weight, including the salmon catch data (all species combined) back to 1916. In 1952, the Department's Ocean Salmon Project began a systematic sampling of commercial ocean salmon landings to differentiate Chinook from coho harvest.

Prior to 1990, the industry enjoyed relatively high and consistent salmon landings, averaging about 7.5 million pounds (3400 metric tons) annually (Figure 5-2). The largest commercial landings observed in California occurred in 1988 when more than 14. million pounds of Chinook (6500 metric tons; 1.3 million fish) and 319,500 pounds of coho (145 metric tons; 51,000 fish) were landed (Figure 5-3). During the last two decades, salmon landings have been much more variable and overall lower, averaging 3.5 million pounds (1580 metric tons) a year. Although oceanic and river conditions play a major role in annual salmon catches, variation among years can also be attributed to changes in fishery regulations and fishing effort. In 1993, the retention of coho salmon was prohibited in all California commercial fisheries to protect depressed coho stocks in central and northern California coastal streams.

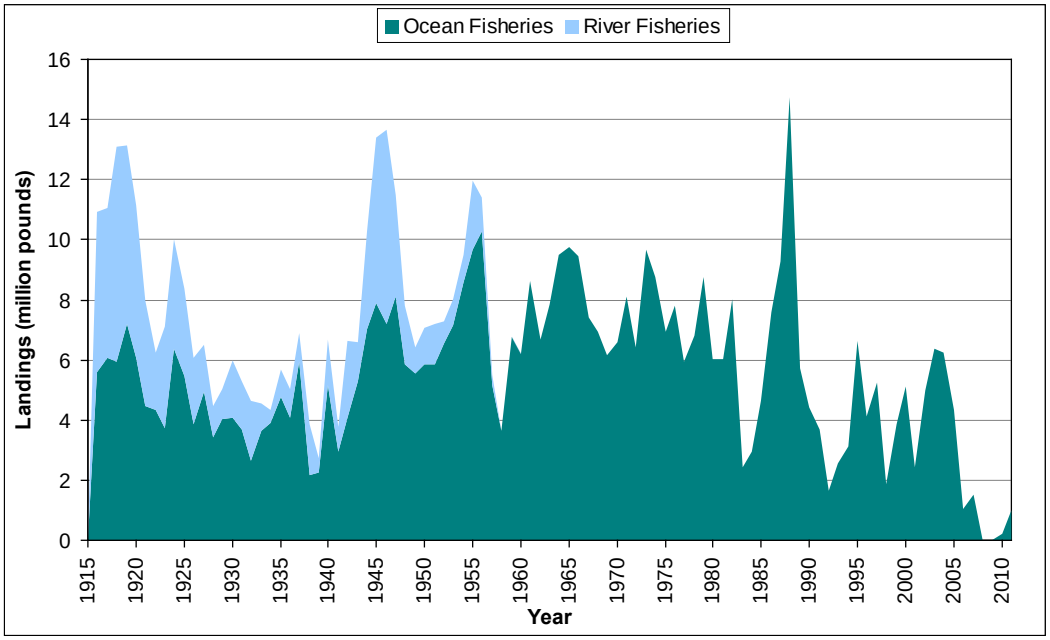

Figure 5-2. Pacific salmon commercial landings, 1916-2011, in California river and ocean fisheries. The last river fishery closed in 1957. Data source: Department catch bulletins (1915-1951), and Department Ocean Salmon Project and Pacific Fishery Management Council (PFMC) data (1952-2011), all species and gear types combined.

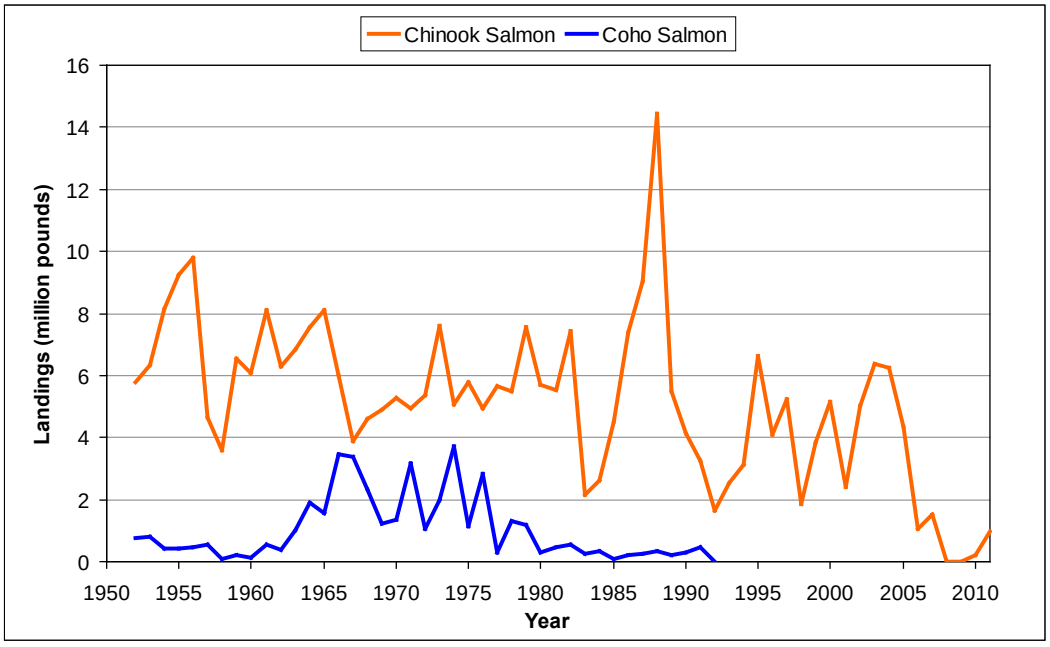

Figure 5-3. Pacific salmon commercial landings by species, 1952-2011. The take of coho salmon was prohibited after 1992. Data source: Department Ocean Salmon Project and Commercial Fisheries Information System (CFIS) data, all gear types combined.

Although California ocean fisheries have been constrained by the Pacific Fishery Management Council (PFMC) to protect various salmon stocks of special concern during the last several decades, it wasn't until the sudden collapse of Sacramento River fall Chinook in 2007 that a complete closure of the fishery was enacted in 2008 and 2009. Although open in 2010 and 2011, commercial ocean salmon fishing remained severely constrained to allow the Sacramento River fall Chinook population to rebuild.

The lowest commercial landings on record occurred during the 2006 through 2011 seasons (Figure 5-2), resulting in a more than doubling of the average price per pound of $5.25 ($2.38 per kilogram) compared to the long term average of $2.11 ($0.96 per kilogram) observed during the previous fifteen years (Figure 5-4). This can be attributed, in large part, to the economics of the fishery today with increased costs to the fisherman and reduced landing totals compared to the historical average.

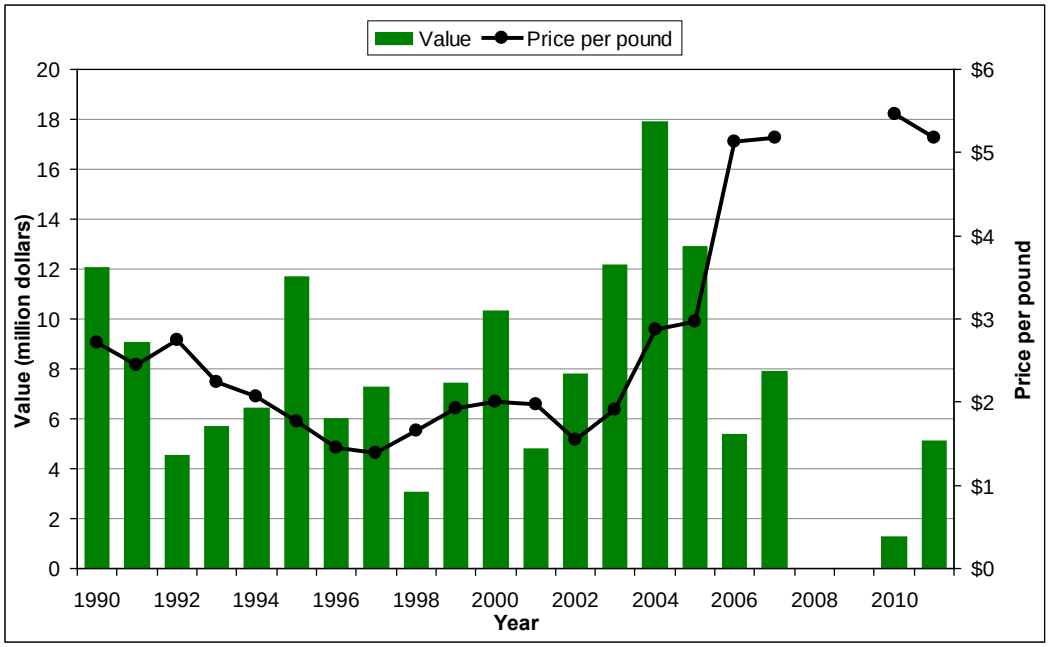

Figure 5-4. Pacific salmon (Chinook and coho) commercial value and average price per pound, 1990-2001. Data source: Department Ocean Salmon Project and CFIS data, all species and gear types combined.

Ocean sport fishing for salmon became popular with the development of the commercial passenger fishing vessel (CPFV) industry after World War II. In 1962, the Department expanded its dockside monitoring to include recreational landings of CPFVs and private skiffs (Figure 5-5). From its initial monitoring through 1989, the sport industry contributed 17 percent on average to the total salmon catch landed annually in California. Most of this sport catch (over two-thirds) was by anglers fishing on CPFVs. Since 1990, the sport fishery contribution to total California salmon landings has increased and generally accounts for about a third of the annual Chinook sport harvest.

During the early 1990s, a fishing technique known as mooching began to gain popularity among salmon anglers in San Francisco and Monterey Bay areas. Mooching is preferred when salmon are feeding on forage fish, such as anchovies or herring, in nearshore areas. Mooching differs from trolling in that the bait is drifted to resemble dead or wounded prey instead of being pulled through the water to simulate live swimming prey. When trolling, the "J" hook generally sets itself in the mouth of the fish as the salmon attacks the moving prey whereas during mooching, line is fed out to the salmon when it strikes to encourage the salmon to swallow the bait and hook. Thus more salmon are gut-hooked or internally damaged when caught by mooching.

Figure 5-5. Department sampler examining a recreationally caught salmon. Photo credit: C Hanson, Media.

Onboard observations conducted by the Department's Ocean Salmon Project (OSP) on CPFVs during the early 1990s found that 60-80 percent of the sublegal salmon less than 20 inches (51 centimeters) total length (TL) caught via mooching were hooked in the guts or gills (Figure 5-6). Since studies have shown that more than 85 percent of sublegal salmon hooked in the gut or gills eventually die due to these injuries, there was concern that this fishing technique could seriously impact salmon populations. Hooking mortality studies conducted by the OSP during 1995-1997 found that the use of circle hooks significantly reduced the gut-hooking of sublegal salmon. Beginning in September 1997, salmon anglers mooching with bait between Horse Mountain and Point Conception were required to use circle hooks (Title 14 §27.80) and subsequent CPFV onboard studies found that the proportion of sublegal salmon gut-hooked was reduced to 41 percent.

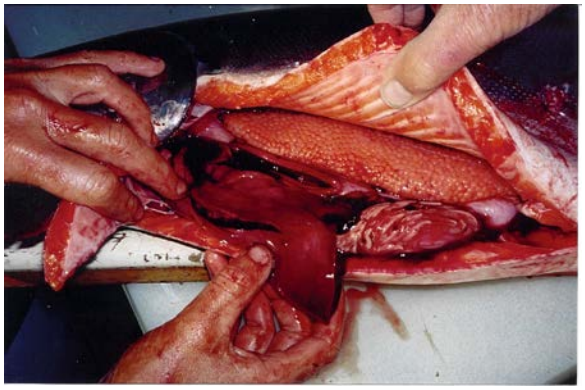

Figure 5-6. Internal injuries of gut-hooked salmon caught via mooching with 'J' hook. Photo credit: M Palmer Zwahlen, CDFW.

The popularity of mooching peaked in 1995 when 80 percent of anglers in the San Francisco and Monterey Bay areas mooched for salmon. Since then, the proportion of anglers mooching has gradually declined each year primarily due to changes in the distribution and schooling patterns of salmon and their prey off of the San Francisco port area. During the last five seasons, the proportion of anglers mooching has averaged 15 percent, with most activity occurring in Monterey Bay.

The highest coho catch in the recreational ocean fishery occurred in 1991 when almost 69,300 fish were caught by anglers (Figure 5-7). As with the commercial fishery the retention of coho in any California ocean sport fishery was prohibited after 1993 specifically to protect declining California coastal coho stocks. The highest Chinook sport landings on record occurred in 1995 when anglers landed 397,200 fish (Figure 5-7). Prior to complete fishery closures in 2008 and 2009, the lowest recreational landings of salmon generally occurred after strong El Niño events (e.g., 1978, 1983, 1992). After the collapse of Sacramento River fall Chinook, the lowest catch on record during an open season occurred in 2010 when only 14,800 Chinook were harvested by anglers statewide.

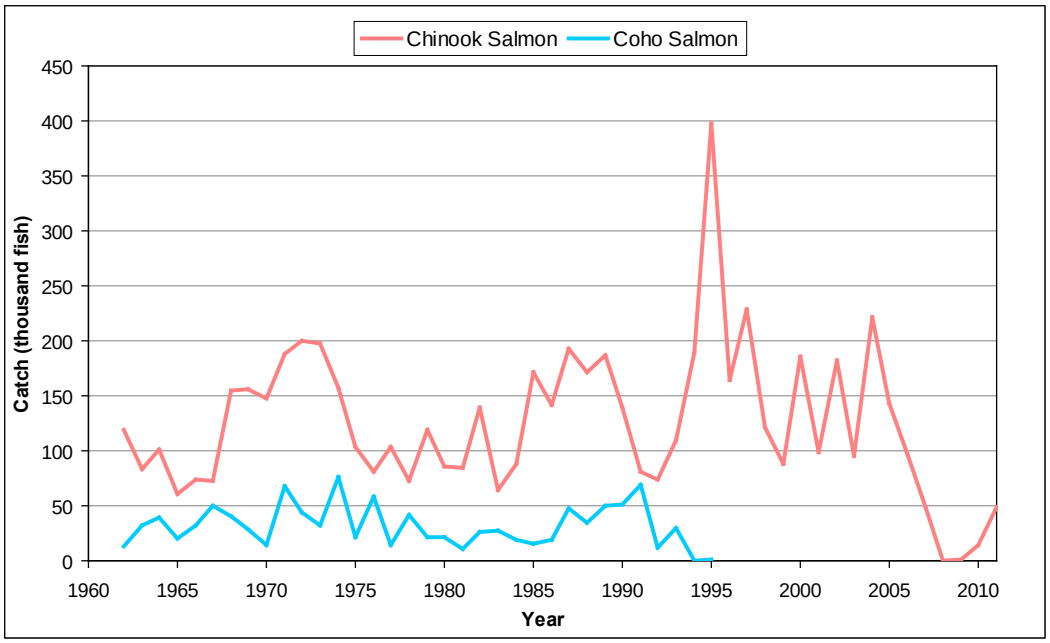

Figure 5-7. Pacific salmon (Chinook and coho) recreational catch, 1962-2011. The take of coho salmon was prohibited statewide after 1993. Data source: Department Ocean Salmon Project and CPFV logbook data.

All commercial river fishing in the Klamath Basin was closed by legislation in 1933; however, the State's jurisdiction over tribal commercial fishing was challenged in 1969 when a Yurok tribe member had his gill nets confiscated by the State for fishing on the lower Klamath River. After years of litigation in the lower courts, the issue was decided by the First District Court of Appeals in 1975. The ruling was that the right of a tribal member to fish on a reservation was created by presidential executive order, which was derived from statute and thus not subject to state regulation. In 1977, the Bureau of Indian Affairs (BIA) took over the management of tribal reservation fisheries in the Klamath Basin and the lower 20 miles (32 kilometers) of the Klamath River was opened to tribal gill net fishing for subsistence and commercial harvest. However, in 1978, the BIA closed the tribal commercial fishery, allowing only subsistence fishing in the Klamath and Trinity rivers. The so-called Conservation Moratorium remained in effect until 1987 when the BIA reopened commercial fishing by Native Americans on the lower

Klamath River. In 1993, the Department of the Interior determined that the Yurok and Hoopa Valley tribes possessed a federally reserved right to take 50 percent of the harvestable surplus of Klamath Basin fall Chinook salmon annually. Since then, the annual tribal harvest has ranged between 8,100 and 56,700 fall run salmon.

Status of Biological Knowledge

Pacific salmon are anadromous and semelparous (die after spawning). Both Chinook and coho salmon have similar spawning requirements and habits. Successful spawning requires cold clear water of temperatures less than 56° F (13° C), suitable gravel, and a stream velocity sufficient to permit excavation of redds (nests) and to provide high subgravel flow to the deposited, fertilized eggs. The female digs the nest, lays the eggs, and covers them after fertilization. After a period of time, depending primarily on water temperature (usually 50 to 60 days in California), the eggs hatch into yolk sac larvae (alevins), which remain buried in the gravel until the yolk sac is absorbed. The young salmon (fry) swim up out of the gravel and begin feeding on microscopic organisms.

When the salmon are about 2 inches (5 centimeters) long, their backs become brown and their bellies light silver so that they blend inconspicuously with their background. Referred to as fingerlings, the length of residency in the stream by these juveniles varies according to species and race. Following a period of rapid growth, the salmon begin changing physiologically in preparation for life in the ocean. A young salmon that has undergone the anatomical and physiological changes that allow it to live in the ocean is called a smolt. Following an instinctive internal cue, the smolts begin migrating in schools downstream towards the ocean. Many of the fish pause in estuaries, remaining there until the smoltification process is completed. The salmon then enter the sea where they begin a period of rapid growth. After spending one to six years in the ocean, depending on species, they become sexually mature and begin their arduous journey upriver to their natal stream to spawn.

Chinook salmon

Chinook salmon, *Oncorhynchus tshawytscha*, (Figure 5-8) are the largest of the salmon species. The State record for a recreationally-caught Chinook is 88 pounds (40 kilograms), landed by an angler on the Sacramento River in 1979. The largest Chinook on record is a 127-pounder (58 kilograms) taken from a trap in Alaska.

Figure 5-8. Chinook salmon, *Oncorhynchus tshawytscha*. Photo credit: M DuVernay, CDFW.

California has two large basins that support most of the State's Chinook salmon runs: the Central Valley, which contains the Sacramento and San Joaquin river basins and

their respective tributaries, and the Klamath Basin, which contains the Klamath and Trinity Rivers and their respective tributaries. Chinook salmon are also found in coastal streams north of San Francisco Bay. Historically, coastal Chinook spawned as far south as the Ventura River in southern California. Spawning migrations can require minimal effort, with spawning occurring within a few hundred feet of the ocean, or it can be a major undertaking, with spawning occurring hundreds of miles upstream. In addition, dams and other diversion structures can seriously impede the upstream passage of adults by creating physical barriers and confounding migration cues due to changes in river flow and water quality.

The female Chinook selects a nesting site that has good subgravel water flow to ensure adequate oxygenation. Since Chinook eggs are larger and have a smaller surface-to-volume ratio, they are also more sensitive to reduced oxygen levels than eggs of other Pacific salmon. Female Chinook will defend their redds (nests) once spawning has begun and will stay on the eggs from four days to two weeks, depending on the time in the spawning period.

Spawning adults can be easily chased off redds by minor disturbances which may result in unsuccessful spawning. At the time of emergence, fry generally swim or are displaced downstream, although some fry are able to maintain their residency at the spawning site. As they grow older, the fingerlings tend to move away from shore into midstream and higher velocity areas. Once smoltification is complete, the young Chinook migrate to the ocean, where they tend to be distributed deeper in the water column than other Pacific salmon species. The same impediments that affect the upstream migration of adults also affect the downstream emigration of juveniles out to sea.

California Chinook stocks generally spend two to five years at sea before returning to spawn in their natal streams. The small percentage of Chinook that mature at age two are predominately males and are commonly referred to as "jacks" or “grilse." The older age classes of Chinook are generally composed of equal proportions of males and females.

All Pacific salmon exhibit a strong tendency to return at a specific time each year to spawn in their natal streams. This has resulted in the development of distinct stocks, or populations, within each species that are, to varying degrees, both reproductively and behaviorally isolated. Stocks are grouped into “runs” based on the time of the year during which their upstream spawning migration occurs. In California, there are four distinct Chinook runs: fall, late-fall, winter, and spring. In a river where all four runs of Chinook spawn, adults migrate upstream and juveniles migrate downstream during almost all months of the year. The timing of Chinook spawning is often influenced by stream flow and water temperature, and therefore varies somewhat from river to river, and even within river systems.

All four Chinook salmon runs are found in the Central Valley basin, with fall run being the most numerous. Although relatively large numbers of winter and spring Chinook

historically occurred in the upper Sacramento basin, they were significantly reduced by the construction of Shasta Dam in 1945, which blocked approximately 50 percent of historical Chinook spawning and rearing habitats. Spring Chinook also existed in the San Joaquin River and reportedly once outnumbered fall Chinook, but the completion of Friant Dam in 1942 contributed to that population's subsequent extinction. Late-fall Chinook are found primarily in the upper Sacramento River.

Fall and spring Chinook salmon are also found in the Klamath basin with the abundance of both runs reduced by barrier dams built in upper river areas during the late 1800s. Fall Chinook also exist in coastal rivers such as the Smith, Eel, Mad, Mattole and Russian. Spring Chinook also appear occasionally in the Eel and Smith rivers. Smaller coastal rivers only have fall Chinook.

Fall run. Fall Chinook salmon are the most abundant salmon run in California today. They arrive in spawning areas between September and December, depending upon the river system, but peak arrival time is usually during October and November. Spawner escapement is generally dominated by three-year-old fish followed by jacks (age 2) and four-year-olds. Five-year-old fish are rare. Spawning occurs in the main stem of rivers and tributaries from early October through December. In general, there is a large outmigration of fry and fingerlings from the spawning areas between January and March. An additional outmigration from the spawning areas, consisting primarily of smolts, occurs from April through June. The juveniles enter the ocean as smolts between April and July.

Late-fall run. Late-fall Chinook arrive in upper-river spawning areas between October and mid-April. The runs tend to consist of equal numbers of three- and four-year-old fish. Spawning occurs from January through mid-April, primarily in the main stem of the Sacramento River. Some of the juveniles start migrating seaward as fry during May, but the majority of the juveniles leave the upper river between October and February. Late fall smolts enter the ocean between November and April.

Winter run. Winter Chinook salmon are unique to the Sacramento River system. Adults arrive in the upper Sacramento River spawning area from mid-December through early April, with a peak in March. Spawning occurs primarily in the main stem of the upper Sacramento River below Keswick Dam between late-April and mid-August. May and June are peak spawning months. The juveniles migrate seaward from early July through the following March, but the majority of the juveniles move seaward in September. Winter-run smolts enter the ocean between December and May. The adults mature and spawn primarily as three-year-olds, unlike the other races, which include many four-year-old fish.

Spring run. Spring Chinook salmon arrive in the spawning areas between March and June, with the peak time of arrival usually occurring in May or June, depending upon flows. They rest in the deep, cooler pools during the summer and then move onto the gravel riffles to spawn between late August and early October. Outmigration of juveniles varies among drainages; however the majority of fry and fingerlings leave the

spawning areas between January and March. While this is true some juveniles remain throughout the summer, exiting the following fall as yearlings, usually with the onset of storms starting in October. Yearling emigration from the tributaries may continue through the following March, with peak movement usually occurring in November and December. Juvenile emigration alternates between active movement, resting and feeding. Juvenile salmon may rear for up to several months within the Delta before ocean entry. Spring Chinook runs tend to be dominated by three-year-old fish followed by four-year-olds and jacks.

Ocean distribution. The development and widespread use of coded wire tag (CWT) recoveries since the mid 1970s have provided extensive data on the ocean distributions of Pacific coast salmon stocks. Recovery of CWTs in ocean salmon fisheries has provided a better understanding of the temporal and spatial distribution of various Chinook stocks, particularly those from the Central Valley and Klamath Basin. For example, although Sacramento River fall Chinook are distributed primarily off of California and Oregon, they are also occasionally caught off Washington and British Colombia coasts. A few fish have even ventured as far north as Alaska. Klamath River fall Chinook, on the other hand, are more narrowly distributed primarily between Cape Falcon, Oregon and Point Sur, California. Ocean conditions have also been shown to affect the ocean distribution patterns of these and other Pacific coast salmon stocks.

Coho salmon

Coho salmon, *Oncorhynchus kisutch*, (Figure 5-9) are smaller than Chinook salmon; the average size of a mature coho is 7 to 12 pounds (3 to 5 kilograms). The California record for a recreationally-caught coho is 22 pounds (10 kilograms), taken on Paper Mill Creek (Marin County) in 1959. The world record is a 33 pound (15 kilograms) coho caught by an angler in British Columbia in 1989.

Figure 5-9. Coho salmon, *Oncorhynchus kisutch*. Photo credit: K Lesher, CDFW.

In California, coho salmon spawn in coastal rivers and streams from northern Monterey Bay to the Oregon-California border. They are rarely found in the Central Valley basin. Coho enter many small streams that are not utilized by Chinook, but also spawn in larger river systems where Chinook also reside. Compared to Chinook salmon, there are relatively few coho in California today. Most California streams utilized by coho are short in length, but some coho do make relatively long migrations, particularly into the Eel River system. Many smaller coastal rivers have runs of coho that enter during brief periods after the first heavy fall rains and move upstream.

Within California river systems, coho salmon populations include only one run, which is generally consistent as to spawning area used and time of spawning. Most spawning

occurs between December and February. The juveniles usually spend a little more than a year in freshwater before migrating to the ocean; a few spend two years. Most coho mature at the end of their third year of life. Coho salmon older than three years are relatively rare. A few males, or jacks, mature at age two.

Genetic analysis of California coho salmon populations has indicated a wide degree of mixing of the stocks in the past, probably reflecting historical stocking and transplantation practices involving hatchery fish. Historical recoveries of CWTs from California hatchery coho stocks showed that most were harvested in the ocean fisheries during their third year of life. Some were caught as far north as the central Washington coast, but most were recovered within 100 miles (161 kilometers) of the stream from which they entered the ocean.

Status of Spawning Populations

In the Central Valley and Klamath Basin, a multitude of factors have contributed to the decline of salmon stocks, including species listed under the California Endangered Species Act (CESA) and the federal Endangered Species Act (ESA). Factors include construction of dams that cut off historical spawning habitat, unscreened irrigation diversions in the Delta and Sacramento-San Joaquin river basins, poor or lost gravel deposition in salmon spawning and rearing areas, water pollution, aberrant river flow fluctuations caused by alternating water release schedules from dams to meet downstream water quality standards and water diversion contracts, elevated water temperatures stemming from commercial water usage, reduced riparian habitat due to channelization, and other physical impediments to migration and spawning grounds. Populations in these areas have been reduced from their more robust historical abundances. While most of that information was qualitative and anecdotally reported, those abundances were presumably grand in comparison to averages from modern day.

Central Valley Fall Chinook – There are two major fall runs in the Central Valley. The most numerous are the Sacramento River fall Chinook, which includes salmon from the Sacramento River and its tributaries. Major tributaries of the Sacramento River are the Feather, American, and Yuba rivers among others. San Joaquin River fall Chinook include salmon from the San Joaquin River and its tributaries. Major tributaries of the San Joaquin River are the Mokelumne, Merced, and Tuolumne rivers. Both runs are heavily supplemented with hatchery production. Coleman National Fish Hatchery, Feather River Hatchery, and Nimbus Fish Hatchery produce approximately 30-32 million Sacramento River fall Chinook annually while Mokelumne River Hatchery and Merced River Fish Facility produce 2-6 million San Joaquin River fall Chinook, depending on the previous year's adult escapement. During the last four decades, Sacramento River fall Chinook has accounted for approximately 94 percent of all Central Valley fall Chinook escapement.

Prior to 1995, annual Sacramento River fall Chinook escapement was relatively constant, generally ranging between 122,000 and 250,000 adult spawners returning to

the Sacramento River Basin each fall (Figure 5-10). Beginning in 1995, Sacramento River fall Chinook escapement began to steadily increase, peaking at a record high 770,000 salmon in 2002, before declining back to near normal levels in 2006. In 2007, Sacramento River fall Chinook escapement suddenly declined resulting in one of the lowest returns (91,400 adults) on record. In addition, the number of Sacramento River fall Chinook jacks (age 2) that returned was an all-time record low (1,900 salmon), which represented 5 percent of the long term average (36,000 salmon) observed during the previous 35 years. This marked the beginning of the Sacramento River fall Chinook collapse as escapement declined even more in 2008 and 2009 when only 65,400 and 40,900 adults returned, respectively, the two lowest returns on record.

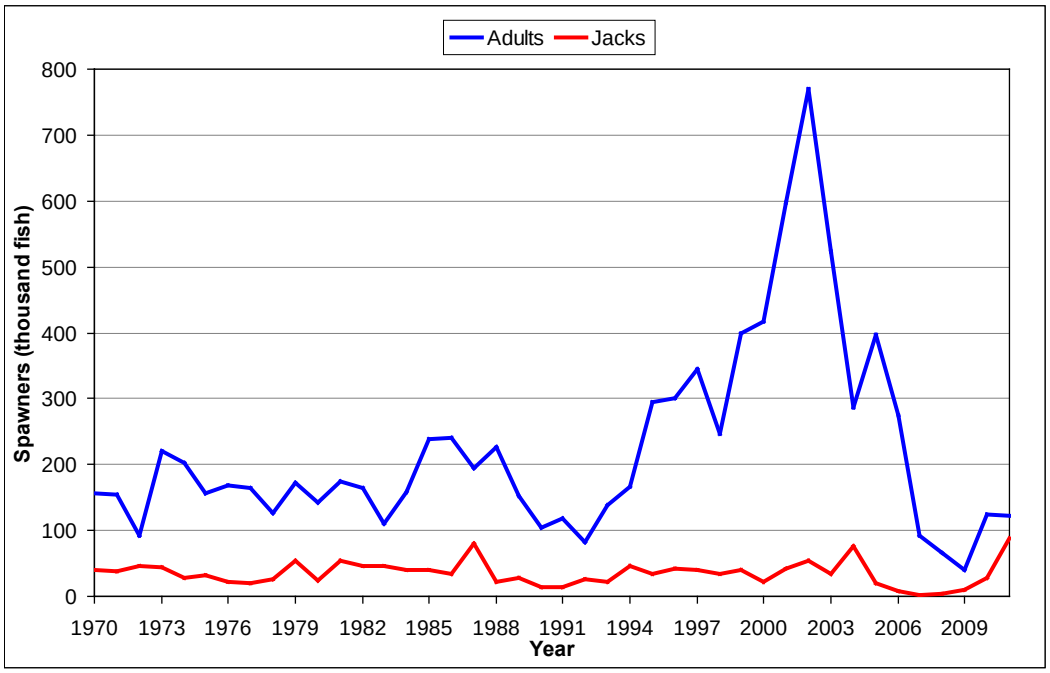

Figure 5-10. Sacramento River fall Chinook salmon escapement to the Central Valley, 1970-2011. Data source: Department Ocean Salmon Project and PFMC data.

A multi-agency, multi-disciplinary scientific panel was assembled to determine the cause of the Sacramento River fall Chinook collapse and began investigating more than 40 potential environmental and physical factors. The panel found that extremely poor ocean conditions off the California coast during 2005 and 2006 had significantly reduced the survival rate for Sacramento River fall Chinook juvenile salmon emigrating to the ocean during this time. These poor ocean conditions were characterized by weak upwelling, warm sea surface temperatures, and a scarcity of food. The panel also identified the long term cumulative effect of poor river conditions as another primary factor. During 2010 and 2011, the stock rebounded slightly with 124,300 and 121,700 Sacramento River fall Chinook adults returning, respectively. More recently, a record number of Sacramento River fall Chinook jacks (88,200) returned in 2011 indicating good survival of juveniles and a relatively high ocean abundance of Sacramento River fall Chinook adults available for harvest in 2012.

Central Valley Spring Chinook – Central Valley spring Chinook from the Sacramento River drainage have been listed as threatened under CESA since February 1999 and under the federal ESA later the same year. Spring Chinook, which historically were the second most abundant run in the Central Valley, now spawn in relatively small numbers in the upper Sacramento River and tributaries (Butte, Deer, and Mill creeks). Central Valley Spring Chinook also occur in the Feather River and the run there is supplemented by Feather River Hatchery, which produces approximately 2 million spring Chinook annually. Genetic analyses have shown that Spring Chinook occurring in Butte, Deer, and Mill creeks are genetically divergent from those found in the Feather River and are thus the only true spring run populations in the Central Valley. Feather River spring run are genetically homogenous to fall run Chinook found throughout the Central Valley, although they continue to express spring run life history traits and are included in the Central Valley Spring Chinook evolutionarily significant unit (ESU). In addition, there are small spring run escapements that occur in other tributaries of the Sacramento River such as Clear Creek and the Yuba River. These populations occur with some frequency however they are not recognized as a part of the Central Valley Spring Chinook ESU. While regular surveys occur in the above tributaries, spawning totals for the upper Sacramento after 2008 are unavailable as changes to the Red Bluff Diversion Dam operations made the counting facility there obsolete. Total escapement to these tributaries has averaged 15,000 fish since 1995 with some years exceeding 20,000 spawners (Figure 5-11). The latest escapement totals have been roughly half the recent average. Although spring Chinook haven't existed in the San Joaquin River since the 1940s, plans are currently underway to reintroduce the run to the San Joaquin basin within the next few years.

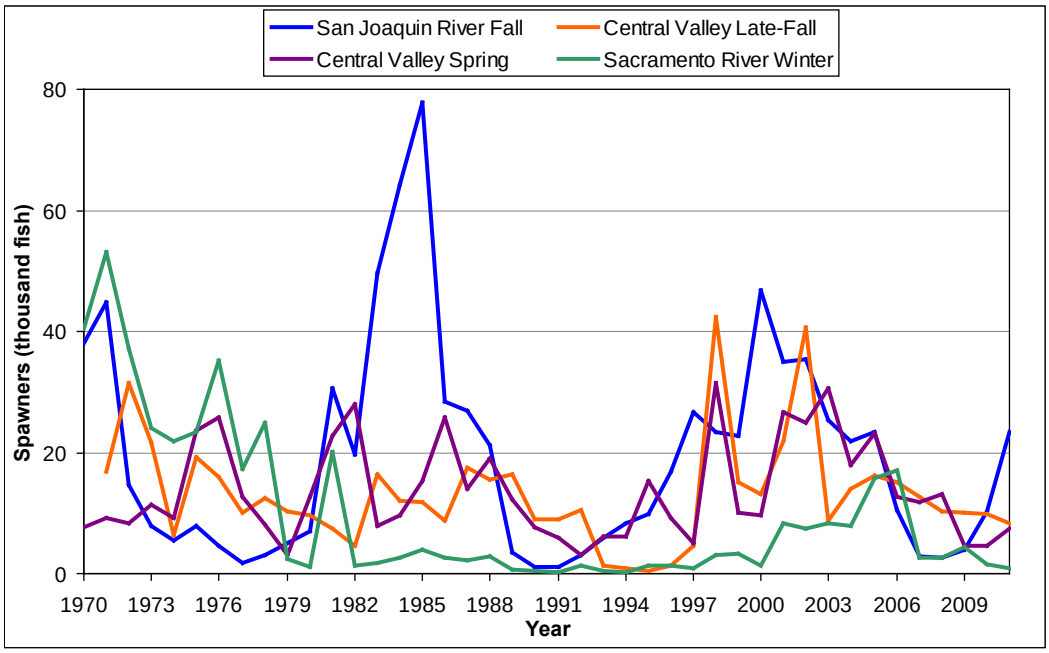

Figure 5-11. Other runs of Chinook salmon escapement to the Central Valley, 1970-2011. Data source: Department Ocean Salmon Project and PFMC data.

Central Valley Late-Fall Chinook – Central Valley Late-Fall Chinook spawn primarily in the upper Sacramento River and Battle Creek although some late-fall escapements have been reported in other Sacramento River tributaries such as the Yuba and American Rivers. The run was not identified until monthly spawner counts began at the Red Bluff Diversion Dam in the 1960s. Prior to that, Late-Fall Chinook were presumably considered to be part of the fall or winter run escapements. A carcass survey has been conducted in recent years on the upper Sacramento River to provide annual escapement totals in lieu of the dam counts. The run is supplemented by Coleman National Fish Hatchery, which produces approximately 1 million fish annually. Since 1995 escapement has averaged roughly 14,000 fish with a peak of nearly 40,000 spawners during that time period (Figure 5-11). The Central Valley Late-Fall Chinook escapement is highly variable and experienced an increasing trend through the mid 2000s after a severe decline in the mid 1990s. Escapement totals have been decreasing since 2006, but not to the levels experienced in the previous decade.

Sacramento River Winter Chinook – Sacramento River Winter Chinook salmon were listed as endangered in 1989 under CESA, and threatened under the federal ESA. The stock was downgraded to endangered under the federal ESA in 1994. Unfortunately Sacramento River Winter Chinook no longer exist in any of the original spawning habitat, all located above Shasta Dam, and the run persists in a relatively short section below the dam made suitable by cold water releases into the upper Sacramento River. The spawning population below Shasta Dam declined from an average of 28,000 fish observed in the 1970s to only a few hundred in the early 1990s (Figure 5-11). For a brief period, Sacramento River Winter Chinook were propagated at Coleman National Fish Hatchery on Battle Creek. However, due to difficulties in operating the hatchery as a conservation facility aimed at recovering Winter Chinook in the upper Sacramento River, the need for a new hatchery located adjacent to the desired spawning habitat was identified. As a result Livingston Stone National Fish Hatchery was built in 1997 at the base of Shasta Dam. The hatchery was specifically designed to develop an integrated-recovery program that collects and utilizes natural-origin Sacramento River Winter Chinook broodstock to produce approximately 200,000 juveniles annually, while preserving the genetic integrity of the ESU. These hatchery-origin Sacramento River Winter Chinook are intended to return as adults to the upper Sacramento River, spawn in the wild, and become reproductively and genetically assimilated with the natural population to aid in recovery of the species. The population experienced an increase in abundance from 2000 to 2006 when it peaked at over 17,000 fish but has since declined similar to the trend observed with Sacramento River Fall Chinook and other Central Valley Chinook stocks. Only 1,596 and 824 Sacramento River Winter Chinook returned to spawn in 2010 and 2011, respectively.

Klamath River Fall Chinook – In the Klamath basin, there are two hatcheries - Iron Gate Hatchery and Trinity River Hatchery - that supplement Fall and Spring Chinook production on the Klamath and Trinity rivers. Adult spawner totals for Klamath River fall Chinook has ranged from a low of 18,000 (hatchery and natural) in 1991 to 180,000 in 1995 (Figure 5-12). Monitoring of Klamath River Spring Chinook escapement has been

sporadic over the years and complete counts of hatchery and natural returns are not available at this time. The population seems to be cyclical with several years of high spawners followed by a few years of low returns.

In 2002, an unprecedented fish kill occurred in the Klamath Basin. Approximately 35,000 salmon, among other fishes, died prior to spawning, primarily due to disease outbreaks as a result of reduced water flow, increased water temperature, and high fish density. The two responsible pathogens were the myxozoan parasite *Ichthyopthirius multifilis* (commonly referred to as Ich) and a bacterial pathogen *Flavobacterium columnare* (columnaris). These two common pathogens are found in the Klamath River at all times, but rarely cause significant problems unless other factors such as stressful environmental conditions are present. Reduced water flow, resulting in warm water temperatures, coupled with high fish densities created an ideal condition for the spread of disease which ultimately resulted in the fish kill.

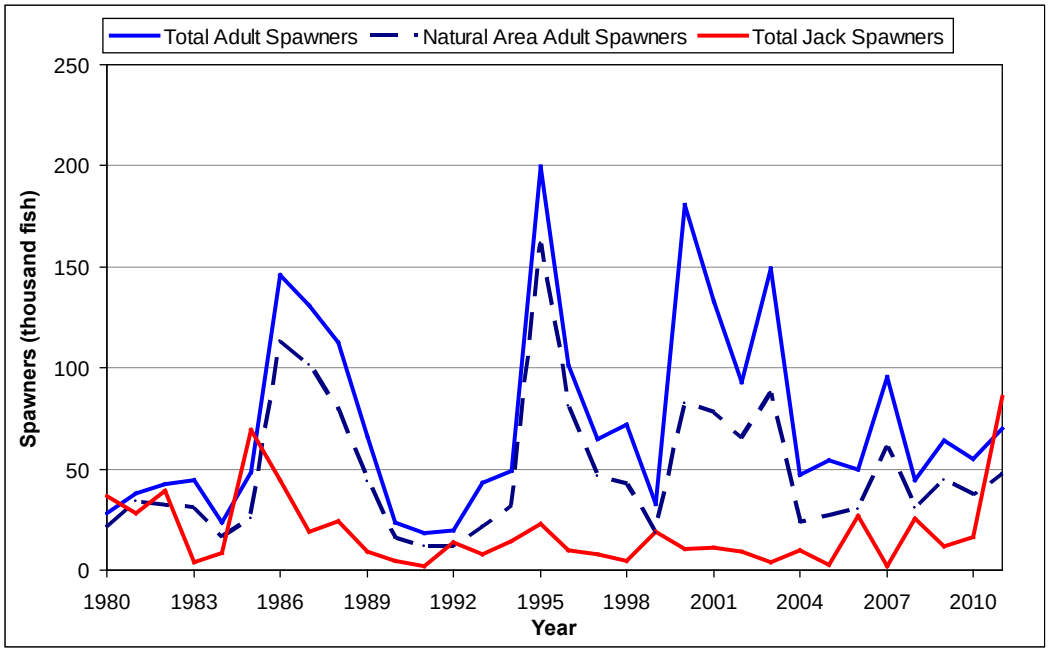

Figure 5-12. Klamath River Fall Chinook salmon escapement, 1980-2011. Data source: Department Ocean Salmon Project and PFMC data.

Total adult returns to the Klamath Basin have averaged 123,000 fish since 1995 with some years exceeding 200,000 Chinook salmon. In 2011, returns of Fall Chinook adult spawners to hatcheries and natural areas in the Klamath Basin totaled more than 22,300 and 47,800 fish, respectively, with another 31,000 being harvested from the river. In addition, a record 74,000 Klamath River Fall Chinook jacks returned in 2011, indicating a large ocean abundance of age 3 Klamath River Fall Chinook available for harvest in 2012.

Coastal Chinook and Coho Populations - Declines in coastal river Chinook and coho salmon populations have been caused by many of the same factors that affect the

Central Valley. Habitat blockages, agriculture, urbanization, and water withdrawals have resulted in widespread declines of both species. In addition, many of these areas have been affected by past and, in some instances, current timber harvest practices. Some of these practices have reduced stream shading, resulting in increased water temperatures, and have accelerated watershed erosion and sedimentation of spawning habitat.

The Central California coast coho south of San Francisco Bay were listed as endangered in 1996 under CESA. This was increased to encompass all waters south of Punta Gorda (just below Cape Mendocino) in 2005. On the federal side, the Central California coast coho ESU was listed as threatened in 1996 and downgraded to endangered in 2005 under the ESA. The Southern Oregon-Northern California coast coho ESU was listed as threatened in 1997 under the ESA. In 2005, California also listed the Southern Oregon-Northern California coast coho (Punta Gorda to the California/Oregon border) as threatened under CESA.

In recent years, there has been a significant decrease in the number of spawning Central California coastal and Southern Oregon-Northern California coast coho adults and the Department is currently part of a Coho Recovery Team focused on implementing strategies aimed at restoring and rebuilding California coho populations. Spawning occurs for Central California coastal coho from the San Lorenzo River in the south to the Big River in the north while Southern Oregon-Northern California coast coho range from the Mattole River in California to the Elk River in Oregon. Monitoring in these streams ranges from annual systematic to sporadic nonsystematic surveys depending on the location and flows.

The California Coastal Chinook ESU, which includes northern California coastal streams between, and including, Redwood Creek and the Russian River, have been listed as threatened under the ESA since 1999. Monitoring occurs annually in the Russian River; however additional spawning population estimates are limited for coastal Chinook to nonsystematic surveys of the remaining coastal streams.

In 2011, the Department published a document entitled “California Coastal Salmonid Population Monitoring: Strategy, Design, and Methods.” This document outlines current needs for monitoring salmonids along the coast for evaluating the effectiveness of restoration, recovery and management practices to date as required by CESA. The plan uses the Viable Salmonid Population concept to assess salmon viability in terms of four key population characteristics: abundance, productivity, spatial structure, and diversity. Implementation of the plan is currently under way.

Salmon Management

In 1947, the Pacific Marine Fisheries Commission, now known as the Pacific States Marine Fisheries Commission (PSMFC), was formed by the states of Alaska, Washington, Oregon, Idaho, and California. The primary objective of the alliance was to make better use of the marine resources shared by the member states. Prior to that

time, there was minimal coordination of marine fishing regulations between the states, including season dates and size limits. The first commercial salmon recommendation of the PSMFC was a 25 inch (66 centimeters) TL minimum size limit and a March 15 to October 31 maximum season length for Chinook. For many years the states uniformly adopted the 25 inch (66 centimeters) TL size limit and an April 15 opening date for commercial Chinook fishing with a general September 30 closing date.

In 1976, the Magnuson Fishery Conservation and Management Act (Magnuson-Stevens Act) established the Exclusive Economic Zone and the authority of the Secretary of Commerce to manage fisheries covered under federal fishery management plans from 3 to 200 miles (5 to 322 kilometers) offshore. The Magnuson-Stevens Act created regional fishery management councils to develop fishery management plans and recommend fishing regulations to the states, Native American tribes, and NOAA Fisheries Service. Thus the PFMC was created with management authority over the federal fisheries off the coasts of California, Oregon, and Washington. Representation on the PFMC currently includes the chief fishery officials of California, Idaho, Oregon, and Washington, NOAA Fisheries Service, a Native American representative, and eight knowledgeable private citizens. The PFMC receives advice on salmon issues from a Salmon Technical Team and a Salmon Advisory Sub-panel composed of various industry, tribal, and environmental representatives.

The PFMC's Salmon Fishery Management Plan (Salmon FMP) was developed in 1977 and was the first FMP implemented by the organization. The PFMC annually develops management measures that establish fishing areas, seasons, quotas, legal gear, possession and landing restrictions, and minimum lengths for salmon taken in federal waters off California, Oregon, and Washington. The management measures are intended to prevent overfishing while achieving optimum yield and to allocate the ocean harvest equitably among commercial and recreational ocean fisheries. The management measures must meet the goals of the Salmon FMP that address spawning escapement needs (i.e., conservation objectives) and allow for freshwater fisheries. The needs of salmon species listed under the ESA must also be met as part of the process. The measures recommended to NOAA Fisheries Service by the PFMC must be approved and implemented by the Secretary of Commerce.

While the PFMC is responsible for recommending management measures within federal waters, the California Fish and Game Commission (Commission) maintains authority to manage salmon fisheries within state waters (in-river and coastal ocean areas within 3 nautical miles [5 kilometers] of shore). The Commission generally adopts fishing seasons and regulations consistent with those recommended by the PFMC.

In 2006, the Magnuson-Stevens Act was reauthorized and included new guidelines and definitions to protect marine resources and prevent overfishing. The law required an amendment to the Salmon FMP, which features new conservation objectives for Klamath River fall Chinook and Sacramento River fall Chinook, and guidelines for

establishing ocean fisheries during periods of very low salmon abundance. The new guidelines were first used during the 2012 PFMC management process.

Klamath River fall Chinook was one of the first salmon stocks to be managed under the PFMC's Salmon FMP in 1983. The original Klamath River fall Chinook conservation objective required that a minimum of 35,000 adults return to spawn in natural areas each year and that the natural spawner reduction rate in ocean fisheries did not exceed 67 percent. In 1994, PFMC management was modified to ensure that the Klamath tribes (Yurok and Hoopa Valley) received their federally reserved fishing right of 50 percent of the total allowable Klamath River fall Chinook harvest. In 2011, Amendment 16 to the Salmon FMP revised the minimum natural area spawners to the maximum sustainable yield, which was determined to be 40,700 adults. In addition, the annual spawner reduction rate from ocean fisheries is not permitted to exceed 68 percent.

The Salmon FMP also established a conservation objective for Sacramento River fall Chinook that required ocean fisheries be managed to allow a range of 122,000 to 180,000 natural and hatchery adults to return each year to spawn. In 2007, Sacramento River fall Chinook failed to meet the minimum conservation goal of 122,000 adult spawners required to ensure the long term survival of the stock. Sacramento River fall Chinook is considered the primary salmon stock supporting California ocean fisheries, historically comprising 80-95 percent of the salmon catch. When fishery scientists predicted less than 60,000 Sacramento River fall Chinook would return the following year, the PFMC took emergency action to close all California and Oregon ocean salmon fisheries in 2008 to protect this important stock and the Commission approved the same fishery closure in California state waters. The fisheries remained closed in 2009 and were severely constrained in 2010 when Sacramento River fall Chinook failed to meet the minimum spawner goal.

In response to the Sacramento River fall Chinook collapse, new management tools were developed to estimate relative Sacramento River fall Chinook ocean abundance (Sacramento Index) and evaluate the impacts of California and Oregon ocean salmon fisheries by time and area (Sacramento Harvest Model). In 2010, Sacramento River fall Chinook met their conservation goal and relatively high numbers of returning jacks (age 2 fish) allowed for the resumption of recreational and commercial ocean fisheries, albeit somewhat constrained to protect Sacramento River fall Chinook. In 2011, Amendment 16 to the Salmon FMP established an additional management threshold in the form of a 70 percent marine exploitation rate. The minimum spawning escapement goal range of 122,000 to 180,000 adults was left unchanged in the new amendment, although there is interest in revisiting the suitability of this management goal.

Currently, there are 3 ESA-listed Chinook stocks (Sacramento River winter, Central Valley spring, California Coastal), and 2 coho stocks (Southern Oregon/Northern California, Central California Coast) in California. As the listings have occurred, NOAA Fisheries Service has initiated formal consultation standards and issued Biological Opinions (BO) that consider the impacts resulting from implementation of the Salmon

FMP or from annual management measures to ESA-listed salmon stocks. NOAA Fisheries Service has also reinitiated consultation on certain stocks when new information has become available on their status or on the impacts of the Salmon FMP on these stocks. Amendment 12 of the Salmon FMP added the generic category "species listed under the ESA" to the list of stocks in the salmon management unit and modified respective escapement goals to include "manage consistent with NOAA Fisheries Service jeopardy standards or recovery plans to meet immediate conservation needs and long term recovery of the species." Amendment 14 of the Salmon FMP specified those listed stocks and clarified which stocks in the FMP management unit were representative of the listed stock.

NOAA Fisheries Service has concluded that harvest of the relatively abundant Sacramento River fall Chinook can continue at reduced levels in California's ocean fisheries without jeopardizing the recovery of listed Chinook and coho populations. The Commission, PFMC and NOAA Fisheries Service have implemented various protective regulations to reduce fishery impacts on California populations of Sacramento River winter, Central Valley spring, California coastal Chinook, and coho, all of which are state and federally listed (California coastal Chinook are only federally listed).

When Sacramento River winter Chinook were listed as endangered under the ESA in 1994, a new dimension was added to salmon management. The ESA requires that NOAA Fisheries Service assess the impacts of ocean fisheries on listed salmon populations and develop standards that avoid the likelihood of jeopardizing their continued existence. The original standard for Sacramento River winter Chinook required a 31 percent increase in the adult spawner replacement rate relative to the observed mean rate from the base period of 1989 to 1993. Although contacted only incidentally in California ocean fisheries, primarily in the recreational fishery south of Point Arena, additional restrictions were placed on California's commercial and recreational fisheries in 2002. These restrictions included minimum size limits designed to protect the smaller-at-age Sacramento River winter Chinook and season opening and closing date restrictions. In 2010, NOAA Fisheries Service issued an updated BO with the conclusion that ocean salmon fisheries continued to jeopardize the continued existence of this depressed stock in spite of existing fishing restrictions. The updated BO required the development of new tools to quantify impacts of fisheries on Sacramento River winter Chinook and assess potential impacts of proposed fisheries. Although ocean fishery impacts on Sacramento River winter Chinook have remained relatively constant over the past decade, the spawning population of Sacramento River winter Chinook has fluctuated and most recently declined. This downward trend cannot be readily explained by ocean harvest, especially since California fisheries were completely closed in 2008 and 2009. In 2012, NOAA Fisheries Service issued a new consultation standard limiting ocean fishery impact rates based on the number of fish returning to spawn in the previous three years in addition to the typical minimum size and season restrictions south of Point Arena. The impact rate cap is expected to change annually based on the number of Sacramento River winter Chinook returning to the river to spawn, and may close some ocean salmon fisheries should the three year

mean of the population fall below 500 fish. NOAA Fisheries Service has concluded that the conservation measures in place to protect winter run Chinook are sufficient to protect Central Valley spring Chinook as well.

To protect California Coastal Chinook, NOAA Fisheries Service placed a cap on the ocean harvest rate (≤16 percent) of age 4 Klamath fall Chinook in 2000. Since ocean distribution information on California coastal Chinook was very limited, Klamath River fall Chinook were considered the best available surrogate for estimating ocean fishery impacts on these stocks.

In 1992, the PFMC began to severely curtail the ocean harvest of all coho salmon in California due to the depressed condition of most coastal stocks. In anticipation of the federal listing of California coho salmon stocks, NOAA Fisheries Service extended the protective measures to a complete prohibition of coho retention off California.

Inland Management

The decline in California's salmon populations vary somewhat from river to river, but loss of habitat and water diversion are the two major underlying causes. As a result of habitat loss and the associated reduction in life history types that utilize those habitat niches, the resiliency of California salmon stocks as a whole has been diminished. For example, diminished resiliency among salmon stocks in the Central Valley coupled with poor ocean conditions in 2005 and 2006 resulted in historically low escapement during the latter half of the decade. Water diversion is an issue that affects both juveniles and adults alike. Diversions can confuse escapement and emigration routes, decrease water quality for spawners and their progeny, entrain outmigrants, and create predator niches among other things. These two major causes of decline are largely responsible for the eventual listing of stocks under the ESA today.

Although the listing of salmon populations under CESA and/or ESA has meant new restrictions on recreational and commercial fishing, it has also provided a mechanism for addressing the effects of dams, water diversion, logging, gravel extraction, road construction, etc. on aquatic environments. Species management under provisions of the ESA requires that existing and proposed federal actions and permitted activities be conducted in a manner that will not jeopardize the continued existence of the animal or result in the destruction or adverse modification of habitat essential to the continuation of the species. Federal agencies must consult with NOAA Fisheries Service when they propose to authorize, fund, or carry out an action that could adversely affect listed salmon or steelhead. Likewise, State-sponsored activities that might affect state-listed species must be reviewed under the provisions of CESA.

Substantial efforts have been made during the past two decades to ensure that the ecological requirements of anadromous fish receive equal consideration with other economic and social demands placed on the State's water resources. The Central Valley Project Improvement Act of 1992 required a program designed to double natural production of anadromous fish in Central Valley streams. In 1995, California and the

federal government initiated the CALFED Bay-Delta program to address environmental and water management problems associated with the Bay-Delta system. The primary mission is to develop a long term comprehensive plan that will restore ecological health and improve water management for the beneficial uses of the Bay-Delta system.

In 2002, the California Legislature created the California Bay-Delta Authority to oversee implementation of the Bay-Delta Program. Two years later, Congress approved a 30-year plan that includes goals and science-based planning to facilitate collaborative and informed decisions for future Bay-Delta projects. In 2006, a ten-year action plan was developed to help chart a course for the CALFED, including addressing water supply and ecosystem functioning problems. Projects include providing fish passage ways, dam removal, installing fish screens, aquatic and riparian habitat restoration, channel dynamic and sediment transport improvements, floodplain and bypass restoration, agricultural modifications, local watershed planning, improving natural flow regimes, recovering water and sediment quality, environmental water management, fishery monitoring, and temperature control of water releases.

Red Bluff Diversion Dam, built in 1964 on the upper Sacramento River, was once a major impediment to adult salmon upstream migration, a major point for water diversion and mortality on downstream migrating juveniles, and a haven for predatory Sacramento pikeminnow and non-native striped bass. Lifting of the gates at this facility had been implemented in the fall through spring to protect all races of Chinook; however, after the Bureau of Reclamation determined that dam operations did not adequately allow passage of ESA-listed salmonids, they began raising the gates for ten months (closed July and August) and plans were created to add a new pumping station to provide agricultural water. In 2008, a federal judge ordered the dam gates be lifted permanently to protect ESA-listed species and the Red Bluff Diversion Dam Fish Passage Improvement Project was created. Construction of a new screened pumping station began immediately to reduce the impacts of water diversion on salmonids and other listed species while still delivering water to agricultural interests. During construction, the Red Bluff Diversion Dam continued to operate with the gates open ten months a year to allow optimum conditions for fish passage while honoring water deliveries. In September 2011, the gates were raised for the final time, ending use of the dam as a water diversion. The new screened pumping station went online September 2012 and will improve fish passage conditions while ensuring continued water deliveries to agricultural needs in the Central Valley.

Many similar improvements have also been made in the Klamath Basin. The federal Trinity River Basin Fish and Wildlife Restoration Act was enacted in 1984 to restore fish populations to levels existing prior to the diversion of water to the Central Valley. In 1986, Congress adopted the Klamath River Basin Fishery Resources Restoration Act, a 20-year-long cooperative program to restore anadromous fisheries within the Basin. With a $21 million budget, many conservation projects were completed including instream, riparian, and upland protection and restoration, fish rearing, water conservation and water quality improvement, assessment and research, and community

education. In 2010, a coalition of tribes, landowners, local government, state and federal agencies, conservationists, and the local utility that owns and operates the dams on the upper Klamath River reached the Klamath Hydroelectric Settlement Agreement and the Klamath Basin Restoration Agreement. These agreements have most notably paved the way for the removal of four dams on the upper Klamath River, restoring access to hundreds of miles of spawning habitat previously inaccessible due to dam construction. While dam removal continues to be debated further and has yet to commence, these agreements and their potential for the Klamath Basin are significant steps forward in the restoration of salmon habitat in California.

Hatchery fish have been important to maintaining ocean and in-river fisheries, but have incorrectly been perceived as a viable alternative to maintenance of natural spawning populations. Unfortunately, a successful hatchery program can sometimes mask the decline in the natural run, and this appears to be the case for Chinook salmon in many areas of the Central Valley and the Klamath River basin. Hatchery adults spawning in the wild can compete with naturally produced fish for adult spawning and juvenile fish rearing areas. Interaction of hatchery and naturally produced salmon is most acute in the close vicinity of the rearing facilities. In 2007, the State began a Constant Fractional Marking (CFM) program in which at least 25 percent of the fall Chinook production are marked with an adipose fin clip and tagged with a uniquely-coded CWT (Figure 5-13). The CFM program was designed to allow fishery managers to determine the contribution of hatchery and natural fish in the spawning population, and thus determine the success of habitat restoration efforts and hatchery operations. The CFM program has been successful in marking and tagging the target numbers of salmon each year at each of the Central Valley hatcheries, and has just begun recovering CWTs in a statistically valid manner throughout the Central Valley.

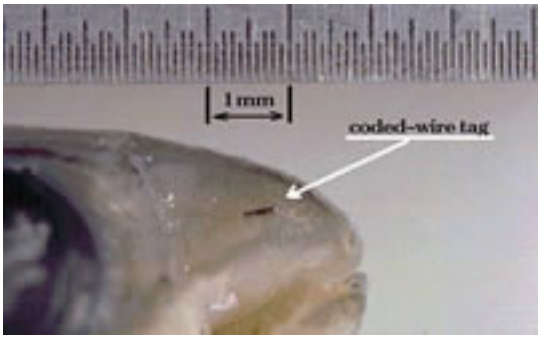

Figure 5-13. Salmon smolt with coded wire tag. Photo credit: USFWS photo.

The CFM program also allows hatchery managers to evaluate various release strategies to improve survival and fishery contribution rates. The 2010 escapement marks the first year when estimates of hatchery and natural proportions have been reported. Additionally, estimates related to the performance of various release strategies were also possible for the first time as a result of the CFM program. Generally speaking, results have shown that hatchery escapement is dominated by hatchery-origin fish while natural escapement is variable. Some streams show a predominance of natural-origin fish while other streams show a predominance of hatchery-origin fish, particularly those with hatcheries. Furthermore, results indicate that releasing Chinook salmon outside of their natal streams via trucking does indeed increase relative survival while showing moderate increases in stray rates. Also, fish that are transported in trucks to the Delta for release contribute at a higher

rate to ocean fisheries. The results from this program will provide the best opportunity to manage Chinook based on scientifically defensible data.

Prior to the CFM program, the primary purpose of Central Valley Chinook salmon escapement monitoring was to provide basic status information (e.g., jack and adult escapement counts) by individual stocks and basins for California hatchery and ocean harvest management needs. The marking, tagging, or collection of CWT fish was not a high priority. Central Valley escapement monitoring has expanded to provide data for a broad range of management applications related to recovery planning for listed stocks. These applications include assessing recovery efforts, including habitat restoration work, improving ocean and river fisheries management, and evaluating Central Valley salmon hatchery programs to ensure both mitigation and conservation goals are being met. To meet the needs of these various assessment efforts, a review of current methodologies being employed among Central Valley inland escapement monitoring programs was undertaken by the Department in 2008. The goal of this review was to identify needed changes and/or additions to survey protocols that will ensure both statistically valid estimates of escapement and the collection of biological data, including CWTs and scales, needed for assessment efforts. In 2012, the Department completed the Central Valley Chinook Salmon Escapement Monitoring Plan that recommends methods for estimating escapement and collecting biological data necessary for improved stock assessment. Survey modifications included changes in the current mark-recapture models being utilized, changes in sampling protocols to ensure representative sampling and proper accounting, and the use of counting devices in place of some mark-recapture programs. This monitoring plan is now being implemented to provide the basis for sound Central Valley Chinook assessment and subsequent management.

Many recreational salmon anglers are attracted to rivers from Santa Cruz County north. Historically, almost half of the effort was in the Sacramento-San Joaquin River System. Most of this activity occurs upstream from the city of Sacramento. The main stem of the Sacramento River is the most utilized Central Valley stream, followed by the Feather and American rivers. In 2006, the Central Valley creel census was reinstated to provide improved estimates of inland fishing effort and harvest. The creel survey has continued to sample the Central Valley inland fishery and generate estimates of effort and catch each year since. Of the coastal streams, the Klamath Basin receives by far the most effort, followed by the Smith and Eel rivers. The catch in both of these rivers consists primarily of Chinook salmon. The fishery on the Klamath River is also closely monitored via a creel survey throughout the fishing season.

Ocean Management

Ocean salmon fisheries harvest a mixture of stocks that differ greatly in their respective abundance and productivity. It has long been recognized that the management of mixed stock salmon fisheries is complex. Ocean abundance estimates are not available for most of California's salmon and harvest rates on these stocks are difficult to

evaluate. Without stock- and age-specific mortality and population size estimates, it is difficult to assess the relative effects of harvest, improvements in freshwater habitats, or changes in ocean productivity or climate change.

Ideally, some differences in the spatial and temporal distribution of “strong” and “weak” stocks exist that would allow managers to develop measures that selectively protect stocks of concern. However, identifying individual stocks at time of harvest is not possible for salmon populations without a coded-wire tagging program. Regulations are crafted each year to protect weak stocks using the best available information from CWTs and modeling outputs based on past fishing seasons. This sometimes results in constraining the fisheries’ access to more abundant salmon stocks.

During the last two decades, commercial test fisheries have been conducted in California to evaluate the use of Genetic Stock Identification (GSI) techniques in ocean fisheries management. The GSI technology for identifying Chinook stocks has significantly improved over time; however, data for several stocks continue to lack the detail required for salmon fishery management. Additionally, when stocks of special concern are at low abundance and comprise an extremely small fraction of ocean catches, even GSI methods may not produce accurate estimates of ocean impacts on these populations. Although these challenges exist, a great deal of effort has been placed on continuing and improving GSI studies, and may become a component of ocean fishery management in the future.

To begin addressing the lack of age specific data for some stocks, the Department began a scale aging program to determine the age structure of all Central Valley Chinook salmon escapement in 2005. Age specific data will aid in determining cohort strength, proportions of hatchery and natural stocks in the spawning population, and ocean abundance by age. Preliminary results found differences in the age structure of hatchery and natural spawners as well as among the various stocks and runs present in the Central Valley. As previously stated, results from the continuation of CFM program and scale age analysis are expected to provide the best opportunity to manage Chinook salmon based on scientifically defensible data.

Ocean salmon fishery managers must continually be prepared to respond to changes in the fisheries, population status, and ocean environments. Many times, these changes call for modifying the tools used by fishery scientists and managers necessary for adaptive management.

In 2006, Klamath River fall Chinook were declared “overfished” for failing to meet the conservation objective for three consecutive years. While unfavorable in-river and marine conditions likely contributed to the decline in the population, overfishing did occur in 2004-2006 due to under-forecasting commercial mortality before the season began. Modifications were made to the model used for forecasting mortality to avoid overfishing the stock in the future.

In 2007 an unprecedented decline in Sacramento River fall Chinook was observed, continuing with a historically low spawning population of only 40,900 adults in 2009. In response to the decline, the PFMC, NOAA Fisheries Service, and the Commission were required to close all ocean salmon fisheries in 2008 and 2009, and severely restrict fisheries in 2010.

As a result of two major stock declines, fishery managers sought methods to allow management flexibility while continuing to protect the long term viability of each stock. Following the decline of Klamath River fall Chinook, Amendment 15 to the Salmon FMP was developed to allow for limited harvest of Klamath River fall Chinook in ocean fisheries whenever shortfalls were projected. Several years later, when Sacramento River fall Chinook began to decline, it became apparent that additional flexibility in fisheries management was needed during periods of low abundance. As part of the Amendment 16 process in 2011, new harvest control rules were developed to guide west coast management decisions during periods of very low salmon abundance to allow for small scale "de minimus" fisheries while continuing to protect salmon stocks.

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Commercial salmon harvest (pounds), 2000-2011.						
Year[a]	Chinook	Coho[b]	Ocean Total	Sacramento[c]	Klamath[d]	Total
2000	5,130,763	-	5,130,763	-	-	5,130,763
2001	2,408,609	-	2,408,609	-	-	2,408,609
2002	5,007,523	-	5,007,523	-	-	5,007,523
2003	6,391,621	-	6,391,621	-	-	6,391,621
2004	6,230,198	-	6,230,198	-	-	6,230,198
2005	4,347,388	-	4,347,388	-	-	4,347,388
2006	1,043,353	-	1,043,353	-	-	1,043,353
2007	1,525,243	-	1,525,243	-	-	1,525,243
2008[e]	0	-	0	-	-	0
2009[e]	0	-	0	-	-	0
2010	227,582	-	227,582	-	-	227,582
2011	990,977	-	990,977	-	-	990,977

Notes:

a. Data for 1915-1999 available in the Status of the fisheries report – an update through 2006.
b. Coho were no longer permitted for take after 1992.
c. Sacramento ports closed after 1959.
d. Klamath and other coastal ports closed after 1933.
e. The commercial fishery was closed due to low escapement.

Data source: Department Ocean Salmon Project and CFIS data, all gear types combined.

Commercial salmon value and average price per pound, 1990-2011.					
Year	Value	Average price per pound	Year	Value	Average price per pound
1990	$12,056,000	$2.72	**2001**	$4,773,000	$1.98
1991	$9,047,000	$2.45	**2002**	$7,776,000	$1.55
1992	$4,505,000	$2.74	**2003**	$12,181,000	$1.91
1993	$5,707,000	$2.25	**2004**	$17,895,000	$2.87
1994	$6,437,000	$2.07	**2005**	$12,913,000	$2.97
1995	$11,693,000	$1.76	**2006**	$5,350,000	$5.13
1996	$5,984,000	$1.45	**2007**	$7,902,000	$5.18
1997	$7,288,000	$1.39	**2008**	--	--
1998	$3,060,000	$1.66	**2009**	--	--

Commercial salmon value and average price per pound, 1990-2011.					
Year	Value	Average price per pound	Year	Value	Average price per pound
1999	$7,429,000	$1.93	**2010**	$1,246,000	$5.46
2000	$10,304,000	$2.01	**2011**	$5,130,000	$5.18

Data source: Department Ocean Salmon Project and CFIS data, all gear types combined. The commercial fishery was closed in 2008 and 2009 due to low escapement.

Recreational salmon catch (number of fish), 2000-2011.					
	Chinook		Coho[a]		
Year	CPFV	Skiff	CPFV	Skiff	Total
2000	91,900	94,000	5	400	186,305
2001	43,200	55,600	81	1,243	100,124
2002	85,107	96,937	43	785	182,872
2003	48,300	46,387	100	550	95,337
2004	124,656	96,458	18	1,406	222,538
2005	61,347	81,910	37	662	143,956
2006	35,326	60,966	23	1,603	97,918
2007	12,352	35,352	12	734	48,450
2008[b]	0	6	0	0	6
2009[b]	103	570	0	8	681
2010	4,740	10,069	0	175	14,984
2011	17,883	31,137	4	312	49,336

Notes:

a. Coho no longer permitted for take after 1995. These fish represent misidentified or illegally caught fish.

b. 2008 and 2009 fisheries were either completely closed (2008) or severely constrained (2009).

Data source: Department Ocean Salmon Project.