Chapter 3 Basic Biology, Life History and Baseline for Central Valley Steelhead

This Chapter provides information on the basic biology, life history, distribution and abundance, critical habitat conditions, and status of Central Valley steelhead (*Oncorhynchus myisss*) in the action area. In general, the majority of Central Valley steelhead are confined to non-historical spawning and rearing habitat below impassable dams, but the existing spawning and rearing habitat can sustain steelhead at current population levels. In addition, monitoring data indicates that much of the anadromous form of the species is hatchery supported. There is also a strong resident component to the population (referred to as rainbow trout) that interacts with and produces both resident and anadromous offspring.

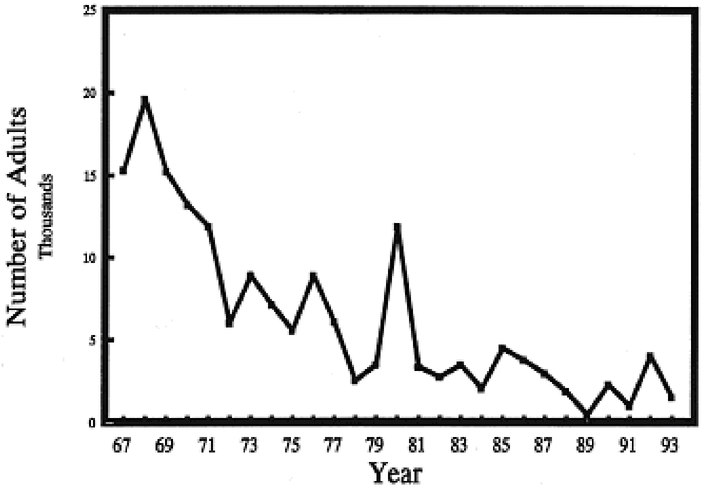
Status

Central Valley steelhead were listed as threatened under the Endangered Species Act (ESA) on January 5, 2006 (71 FR 834). This Distinct Population Segment (DPS) consists of steelhead populations in the Sacramento and San Joaquin River (inclusive of and downstream of the Merced River) basins in California's Central Valley. Critical habitat was designated for Central Valley steelhead on September 2, 2005 (70 CFR 52488).

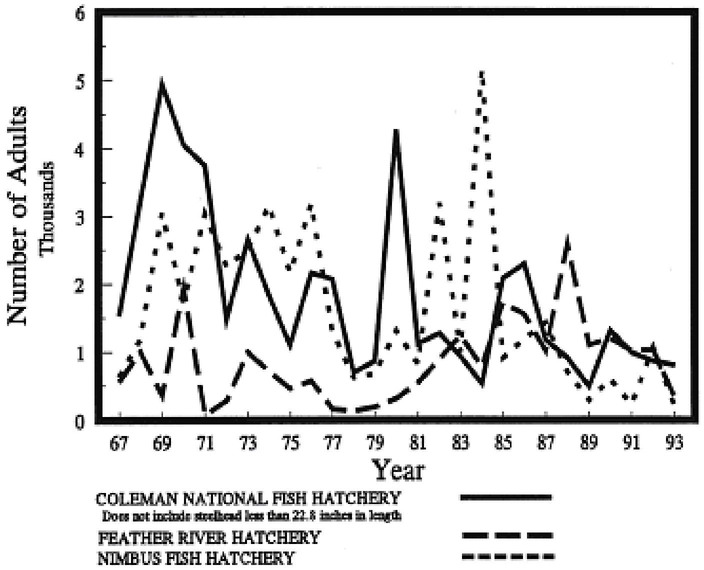
Populations of naturally spawned Central Valley steelhead are at lower levels than were found historically (Figure 3-1) and are composed predominantly of hatchery fish. Steelhead require cool water to rear through the summer, and much of this habitat is now upstream of impassable dams. The California Fish and Wildlife Plan of 1965 estimated the combined annual run size for Central Valley and San Francisco Bay tributaries to be about 40,000 during the 1950s (DFG 1965, as cited in McEwan and Jackson 1996). The spawning population during the mid-1960s for the Central Valley basin was estimated at nearly 27,000 (DFG 1965, as cited in McEwan and Jackson 1996). These numbers likely consisted of both hatchery and wild steelhead. McEwan and Jackson (1996) estimated the annual run size for the Central Valley basin to be less than 10,000 adults by the early 1990s. Much of the abundance data since the mid-1960s was obtained by visual fish counts at the Red Bluff Diversion Dam (RBDD) fish ladders when gates were closed during much of the steelhead migration season. Current abundance estimates are unavailable for naturally spawned fish since RBDD gate operations were changed, so the extent to which populations have changed following the 1987–94 drought is unknown. National Marine Fisheries Service (NMFS) (NOAA Fisheries 2003) status review estimated the Central Valley steelhead population at less than 3,000 adults. This document is primarily limited to a discussion of the status of Central Valley steelhead stocks in habitats influenced by Central Valley Project (CVP) and State Water Project (SWP) operations. According to McEwan (2001), the primary stressors affecting Central Valley steelhead are all related to water development and water management, and the greatest stressor is the loss of spawning and rearing habitat due to dam construction.

The Central California Coast (CCC) steelhead DPS was listed as a threatened species on January 5, 2006 (71 FR 834). The Central California Coast steelhead DPS extends from the Russian

River on the north to the San Lorenzo River on the south and includes Suisun Bay, San Pablo Bay, and San Francisco Bay. Critical habitat was designated for Central California Coast steelhead on September 2, 2005 (70 CFR 52488). Overall, the abundance of the CCC steehead ESU has declined from an estimated 94,000 returning adults in the 1960s to estimates of less than 10,000 in recent times (Busby *et al.* 1996; NOAA Fisheries 1997). These numbers represent over an 85 percent decline in the population. Project effects to the migratory pathway of CCC steelhead are expected to be minimal to water quality because the tidal flows through the area of CCC habitat are so much larger. The steelhead effects analysis throughout this BA does not identify any effects of the project on steelhead that occur in the Central California Coast DPS; therefore, they are not specifically referenced except in the determination of effects. Because the project area overlaps this DPS, these fish are being addressed in this Biological Assessment (BA). Central Valley Project (CVP) and State Water Project (SWP) operations are not expected to influence conditions significant to steelhead in these areas, so effects to Central California Coast Steelhead are not anticipated. Central California Coast steelhead critical habitat is shown in Figure 3-19. Suisun Creek was not included in the Critical Habitat designation (70 CFR 52488).



Adjusted adult steelhead counts at Red Bluff Diversion Dam on the Sacramento River, 1967-1993.



Adult steelhead counts at Coleman, Feather River, and Nimbus fish hatcheries, 1967-1993.

Figure 3-1 Adult steelhead counts at RBDD, 1967–93 (top) and adult steelhead counts at Coleman National Fish Hatchery, Feather River Fish Hatchery, and Nimbus Hatchery, 1967-93 (bottom). The revised Red Bluff gates open period after 1993 eliminated RBDD counting ability. *Source: McEwan and Jackson 1996.*

Taxonomy

Steelhead is a name used for anadromous rainbow trout (*Oncorhynchus mykiss*), a salmonid species native to western North America and the Pacific coast of Asia. In North America, steelhead are found in Pacific coast drainages from Southern California to Alaska. In Asia, they are found in coastal streams of the Kamchatka Peninsula, with scattered populations on the Siberian mainland (Burgner et al. 1992, as cited in McEwan and Jackson 1996). Known spawning populations are found in coastal streams along much of the California coast, as well as in the Central Valley.

Only two subspecies of North American rainbow trout contain both resident (nonmigratory) and anadromous (migratory or sea-run) forms: coastal rainbow trout (*O. m. irideus*) and Columbia River redband trout (*O. m. gairdneri*). Columbia River redband trout occur in tributaries of the upper Columbia River east of the Cascades (McEwan and Jackson 1996). Coastal rainbow trout occupy coastal streams from California to Alaska, including tributaries to the San Francisco Estuary. All California steelhead populations are *O. m. irideus,* including those in the Central Valley.

Historically, resident rainbow trout and steelhead were considered separate subspecies or different species altogether. However, researchers have found little or no morphologic or genetic differentiation between the two forms inhabiting the same stream system (Behnke 1972; Allendorf 1975; Allendorf and Utter 1979; Busby et al. 1993; Nielsen 1994, all as cited in McEwan and Jackson 1996), indicating there is substantial interbreeding. However, differences in mitochondrial DNA have been found by some researchers (Wilson et al. 1985, as cited in McEwan and Jackson 1996). Based on the cumulative genetic evidence, researchers have proposed that steelhead and related resident rainbow trout with the potential to interbreed be considered as one unit for restoration and management purposes (Busby et al. 1993, as cited in McEwan and Jackson 1996; NMFS 1996).

NMFS (1998) divided West Coast steelhead into 15 ESUs based on distinct genetic characteristics, freshwater ichthyogeography, and other parameters. Most steelhead stocks found in the Central Valley comprise the Central Valley ESU, which recent genetic data indicate is distinct from other coastal steelhead stocks (Busby et al. 1996; NMFS 1997b, 1998). DNA analysis of steelhead tissue samples collected from the Coleman National Fish Hatchery, Feather River Hatchery, Deer and Mill Creeks, and the Stanislaus River demonstrated these stocks are genetically similar to each other. Coleman National Fish Hatchery and Feather River Hatchery steelhead stocks are considered part of the Central Valley ESU because broodstock histories and genetic evidence show these two stocks are similar to naturally spawned steelhead in Deer and Mill Creeks.

NMFS (1998, 1999) does not consider Nimbus Hatchery and Mokelumne River Fish Installation stocks to be part of the Central Valley ESU. Genetic analysis indicated steelhead from the American River (collected from both the Nimbus Hatchery and the American River) are genetically more similar to Eel River steelhead (Northern California ESU) than other Central Valley steelhead stocks. Eel River steelhead were used to found the Nimbus Hatchery stock. Mokelumne River rainbow trout (hatchery produced and naturally spawned) are genetically most similar to Mount Shasta Hatchery trout, but also show genetic similarity to the Northern

California ESU (Nielsen 1997, as cited in NMFS 1997b). Nielsen et al 2005 found American River steelhead to be genetically different from other Central Valley stocks (Figure 3-2).

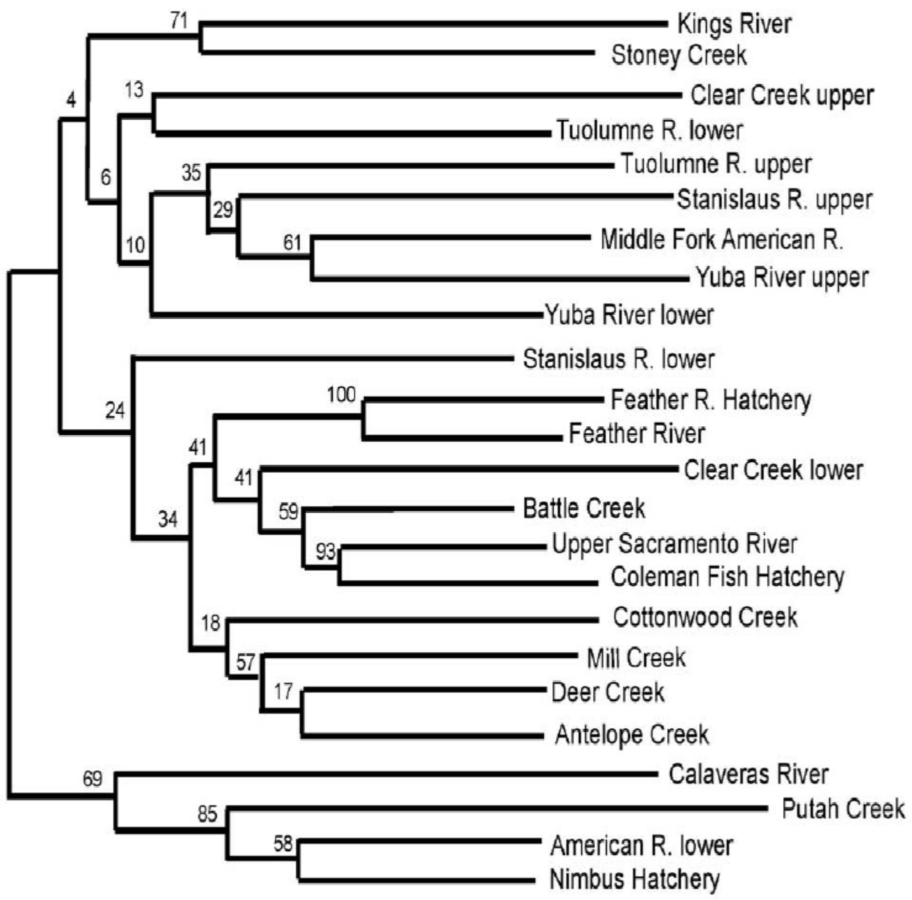


Figure 3-2 Unrooted Neighbor-Joining tree based on Cavalli-Sforza and Edwards chord distance for the Central Valley system derived from allelic variation at 11 microsatellite loci. Branches with bootstrap values (percent of 2000 replicate trees) are provided (from Nielsen et al. 2005).

Steelhead Biology and Life History

Steelhead, as currently defined, is the anadromous form of rainbow trout (McEwan and Jackson 1996). However, as stated above, steelhead life history can be quite variable, with some individuals or populations reverting to residency when flow conditions block access to the ocean. The following is an idealized life history for Central Valley stocks. McEwan and Jackson (1996) provided an extensive summary of the biology of coastal and Central Valley stocks and a list of useful references that contain more detailed information.

Adult migration from the ocean to spawning grounds occurs during much of the year, with peak migration occurring in the fall or early winter (Figure 3-4). Migration through the Sacramento River mainstem begins in July, peaks at the end of September, and continues through February or March (Bailey 1954; Hallock et al. 1961, both as cited in McEwan and Jackson 1996). Counts made at RBDD from 1969 through 1982 (Hallock 1989, as cited in McEwan and Jackson 1996) and on the Feather River (Painter et al. 1977; DWR unpublished) follow the above pattern, although some fish were counted as late as April and May. Weekly counts at Clough Dam on Mill Creek during a 10-year period from 1953 to 1963 showed a similar migration pattern as well. The migration peaked in mid-November and again in February. This second peak is not reflected in counts made in the Sacramento River mainstem (Bailey 1954; Hallock et al. 1961, both as cited in McEwan and Jackson 1996) or at RBDD (Hallock 1989, as cited in McEwan and Jackson 1996).

Central Valley steelhead are mostly ‘winter steelhead’ and may contain some ‘summer steelhead’ (the naming convention refers to the seasonal period of adult upstream migration). Winter steelhead mature in the ocean and arrive on the spawning grounds nearly ready to spawn. In contrast, summer steelhead, or stream-maturing steelhead, enter freshwater with immature gonads and typically spend several months in freshwater before spawning. The optimal temperature range during migration is unknown for Central Valley stocks. Based on northern stocks, the optimal temperature range for migrating adult steelhead is 46 to 52 degrees Fahrenheit (°F) (Bovee 1978; Reiser and Bjornn 1979; Bell 1986, all as cited in McEwan and Jackson 1996). The reported minimum depth for successful passage is about 7 inches (Reisner and Bjornn 1979, as cited in McEwan and Jackson 1996). Depth is usually not a factor preventing access to spawning areas in the rivers currently under consultation. However, excessive water velocity (>10 to 13 feet per second [ft/s]) and obstacles may prevent access to upstream spawning grounds.

Historically, Central Valley steelhead spawned primarily in upper stream reaches and smaller tributaries, although steelhead spawn in most available channel types in unimpounded stream reaches of the Pacific Northwest (Montgomery et al. 1999). Due to water development projects, most spawning is now confined to lower stream reaches below dams. In a few streams, such as Mill and Deer Creeks, steelhead still have access to historical spawning areas. Peak spawning generally occurs from December through April (McEwan and Jackson 1996) (Figure 3-4).

Males typically arrive in the spawning areas first (McMillan et al 2007). Upon arrival, the female selects a site and excavates a redd (nest) in the gravel and deposits her eggs, while an attendant male fertilizes them. Occupied redds in the American River typically have one male and one female but occasionally two and sometimes three males are present. The ratio of male to female steelhead arriving at Nimbus Hatchery is higher than one and ranged from 1.09 to 1.52 males per female between 2002 and 2007 (Hannon and Deason 2007).

Fecundity is directly related to body size (Moyle 1976). Spawning females average about 4,000 eggs, but the actual number produced varies among stocks and by the size and age of the fish (Leitritz and Lewis 1976). The eggs are covered with gravel when the female excavates another redd upstream. Spawning occurs mainly in gravel substrates (particle size range of about 0.2–4.0 inches). Sand-gravel and gravel-cobble substrates are also used, but these must be highly permeable and contain less than 5 percent sand and silt to provide sufficient oxygen to the incubating eggs. Adults tend to spawn in shallow areas (6–24 inches deep) with moderate water velocities (about 1 to 3.6 ft/s) (Bovee 1978, as cited in McEwan and Jackson 1996, Hannon and Deason 2007, Figure 3-3). The optimal temperature range for spawning is 39 to 52°F (Bovee

1978; Reiser and Bjornn 1979; Bell 1986, all as cited in McEwan and Jackson 1996). Egg mortality begins to occur at 56°F (McEwan and Jackson 1996).

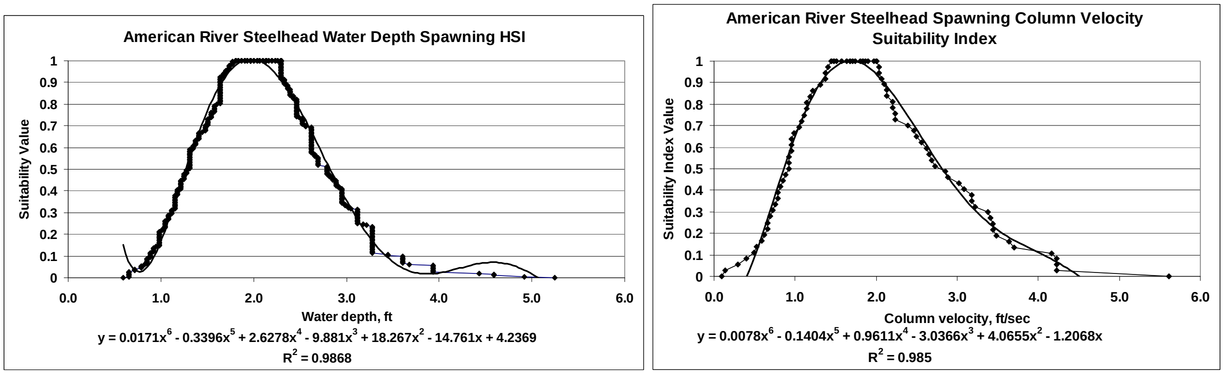


Figure 3-3 Steelhead spawning habitat depth and velocity suitability indices in the American River, Hannon and Deason 2007.

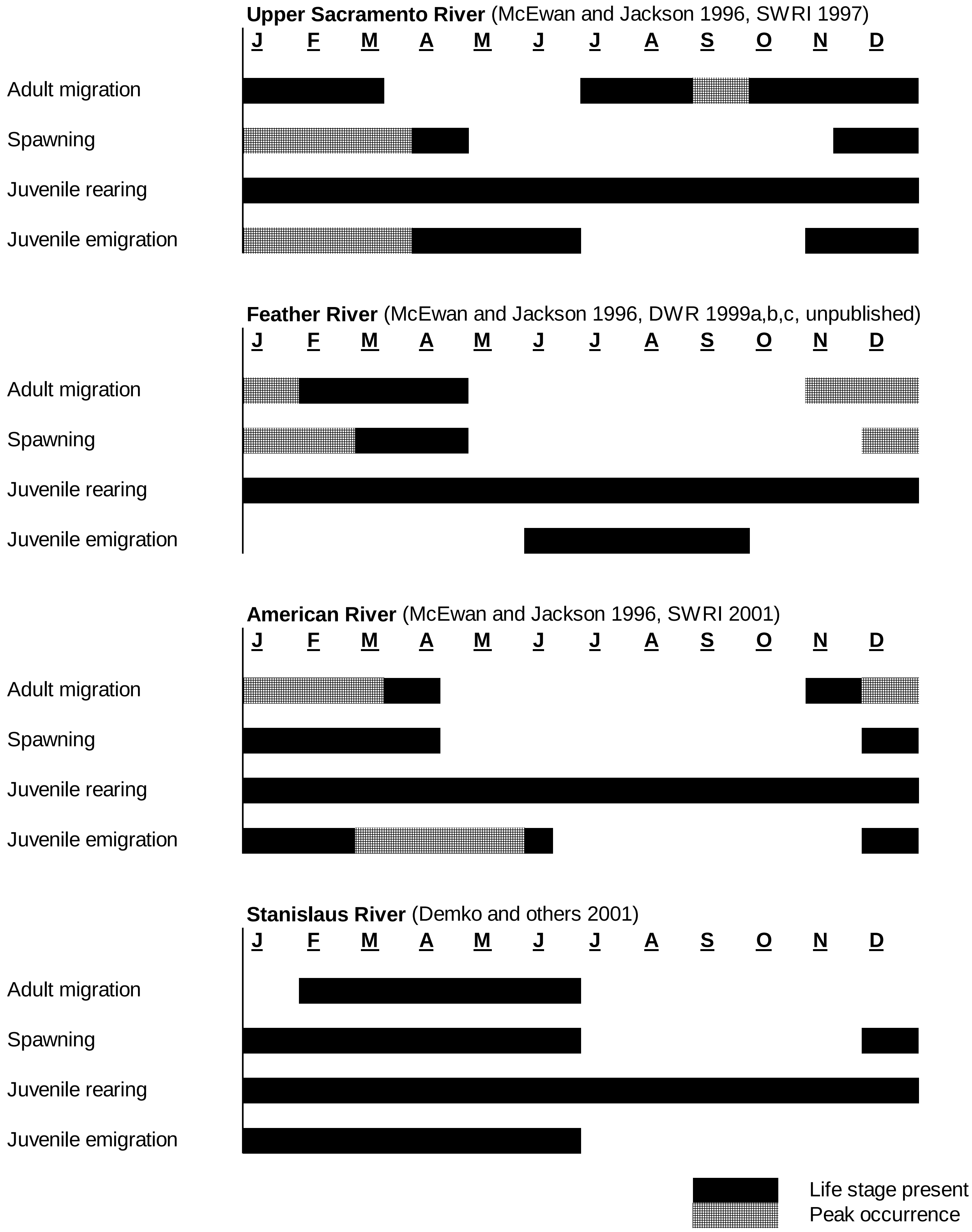


Figure 3-4 Steelhead life cycle for various Central Valley streams.

Unlike Chinook salmon, Central Valley steelhead may not die after spawning (McEwan and Jackson 1996). Some may return to the ocean and repeat the spawning cycle for two or three years. The percentage of adults surviving spawning is generally thought to be low for Central Valley steelhead, but varies annually and between stocks. Recent acoustic tagging of Central Valley steelhead kelts from Coleman Hatchery indicates survival rates can be high, especially for Central Valley steelhead reconditioned by holding and feeding at the hatchery prior to release. Some return immediately to the ocean and some remain and rear in the Sacramento River (Robert Null, personal communication).

The time required for egg development is approximately four weeks, but is temperature-dependent (McEwan and Jackson 1996). For northern steelhead populations, optimal egg development occurs at 48 to 52°F. Egg mortality may begin at temperatures above 56 °F in northern populations (Bovee 1978; Reiser and Bjornn 1979; and Bell 1986, all as cited in McEwan and Jackson 1996). After hatching, the yolk-sac fry or alevins remain in the gravel for another four to six weeks (Shapovalov and Taft 1954, as cited in McEwan and Jackson 1996). At 50°F steelhead fry emerge from the gravel about 60 days after egg fertilization (Leitritz and Lewis 1980). Merz et al (2004) showed that spawning substrate quality influenced a number of physical parameters affecting egg survival including temperature, dissolved oxygen, and substrate permeability. Changes in flow and sediment transport can have negative effects on spawning conditions (Poff et al 1997). These deleterious effects contribute to decreased substrate permeability and dissolved oxygen content.

Upon emergence from the gravel, the fry move to shallow protected areas associated with the stream margin (Royal 1972; Barnhart 1986, both as cited in McEwan and Jackson 1996). Steelhead fry tend to inhabit areas with cobble-rubble substrate, a depth less than 14 inches, and temperature ranging from 45 to 60 °F (Bovee 1978, as cited in McEwan and Jackson 1996). Myrick (1998, 2000) found steelhead from the Feather and Mokelumne preferred temperatures between 62.5°F and 68°F. Older juveniles use riffles and larger juveniles may also use pools and deeper runs (Barnhart 1986, as cited in McEwan and Jackson 1996). However, specific depths and habitats used by juvenile rainbow trout can be affected by predation risk (Brown and Brasher 1995). Central Valley steelhead can show mortality at constant temperatures of 77°F although they can tolerate 85°F for short periods. Hatchery reared steelhead in thermal gradients selected temperatures of 64–66°F while wild caught steelhead selected temperatures around 63°F (Cech and Myrick 2001).

Yearling steelhead in the Central Valley feed mostly on immature aquatic insects but when other items such as emerging mayflies and salmonid eggs are abundant these may dominate their diets (Merz 2002).

Juvenile Central Valley steelhead may migrate to the ocean after spending one to three years in freshwater (McEwan and Jackson 1996). Fork length (FL) data for steelhead emigrating past Chipps Island suggest the Central Valley stocks show little variability in size at emigration (Figure 3-5 and Figure 3-6).

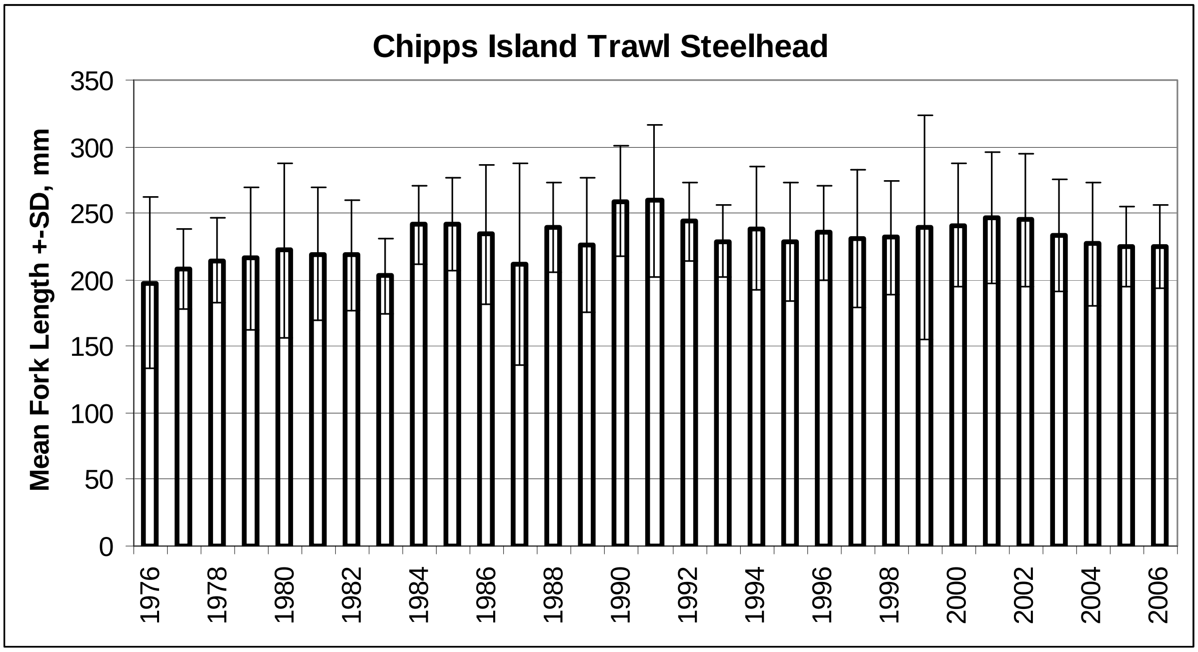


Figure 3-5 Mean FL (mm) plus standard deviation of steelhead collected in the FWS Chipps Island Trawl, 1976-2006 (data from BDAT).

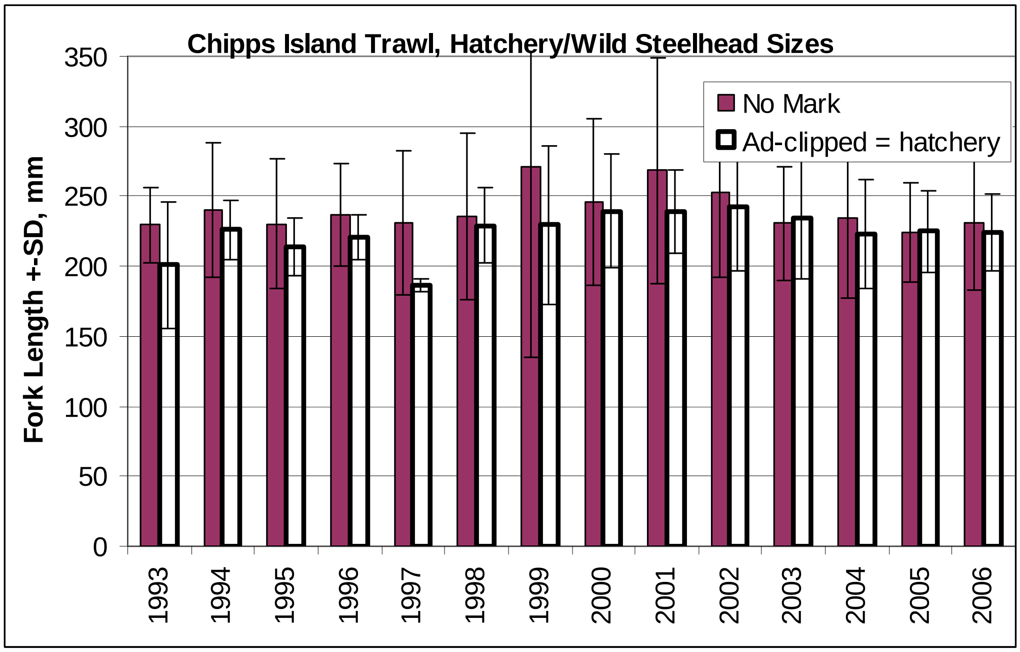


Figure 3-6 Comparison of hatchery and wild steelhead sizes collected in the Chipps Island Trawl, 1993 – 2006 (data from BDAT). 100% adipose clipping of hatchery fish began in 1998.

During their downstream migration, juveniles undergo smoltification, a physiologic transformation enabling them to tolerate the ocean environment and its increased salinity. In addition, the juvenile steelhead lose their parr marks, become silvery, and produce deciduous scales. Temperatures under 57°F are considered best for smolting. Data for steelhead smolts emigrating past Chipps Island generally agree with these findings. Slightly more than 60 percent of the unmarked steelhead smolts collected in the FWS Chipps Island trawl between 1998 and 2000 were collected at temperatures > 57°F, the actual smolting temperature was likely lower upstream than recorded at Chipps Island (Figure 3-7). However, this is likely biased by high proportions of hatchery fish that migrate over a shorter period of time than naturally spawned fish and many other factors. According to Cech and Myrick (2001) steelhead transform from parr to smolt successfully at 44 to 52°F and show little saltwater adaptation above 59°F.

Steelhead are present at Chipps Island between at least October and July, according to catch data from the FWS Chipps Island Trawl (Figure 3-8). It appears that adipose fin-clipped steelhead have a different emigration pattern than unclipped steelhead. Adipose fin-clipped steelhead showed distinct peaks in catch between January and March corresponding with time of release, whereas unclipped steelhead CPUE were more evenly distributed over a period of six months or more. These differences are likely an artifact of the method and timing of hatchery releases.

Once in the ocean, steelhead remain there for one to four growing seasons before returning to spawn in their natal streams (Burgner et al. 1992, as cited in McEwan and Jackson 1996). Little data are available on the distribution of Central Valley stocks in the ocean, but at least some California steelhead stocks may move into the North Pacific Ocean, as do the more northerly distributed stocks.

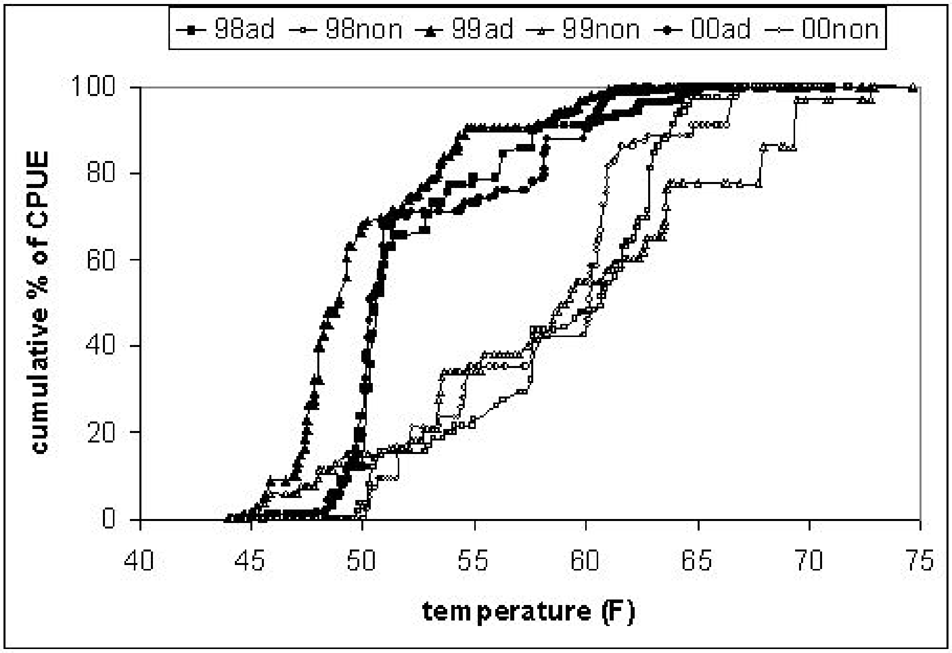


Figure 3-7 Cumulative percentage of steelhead per 10,000 m^3 in the FWS Chipps Island Trawl vs. surface water temperature at Chipps Island. Solid symbols represent hatchery fish (adipose-clipped) and open symbols represent wild fish (non adipose-clipped). 98ad means adipose clipped fish in 1998 and 98non means non-adipose clipped in 1998.

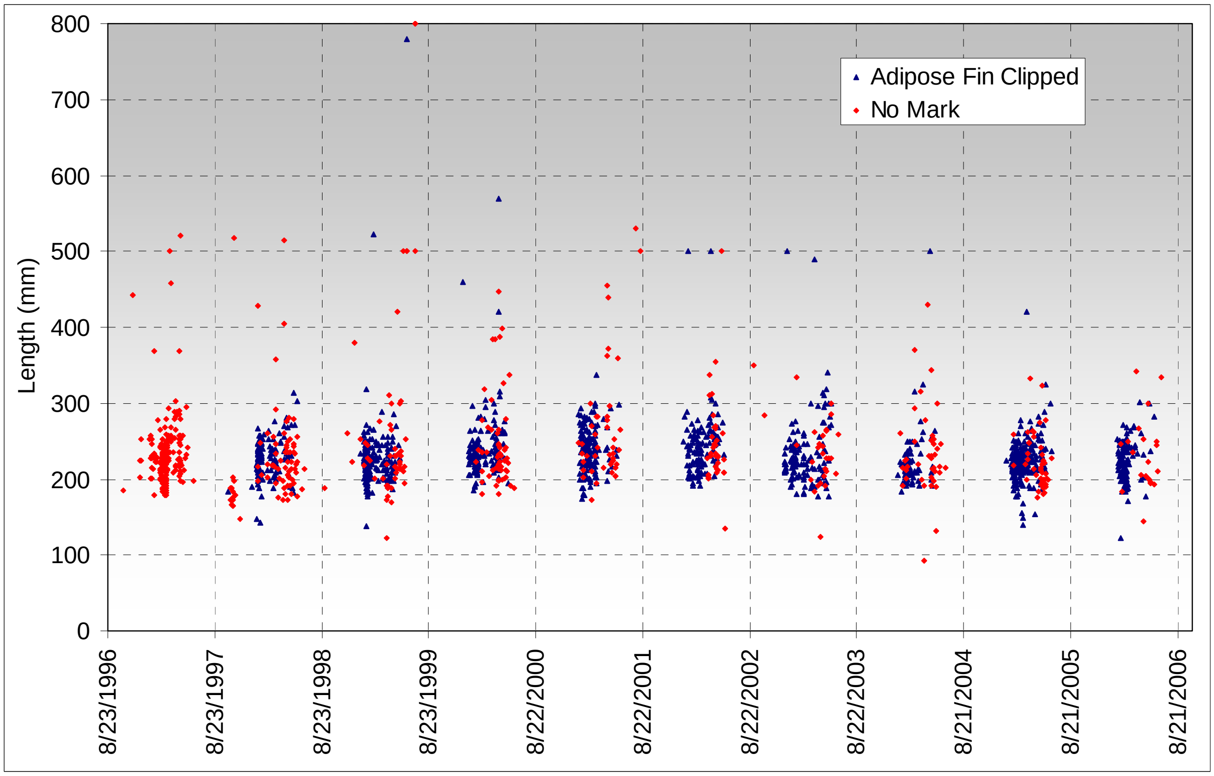


Figure 3-8 Adipose clipped and un-clipped steelhead captured in the Chipps Island Trawl, 1996 – 2006 (BDAT…USFWS unpublished data).

Historical and Current Distribution and Abundance of Central Valley Steelhead

Monitoring data for Central Valley steelhead is limited in comparison with Chinook salmon. Steelhead present more challenges to monitoring programs but a Central Valley wide steelhead monitoring framework is being developed by DFG in cooperation with other agencies. Steelhead ranged throughout many of the tributaries and headwaters of the Sacramento and San Joaquin Rivers prior to dam construction, water development, and watershed perturbations of the 19th and 20th centuries (McEwan and Jackson 1996). Based on the historical distribution of Chinook salmon, steelhead probably inhabited tributaries above Shasta Dam such as the Little Sacramento, McCloud, Fall, and Pit Rivers, and many tributaries on the west side of the Sacramento Valley, such as Stony and Thomes Creeks (Yoshiyama et al. 1996, 1998).

There is little historical documentation regarding steelhead distribution in the San Joaquin River system, presumably due to the lack of an established steelhead sport fishery in the San Joaquin basin (Yoshiyama et al. 1996). However, based on historical Chinook salmon distribution in this drainage and on the limited steelhead documentation that does exist, it appears that steelhead were present in the San Joaquin River and its tributaries from the Kern River northward. During very wet years, steelhead could potentially access the Kern River through the Tulare Basin.

Steelhead distribution in Central Valley drainages has been greatly reduced (McEwan and Jackson 1996). Steelhead are now primarily restricted to a few remaining free-flowing tributaries and to stream reaches below large dams, although a few steelhead may also spawn in intermittent streams during wet years. Naturally spawning steelhead populations have been found in the upper Sacramento River and tributaries below Keswick Dam, Mill, Deer, and Butte Creeks, and the Feather, Yuba, American, and Mokelumne Rivers (CMARP 1998). However, the records of naturally spawning populations depend on the presence of fish monitoring programs. Recent implementation of monitoring programs has found steelhead in additional streams, such as Auburn Ravine, Dry Creek, and the Stanislaus River. It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring or research programs. Although impassable dams prevent resident rainbow trout from emigrating, populations with steelhead ancestry may still exist above some dams (Dennis McEwan, personal communication, 1998).

As stated above, the adult Central Valley steelhead population was estimated to number about 27,000 during the early 1960s (DFG 1965, as cited in McEwan and Jackson 1996). Historical counts of steelhead passing RBDD, which included both Coleman Hatchery and naturally spawned fish, are shown in Figure 3-1. The counts showed an obvious decline in steelhead returns to the upper Sacramento River between 1967 and 1993. Current escapement data are not available for naturally spawned steelhead in most tributaries, in large part because the gates at RBDD are now open more frequently in order to allow for fish passage. In addition there is a general lack of steelhead population monitoring in most of the Central Valley. A continual decline is not apparent in the time series of returning steelhead trapped at Nimbus (Figure 3-9) and Feather River (Figure 3-10) hatcheries, where data for post-drought years are available. The number of steelhead returning to Nimbus and Feather River hatcheries appears not to be related (Figure 3-11) even though both hatcheries use the same release strategy and release about the same number of smolts each year. The estimated number of steelhead spawning in the American River in 2002 was 32 percent of the number that entered Nimbus Hatchery (Hannon and Healey, 2002). An estimated 201–400 steelhead spawned in the American River in 2002, and 243–486 spawned in 2003, based on one to two redds per female. Some escapement monitoring surveys have been initiated in upper Sacramento River tributaries (Beegum, Deer, and Antelope Creeks) using snorkel methods similar to spring-run Chinook escapement surveys.

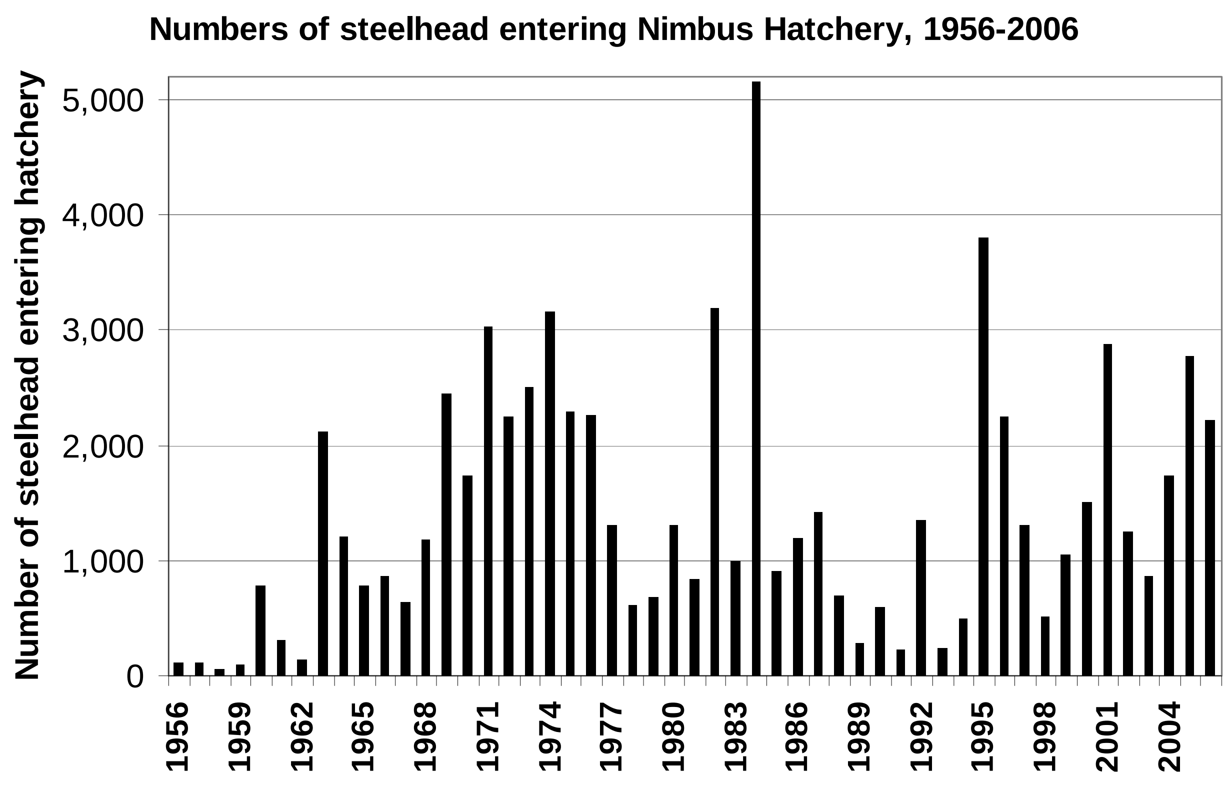


Figure 3-9 Adult steelhead counts at Nimbus Hatchery, 1956-2006.

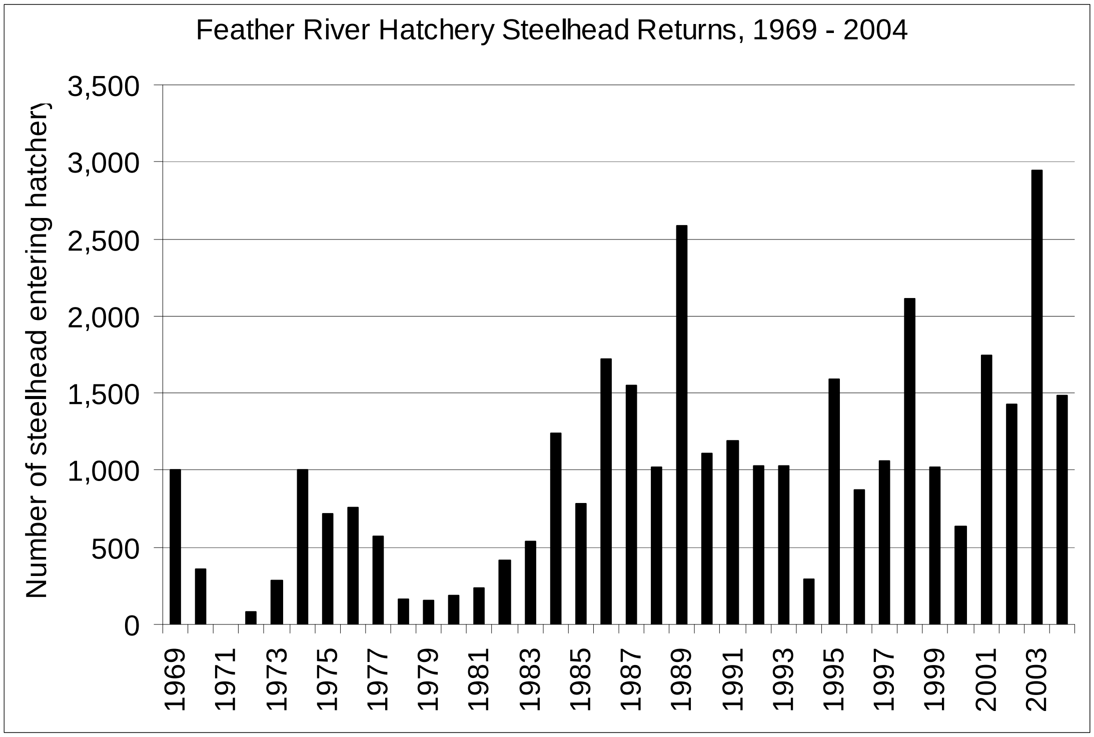


Figure 3-10 Adult steelhead counts at Feather River Hatchery, 1969-2004.

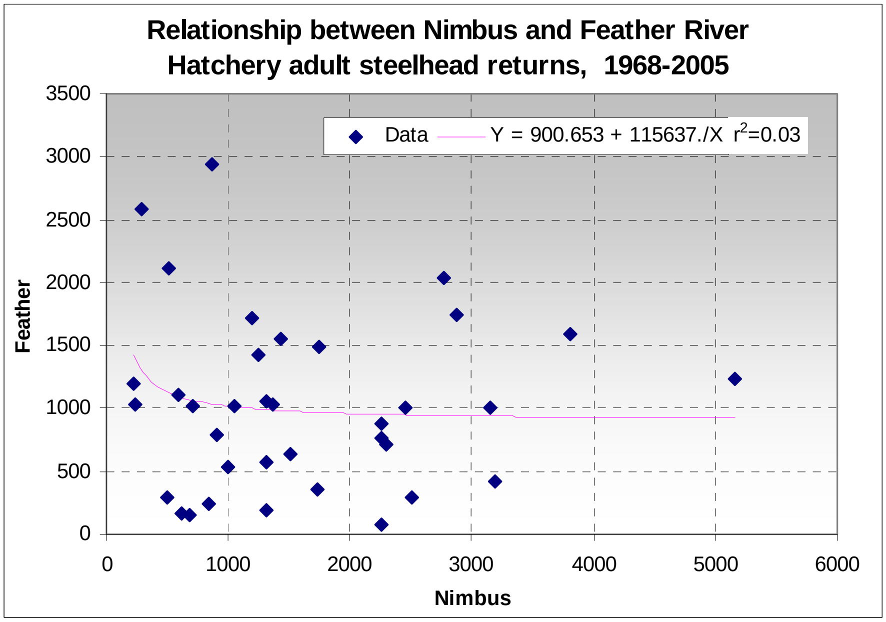


Figure 3-11 Relationship between Nimbus Hatchery and Feather River Hatchery steelhead returns, 1969 – 2004.

Although Coleman Hatchery production was included in counts at RBDD, these time series data presented in Figure 3-1 indicate that abundance patterns may differ between wild and hatchery stocks (and also between individual hatchery stocks), confounding interpretation of factors influencing Central Valley steelhead at the population or regional levels. Abundance patterns are conversely related for wild and hatchery fish and may influence each other as shown in Oregon and Washington (NOAA Fisheries 2003). The following provides an overview of the status of steelhead in Sacramento and San Joaquin tributaries under consultation. More detailed assessments of steelhead status in the Central Valley were provided by McEwan and Jackson (1996) and Busby et al. (1996).

Clear Creek

Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama et al. 1996). Operation of Whiskeytown Dam can produce suitable coldwater habitat downstream to Placer Road Bridge depending on flow releases (DFG 1998). McCormick-Saeltzer Dam, which limited steelhead migrations through ineffective fish ladders, was removed in 2000, allowing steelhead potential access to good habitat up to Whiskeytown Dam. The FWS has conducted snorkel surveys targeting spring-run Chinook (May through September) since 1999. Steelhead/rainbow are enumerated and separated into small, medium, and large (>22 inches) during these surveys; but because the majority of the steelhead run is unsurveyed, no spawner abundance estimates have been attempted (Jess Newton, personal communication, 2001). Redd counts were conducted during the 2001-02 run and found that most spawning occurred upstream, near Whiskeytown Dam. Because of the large resident rainbow population, no steelhead population estimate could be made (Matt Brown, personal communication, June 2002). A remnant “landlocked” population of rainbow trout with steelhead ancestry may exist in Clear Creek above Whiskeytown Dam (Dennis McEwan, personal communication, 1998).

Summertime water temperatures are often critical for steelhead rearing and limit rearing habitat quality in many streams. Figure 3-12 shows that water temperatures in Clear Creek at Igo are maintained below 65°F year-round using releases of cool Whiskeytown Reservoir water. Figure 3-13 shows the daily water temperature fluctuation in Clear Creek at Igo for 1996-2006. This cool water source is maintained by diverting Trinity River water over into Clear Creek.

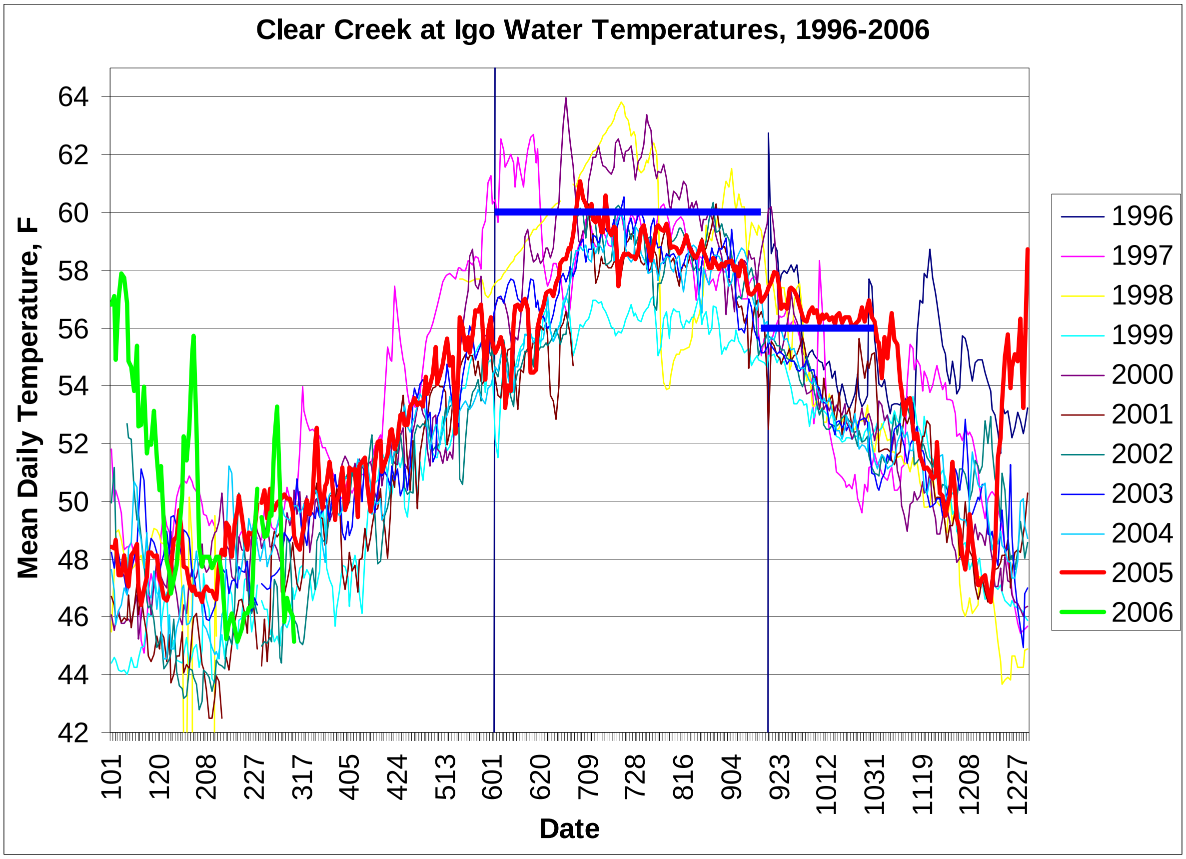


Figure 3-12 Clear Creek water temperature at Igo, 1996-2006 (CDEC). Dates are expressed like 101=January 1, 208=February 8, etc.

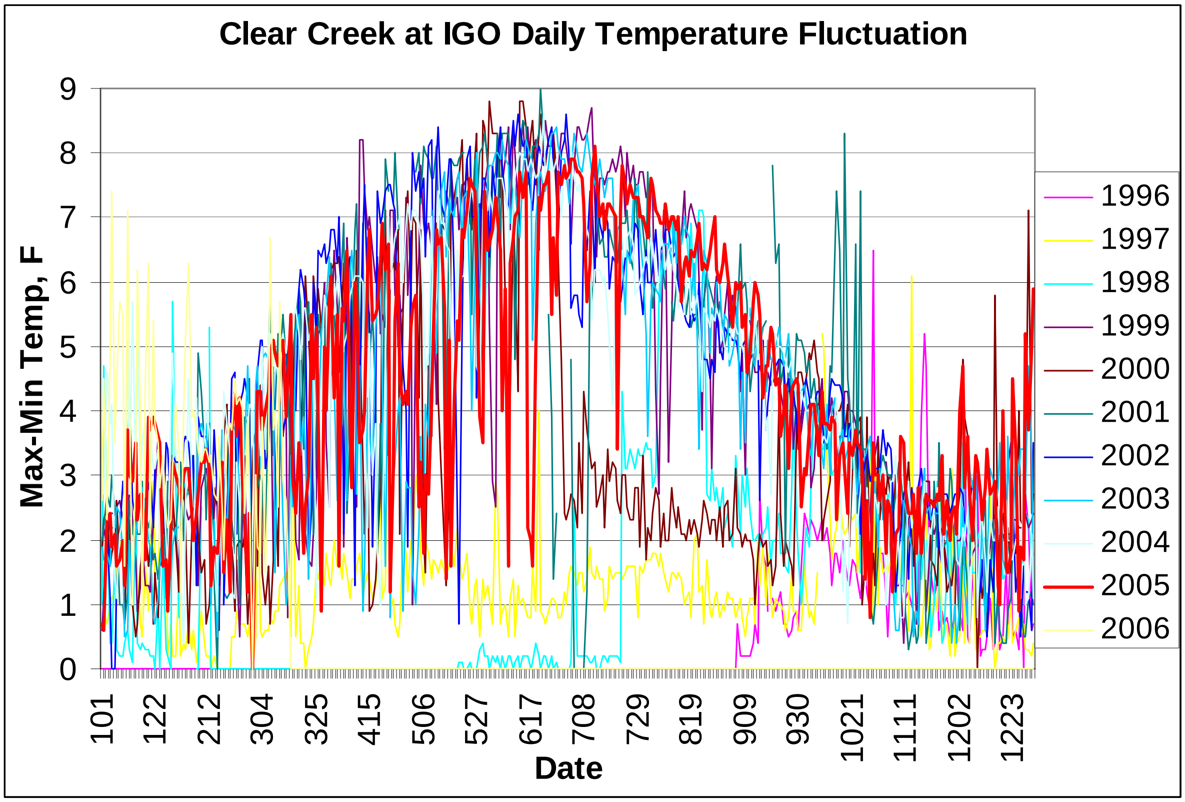


Figure 3-13 Clear Creek daily water temperature fluctuation at Igo, 1996-2006 (CDEC). Dates are expressed like 101=January 1, 208=February 8, etc.

Feather River

Historically, the Feather River supported a large steelhead population (McEwan and Jackson 1996). Today the run is supported almost entirely by the Feather River Hatchery. The hatchery produces about 450,000 yearling steelhead each year to mitigate for Oroville Dam and losses at the SWP Delta facilities. The current run is restricted to the river downstream of the Fish Barrier Dam at the hatchery.

California Department of Water Resources (DWR) initiated fish studies in the Lower Feather River in 1991. The focus and methods used for these studies were altered in 2003 as a result of consultations with NMFS, California Department of Fish and Game (DFG), and others to gather information needed to relicense the Oroville facilities with the Federal Energy Regulatory Commission (FERC). http://orovillerelicensing.water.ca.gov/documents.html .

Since the signing in 2006 of the Settlement Agreement for the FERC relicensing process, the monitoring program refocused on increasing understanding of the listed fish species in the Lower Feather River. The present program consists of several elements to monitor salmonid spawning, rearing, and emigration, including steelhead, and to document any potential impacts of project operations on fish species. A wide variety of equipment and monitoring methods are used including rotary screw traps, fyke traps, snorkel surveys, electrofishing, radio and acoustic tagging, carcass surveys, redd mapping, etc. Reports summarizing the results and findings are prepared and submitted to the regulatory agencies annually. http://wwwdes.water.ca.gov/ecological_studies_branch/frp_program/technicalreports.htm .

Although angler surveys by Painter et al. (1977) indicated adult steelhead were present in the Feather River from September through April, peak immigration probably occurs from September through January. Most of the fish spawn in the hatchery, although some spawn in the low-flow channel. During 2003, redd formation probably began in late December, peaked in late January, and was essentially complete by the end of March. Redd surveys counted 75 steelhead redds and revealed that 48 percent of all redds were in the upper mile of the river between Table Mountain Bicycle Bridge and lower auditorium riffle in 2003 (Kindopp and Kurth 2003).

Screw trap monitoring indicates steelhead fry are present in the river as early as March (DWR 1999b). Snorkel surveys in 1999, 2000, and 2001 showed young steelhead reared through the summer at suitable locations throughout the low-flow channel, primarily along the margins of the channels under riparian cover and in secondary channels with riparian cover (Cavallo et al. 2003). The highest densities of young-of-the-year (YOY) steelhead were observed at the upstream end of the low-flow channel and in an artificial side channel fed by hatchery discharge. Summer water temperatures below Thermalito Afterbay Outlet are relatively high (>70°F), and snorkel surveys in 1999, 2000, and 2001 found almost no steelhead rearing below the outlet. Most YOY steelhead observed in the surveys were 55 to 75 mm FL by August and September, when many fish moved into higher velocity areas in the channel, away from channel margins. Snorkel surveys conducted in September and October 1999 found many steelhead in the 200 to 400 mm size range. These fish apparently represent early adult returns or resident rainbows. Adipose fin-clipped steelhead were also observed among these fish. By mid-September and October, some YOY steelhead were still present, but most YOY steelhead appear to leave the system before fall of their first year. Rotary screw trapping (RST) indicates most steelhead leave before summer (Cavallo et al. 2003).

There appears to be little mixing of hatchery and wild gene pools in the FRFH. This conclusion is based on study findings that show that only adipose clipped steelhead (hatchery-produced, presumably mostly from the FRFH) ever reach the FRFH. Spawned steelhead are released back to the river—there are no data to determine how many of these fish survive to spawn again. A hatchery and genetic management plan (HGMP) is being completed for the FRFH in consultation with NMFS.

Nevertheless, the commingling of spawning adults due to the blockage of fish to historical spawning and rearing habitat in headwater streams presumably provides an opportunity of mixing between FRFH-produced and wild steelhead. Homogenization of the wild Feather River steelhead genetic structure cannot be ascertained as there are no data to show if the river spawners are of direct hatchery origin or the progeny of previous natural spawners. Moreover, as there are no pre-Oroville Facilities genetic data, it is not possible to characterize the distinctness of historical steelhead in the Feather River. However, the existing data suggest that some of the original genetic attributes remain in the current steelhead populations in the Feather River.

American River

Historically, steelhead occurred throughout the upper reaches of the American River (McEwan and Jackson 1996). From 1850 through 1885, hydraulic mining caused the deposition of large quantities of sediment in the American River basin, silting over spawning gravel and nearly exterminating the salmon runs (Gerstung 1989, as cited in Yoshiyama et al. 1996). A series of impassable dams was constructed between 1895 and 1939. Fish ladders were later constructed around these dams, but many of them had passage problems. Access was restricted to the 27-mile reach below Old Folsom Dam after floodwater destroyed its fish ladder in 1950 (Gerstung 1971, as cited in Yoshiyama et al. 1996). Nimbus and Folsom Dams were completed in 1955 and 1956, respectively. Steelhead habitat is now limited to the 23-mile stretch between Nimbus Dam and the Sacramento River, although a remnant population of rainbow trout with steelhead ancestry may exist in the north fork of the American River (Dennis McEwan, personal communication, 1998).

Adult steelhead migrate into the Lower American River from November through April, with peak immigration during December through March (SWRI 2001, Figure 3-4). Juvenile steelhead rear in the Lower American River for one or more years and migrate out of the river during January through June (Snider and Titus 2000). Juvenile steelhead were monitored from July to October 2001 to detect the effects of warmer than normal water temperatures on steelhead abundance and distribution. Juvenile steelhead with good condition factors were found as far downstream as Paradise Beach through July and at Watt Avenue through August. Water temperatures during this period in these areas regularly rose to above 70 °F (Figure 3-14). All steelhead recaptures occurred in the same reach of the river as tagging occurred, indicating many fish remained in the same location for extended periods.

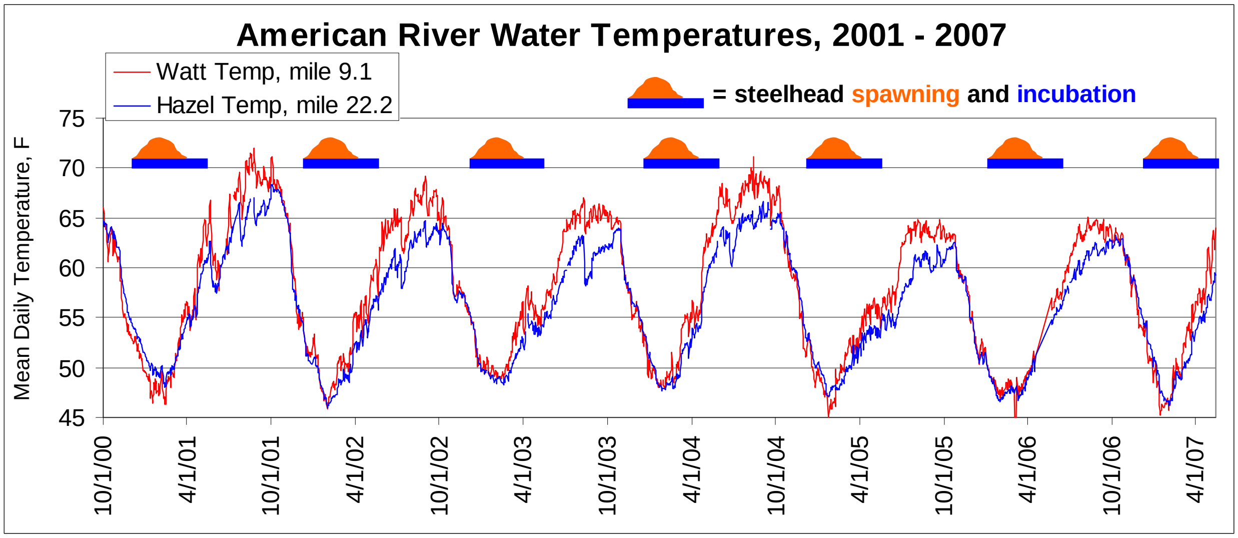


Figure 3-14 American River water temperature 2000 – 2007 (CDEC data).

The Lower American River population is supported mostly by Nimbus Hatchery, although natural spawning does occur (Hannon and Deason 2007). The hatchery produces about 430,000 steelhead yearlings annually to mitigate for Nimbus Dam. The hatchery included Eel River steelhead in its founding stock. Genetic analysis indicates Nimbus Hatchery-produced steelhead are more closely related to Eel River steelhead than other Central Valley stocks and are therefore not considered part of the Central Valley ESU (Busby et al. 1996; NMFS 1997b).

Since 1998, all hatchery-produced steelhead have been adipose fin-clipped to identify them as hatchery fish. Occasionally a few are missed, but the majority get clipped. During 2001 – 2007, 1 percent to 6 percent of the adult steelhead entering Nimbus Hatchery were wild (unclipped) fish (Table 3-1). Steelhead spawning surveys showed around 300 steelhead spawning in the river each year compared to hatchery returns during the same years of 1,200 to 2,700 steelhead (Hannon and Deason 2005). Many of the in-river spawners are hatchery produced fish. Spawning density is higher in the upper 7-mile reach, but spawning occurs down to the lowest riffle in the river at Paradise Beach. Redd depths were measured to assess affects from flow changes. The shallowest redds measured had 20 centimeters (cm) (8 inches) of water over them.

Table 3-2 shows American River steelhead spawning distribution delineated into the reaches used in the Chinook salmon egg mortality model. Figure 3-15 and Figure 3-16 show American River steelhead in-river spawning population estimates between 2002 and 2007.

Table 3-1 Adipose clip status of adult steelhead entering Nimbus Hatchery on the American River.

Year	Steelhead Entering Hatchery	Number Unclipped	Percent Unclipped
2001	2,877	50	1.7%
2002	1,253	69	5.5%
2003	873	27	3.1%
2004	1,741	17	1.0%

2005	2,772	118	4.3%
2007	2,673	116	4.3%

Table 3-2 American River steelhead spawning distribution, 2002-2007 (Hannon and Deason 2007). Data was not collected in 2006.

American River Steelhead redd distribution

		Redds per mile					**Summary**			
Reach	**Reach Miles**	**2002**	**2003**	**2004**	**2005**	**2007**	**Total redds 2002 2007**	**Average redds/mile**	**Steelhead Total %**	**Chinook %**
Above weir										
Nimbus to Sunrise bridge	2.86	28	30	27	28	24	334	**29**	**38%**	31%
Sunrise to Ancil Hoffman	4.73	7	11	9	4	28	213	**11**	**24%**	59%
Ancil Hoffman to Goethe bike bridge	1.89	2	13	15	9	42	84	**11**	**10%**	5%
Arden Rapids (Goethe bridge) to Watt bridge	4.1	7	12	9	3	9	151	**9**	**17%**	3%
Watt to Fairbairn water intake	2.02	0	0	1	0	13	6	**1**	**1%**	1%
Fairbairn to H Street bridge	0.75	0	0	0	0	1	0	**0**	**0%**	0%
H Street bridge to Paradise Beach	1.09	12	0	1	13	0	28	**6**	**3%**	1%
Paradise Beach to 16th st	3.49	0	0		0		0	**0**	**0%**	0%
16th st to Sacramento River	2.01	0	0		0		0	**0**	**0%**	0%
Total	22.94	7	9	8	6	8	874	**10**	**100%**	100%

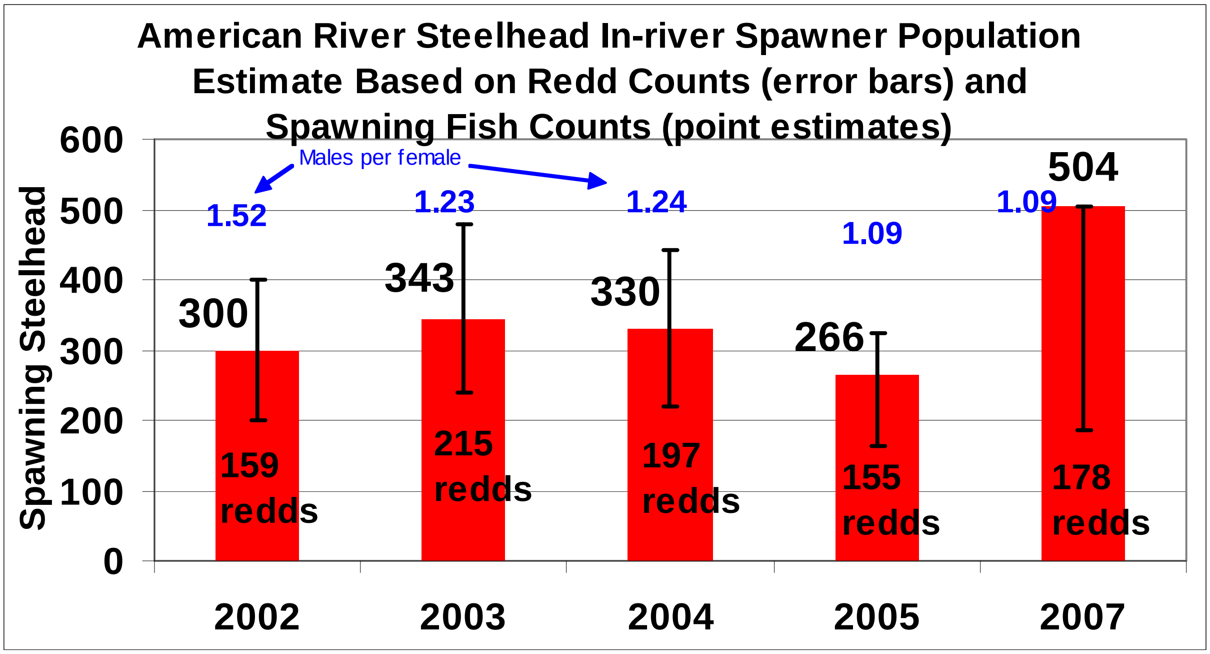


Figure 3-15 American River steelhead in-river spawning population estimate based on redd counts and spawning fish counts (Hannon and Deason 2007).

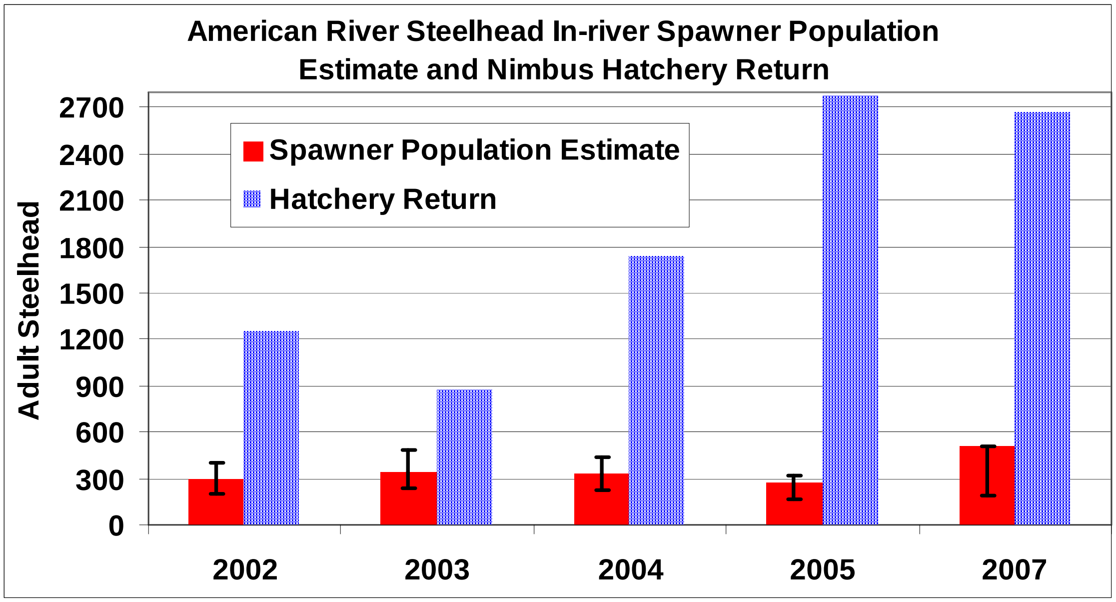


Figure 3-16 American River steelhead in-river spawning population estimate and Nimbus hatchery return (Hannon and Deason 2007).

Stanislaus River

Historically, steelhead distribution extended into the headwaters of the Stanislaus River (Yoshiyama et al. 1996). Dam construction and water diversion for mining and irrigation purposes began during and after the Gold Rush. Goodwin Dam, constructed in 1913, was probably the first permanent barrier to significantly affect Chinook salmon access to upstream habitat. Goodwin Dam had a fishway, but Chinook could seldom pass it. Steelhead may have been similarly affected. The original Melones Dam, completed in 1926, permanently prevented access to upstream areas for all salmonids. Currently, steelhead can ascend over 58 miles up the Stanislaus River to the base of Goodwin Dam. Although steelhead spawning locations are unknown in the Stanislaus, most are thought to occur upstream of the City of Oakdale where gradients are slightly higher and more riffle habitat is available.

The Fishery Foundation of California (Kennedy and Cannon 2002) has monitored habitat use by juvenile steelhead/rainbow since 2000 by snorkeling seven sites from Oakdale to Goodwin Dam every other week. Steelhead fry begin to show up in late March and April at upstream sites, with densities increasing into June and distribution becoming more even between upstream and downstream sites through July. Beginning in August and continuing through the winter months, densities appeared highest at upstream sites (Goodwin to Knights Ferry). Age 1-plus fish were observed throughout the year with densities generally higher at upstream sites (Goodwin to Knights Ferry). Low densities were observed from late December until April. It is unknown whether fish left the system in December or if, with the cooler winter water temperatures, they were less active and more concealed during the day.

Since 1993, catches of juvenile steelhead/rainbow in rotary screw traps (RSTs) indicate a small portion of the Stanislaus River steelhead/rainbow population displays downstream migratory characteristics at a time that is typical of steelhead migrants elsewhere. The capture of these fish in downstream migrant traps and the advanced smolting characteristics exhibited by many of the fish indicate that some steelhead/rainbow juveniles might migrate to the ocean in spring. However, it is not known whether the parents of these fish were anadromous or fluvial (they migrate within freshwater). Resident populations of steelhead/rainbow in large streams are typically fluvial, and migratory juveniles look much like smolts. Further work is needed to determine the parental life histories that are producing migratory juveniles. The Stanislaus River Weir has been installed annually since 2003 at RM 31.4. The primary purpose of the weir is to monitor escapement of fall-run Chinook salmon, so it is installed from September through June each year. Fish passing the weir are monitored using a Vaki infrared RiverWatcher Fish Counter. From 2003 through 2007, *O. mykiss* have been observed passing the weir a total of 16 times. Scale analysis of one individual indicated that it was a steelhead.

Smolts have been captured each year since 1995 in RSTs at Caswell State Park and at Oakdale (Demko et al. 2000). Captures occurred throughout the time the traps were run, generally January through June. Most fish were between 175 and 300 mm at the Caswell site, with only six fish in seven years less than 100 mm. Larger numbers of fry were captured upstream at Oakdale. During 2001, 33 smolts were captured at Caswell and 55 were captured at Oakdale, the highest catch of all years. Although improved traps were used, the higher catch in 2001, was likely due to more fish present and not due to better trap efficiencies (Doug Demko, personal communication, 2001). RSTs are generally not considered efficient at catching fish as large as steelhead smolts and the number captured is too small to estimate capture efficiency so no steelhead smolt outmigration population estimate has been calculated.

Genetic analysis of rainbow trout captured below Goodwin Dam shows that this population has closest genetic affinities to upper Sacramento River steelhead (NMFS 1997b).

The most consistent data available on rainbow/steelhead in the San Joaquin River are collected at the Mossdale trawl site on the lower San Joaquin River (Marston 2003). Figure 3-17 shows that counts were highest in the initial years of the Mossdale trawl survey in 1988–90.

Sacramento-San Joaquin Delta

The Delta serves as an adult and juvenile migration corridor, connecting inland habitat to the ocean. The Delta may also serve as a nursery area for juvenile steelhead (McEwan and Jackson 1996). Estuaries are important nursery grounds for other coastal steelhead populations. However, the historical and current role of the Delta as a steelhead nursery habitat is unknown. Based on fish facility salvage data, most steelhead move through the Delta from November through June, with the peak salvage occurring during February, March, and April. The majority of steelhead salvaged range from 175–325 mm, with the most common size in the 226–250 mm range (Figure 3-18). Unclipped fish tended to have a higher proportion of larger individuals than clipped fish.

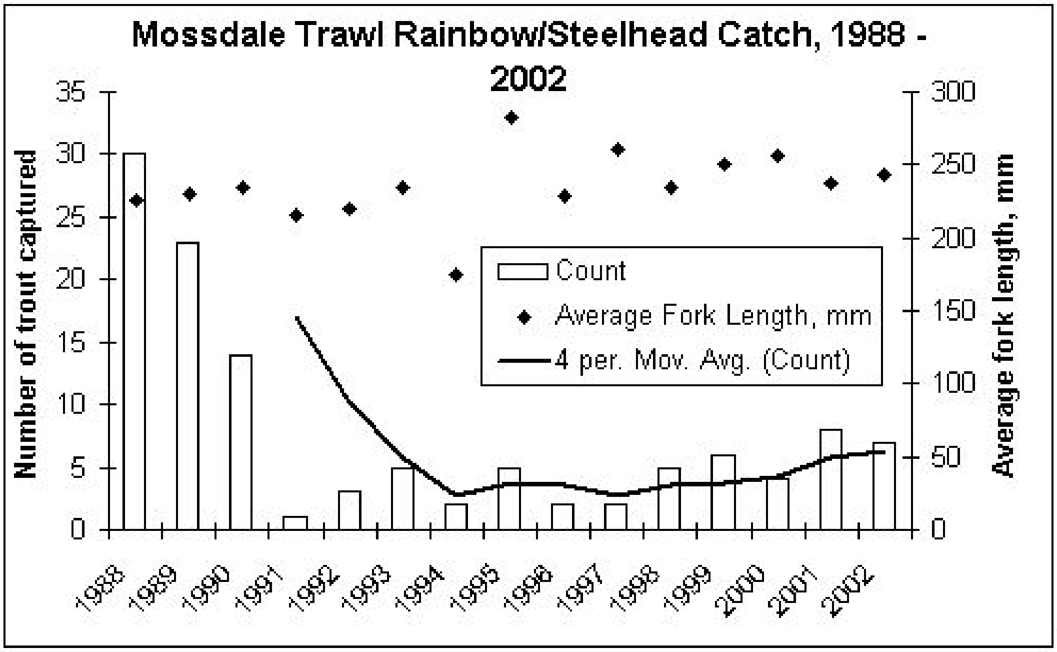


Figure 3-17 Mossdale Trawl rainbow/steelhead catch, 1988-2002 (Marston 2003).

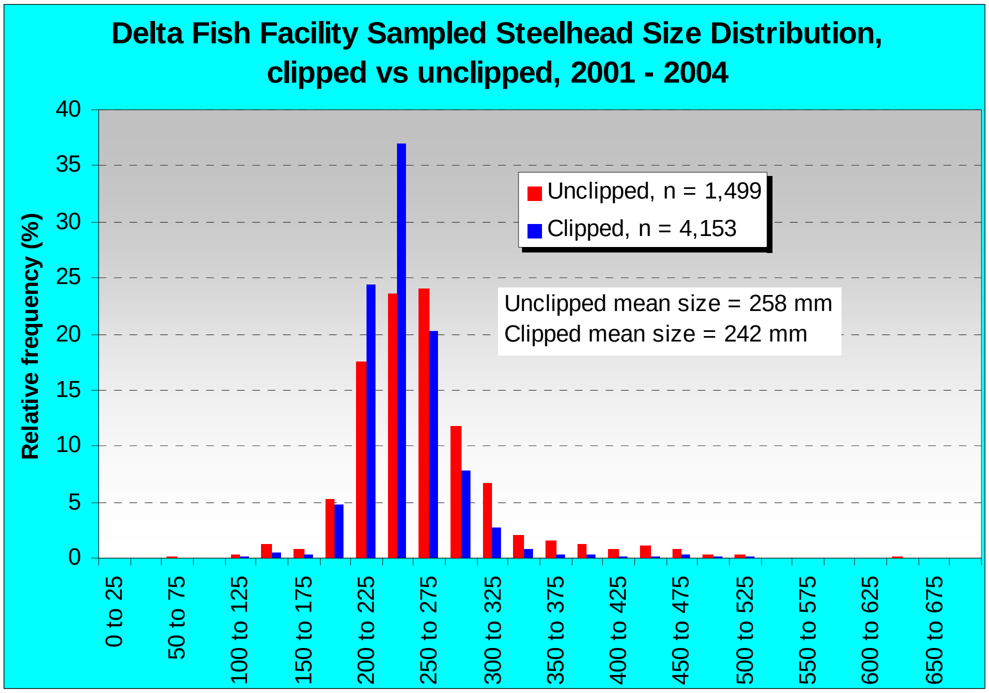


Figure 3-18 Length frequency distribution of clipped and unclipped steelhead salvaged at the CVP and SWP in 2001-2004.

Critical Habitat

The critical habitat designation (70 FR 52488, September 2, 2005) lists primary constituent elements (PCEs) which are physical or biological elements essential for the conservation of the listed species. The PCEs include sites essential to support one or more life stages of the ESU (sites for spawning, rearing, migration, and foraging). The specific PCEs include:

1. Freshwater spawning sites
2. Freshwater rearing sites
3. Freshwater migration corridors
4. Estuarine areas
5. Nearshore marine areas
6. Offshore marine areas

Water operations can affect habitat conditions in the first four of the PCEs. These four PCEs are present in the action area. The designated critical habitat is shown in Figure 3-1.

The Central Valley steelhead critical habitat potentially affected by CVP and SWP operations includes the Sacramento – San Joaquin Delta channels, the San Joaquin River up to the mouth of the Stanislaus River, the Stanislaus River up to Goodwin Dam, the Sacramento River up to Keswick Dam, Clear Creek up to Whiskeytown Dam, the Feather River up to the fish barrier dam, and the American River up to Nimbus Dam (Figure 3-19). The following is a brief summation of the primary constituent elements of the habitat in each of the rivers.

Spawning Habitat

Steelhead in the Sacramento River spawn primarily between Keswick Dam and Red Bluff Diversion Dam during the winter and spring. The highest density spawning area is likely in the upstream portion of this area in the vicinity of the city of Redding, although detailed surveys of steelhead spawning in the mainstem Sacramento River are not available. Most Sacramento River steelhead probably spawn in the tributary streams. Steelhead spawn in Clear Creek mostly within a couple miles of Whiskeytown Dam but spawning extends for about 10 miles downstream of the dam (Matt Brown, pers comm.). Steelhead spawn in the Feather River from the fish barrier dam downstream to Gridley with nearly 50% of all spawning occurring the first mile of the low flow channel (DWR 2003; http://orovillerelicensing.water.ca.gov/pdf_docs/07-30-03_env_att_11.pdf). Steelhead spawn in the American River from Nimbus Dam (mile 23) downstream to the lowest riffle in the river at Paradise Beach (mile 5). Most spawning is concentrated in the upper seven miles of the river (Hannon and Deason 2007). Steelhead (and/or rainbow trout) spawn in the Stanislaus River from Goodwin Dam downstream to approximately the city of Oakdale. Steelhead spawning surveys have not been conducted in the Stanislaus River so detailed spawning distribution is unknown but based on observations of trout fry, most spawning occurs upstream of Orange Blossom Bridge.

Freshwater Rearing Habitat

Juvenile steelhead reside in freshwater for a year or more so they are more dependent on freshwater rearing habitat than are the ocean type Chinook salmon in the Central Valley. Steelhead rearing occurs primarily in the upstream reaches of the rivers where channel gradients tend to be higher and, during the warm weather months, where temperatures are maintained at more suitable levels by cool water dam releases. The Sacramento River contains a long reach of suitable water temperatures even during the heat of the summer. Steelhead rearing in the Sacramento River occurs mostly between Keswick Dam (RM 302) and Butte City (RM 169) with the highest densities likely to be upstream of Red Bluff Diversion Dam. Steelhead rearing in Clear Creek is concentrated in the upper river higher gradient areas but probably occurs down to the mouth. Steelhead rearing in the Feather River is concentrated in the low flow channel where temperatures are most suitable (DWR 2004; http://orovillerelicensing.water.ca.gov/pdf_docs/04-28-04_att_10_f10_3A_steelhead_hab_use.pdf). Steelhead rearing in the American River occurs down to Paradise Beach with concentrations during the summer on most major riffle areas and highest densities near the higher density spawning areas. Steelhead rearing in the Stanislaus River occurs upstream of Orange Blossom Bridge where gradients are highest. The highest rearing densities are upstream of Knights Ferry (Kennedy and Cannon 2005).

Freshwater Migration Corridors

Steelhead migrate during the winter and spring of the year, as juveniles, from the rearing areas described above downstream through the rivers and the Delta to the ocean. The habitat conditions they encounter from the upstream reaches of the rivers downstream to the delta become generally further from their preferred habitat requirements until they reach the ocean. The generally non-turbulent flows and sand substrates found in the lower river reaches are not preferred types of habitat so steelhead do not likely reside for extended periods in these areas except when food supplies, such as smaller young fish, are abundant and temperatures are suitable. Predatory fishes such as striped bass tend to be more abundant in the lower rivers and the Delta. Emigration conditions for juvenile steelhead in the Stanislaus River down through the San Joaquin River and the south Delta tend to be less suitable than conditions for steelhead emigrating from the Sacramento River and its tributaries.

Adult steelhead migrate upstream from the ocean to their spawning grounds near the terminal dams primarily during the fall and winter months. Flows are generally lower during the upstream migrations than during the outmigration period. Areas where their upstream progress can be affected are the Delta Cross Channel Gates, Red Bluff Diversion Dam, and Anderson Cottonwood Irrigation District Diversion Dam.

Estuarine Areas

Steelhead use the San Francisco estuary as a rearing area and migration corridor between their upstream rearing habitat and the ocean. The San Francisco Bay estuarine system includes the waters of San Francisco Bay, San Pablo Bay, Grizzley Bay, Suisuin Bay, Honker Bay, and can extend as far upstream as Sherman Island during dry periods. At times steelhead likely remain for extended periods in areas of suitable habitat quality where food such as young herring, salmon and other fish and invertebrates is available.

Central California Coast Steelhead

Central California Coast steelhead are present only at the downstream end the area affected by CVP and SWP operations. The upstream extent of their habitat is San Pablo Bay and Napa River. The spawning habitat, freshwater rearing habitat, and freshwater migration corridors in Napa

River and other rivers with critical habitat in San Francisco Bay is not affected by CVP and SWP operations. The San Francisco estuary is the portion of the Central California Coast steelhead critical habitat potentially affected by water operations.

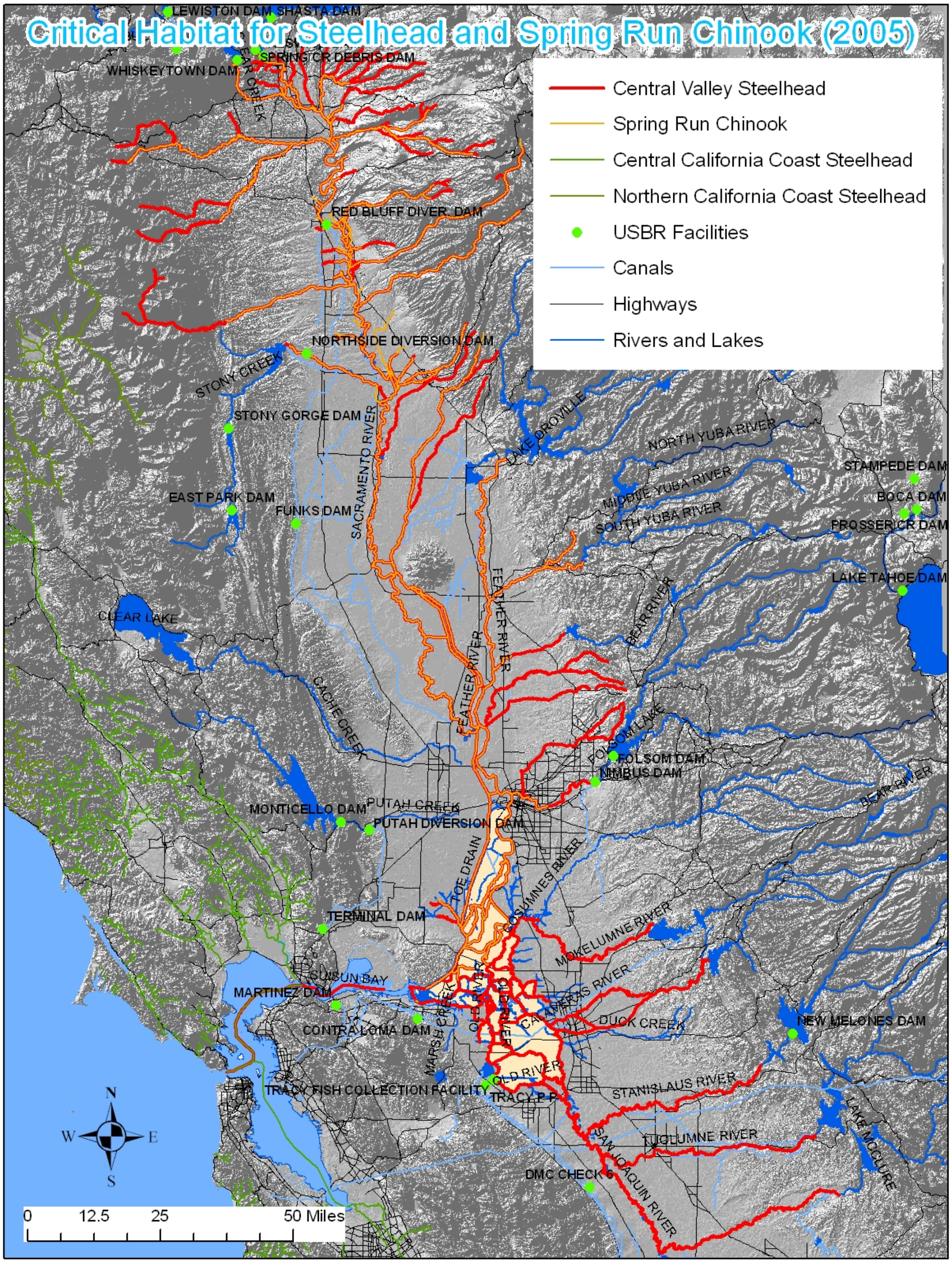


Figure 3-19 Designated critical habitat for Central Valley steelhead, Central Valley spring run Chinook salmon, and Central California Coast steelhead. Note: spring-run Chinook plotted over the top of steelhead (critical habitat GIS coverage from NMFS).

Streamflow

Figure 3-20 through Figure 3-24 show how monthly flows downstream of the terminal dams in each of the affected rivers have changed since operations of the respective dams began. The plots were generated from daily USGS stream gauge data using the Index of Hydrologic Alteration software (Richter et al 1996). The general change has been an increase in flows during the summer and fall months, the time of the historically lowest streamflows, and a decrease in flows during the winter and spring months, the time of the historically highest flows. The result of the change in flows has been a decrease in hydrologic variability and a loss of complexity in the freshwater aquatic habitat. These changes to the habitat are a part of the baseline.

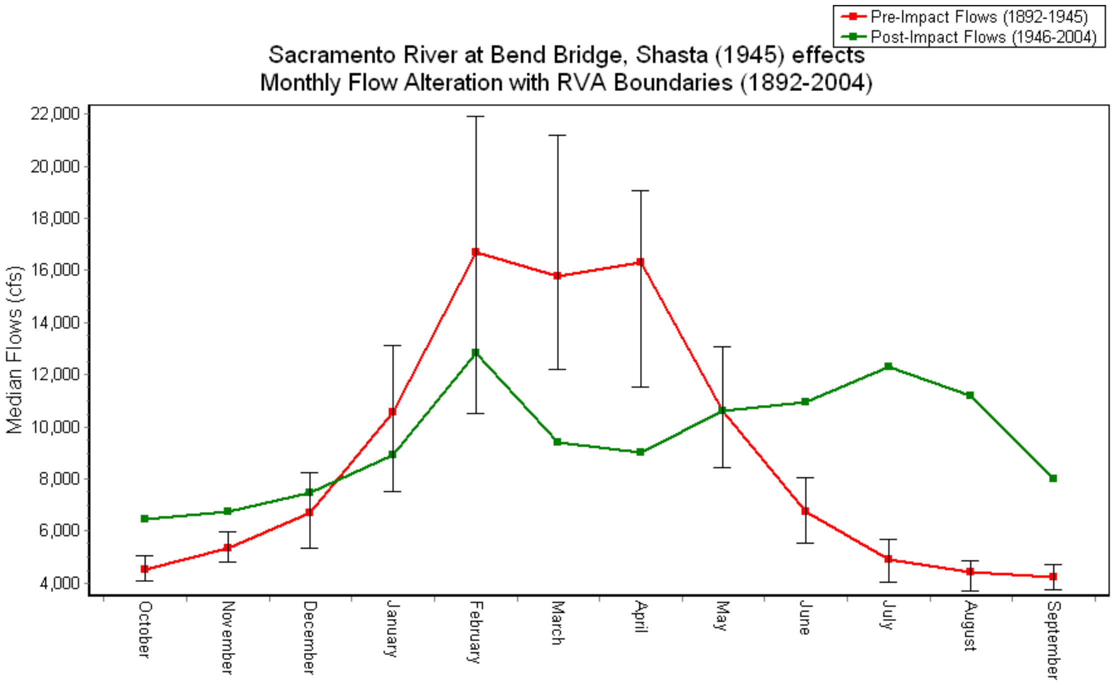


Figure 3-20 Sacramento River at Bend Bridge monthly flows comparing pre-Shasta Dam (1892-1945) to post Shasta (1946-2004) flows. The vertical lines represent range of variability analysis boundaries.

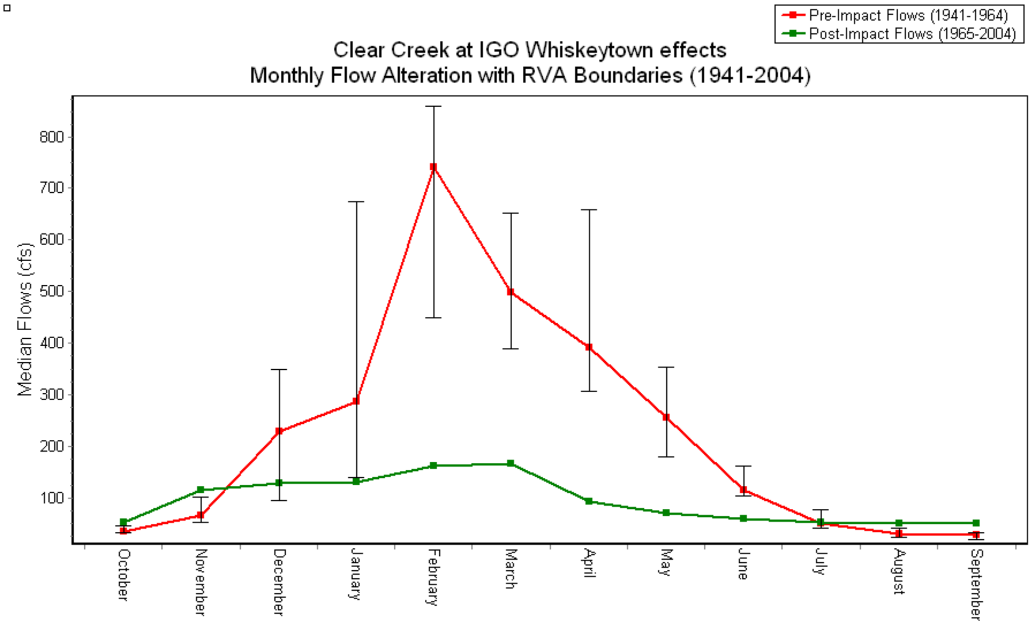


Figure 3-21 Clear Creek monthly flows comparing pre-Whiskeytown Dam (1941-1964) to post Whiskeytown (1965-2004) flows. The vertical lines represent range of variability analysis boundaries.

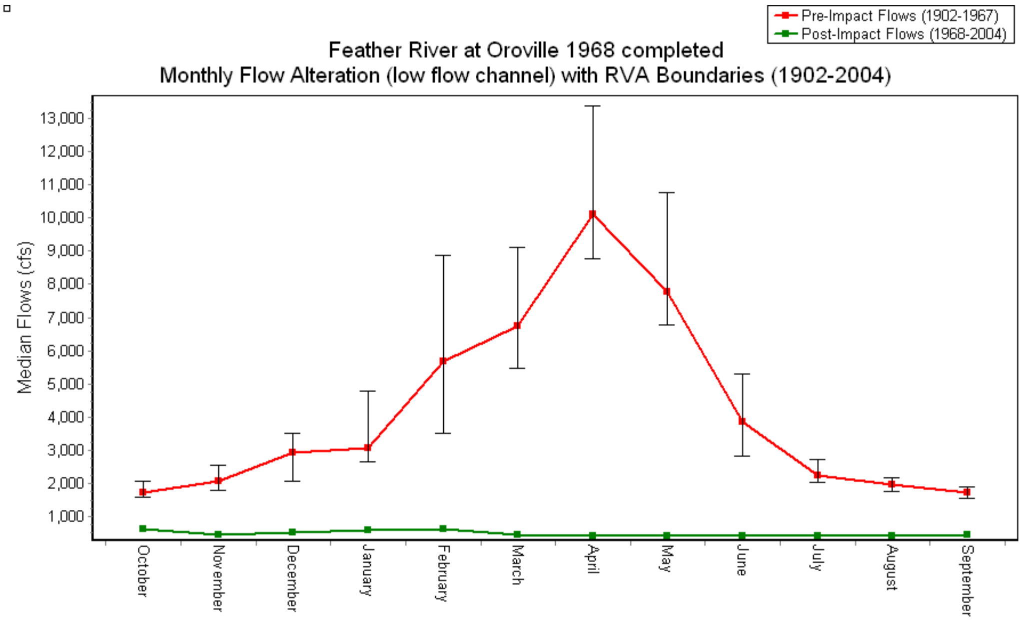


Figure 3-22 Feather River monthly flows comparing pre-Oroville Dam (1902-1967) to post Oroville (1966-2004) flows in the low flow channel, total releases from Oroville Dam are much higher than those reported here. The vertical lines represent range of variability analysis boundaries.

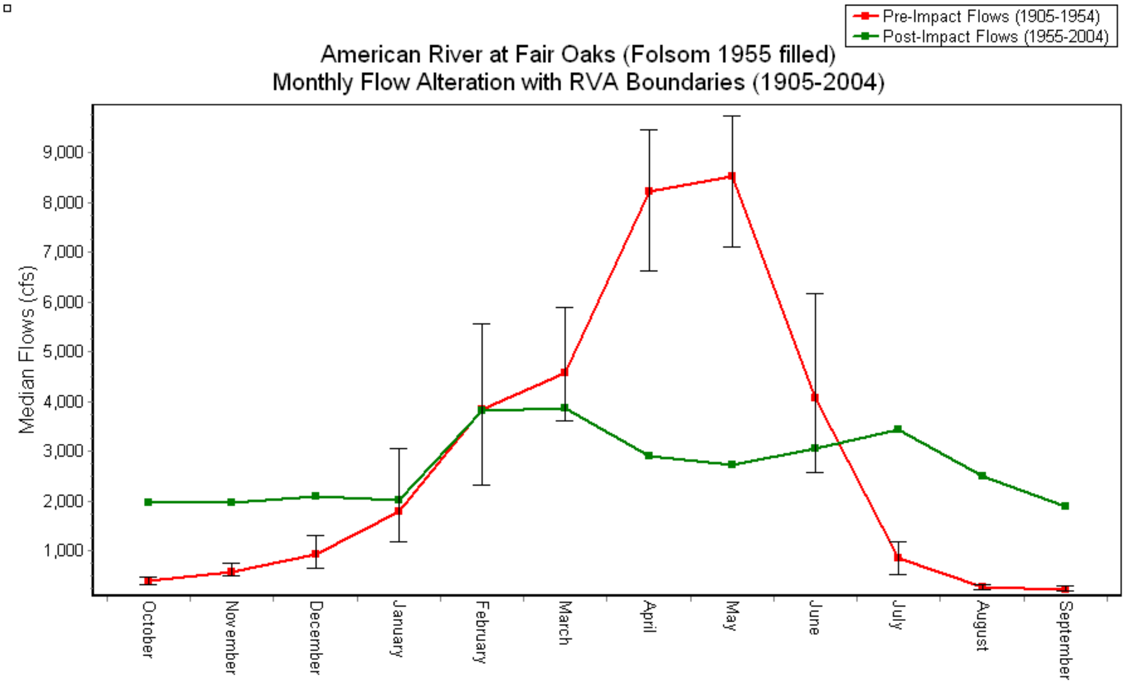


Figure 3-23 American River at Fair Oaks monthly flows comparing pre-Folsom Dam (1905-1954) to post Folsom (1955-2004) flows. The vertical lines represent range of variability analysis boundaries.

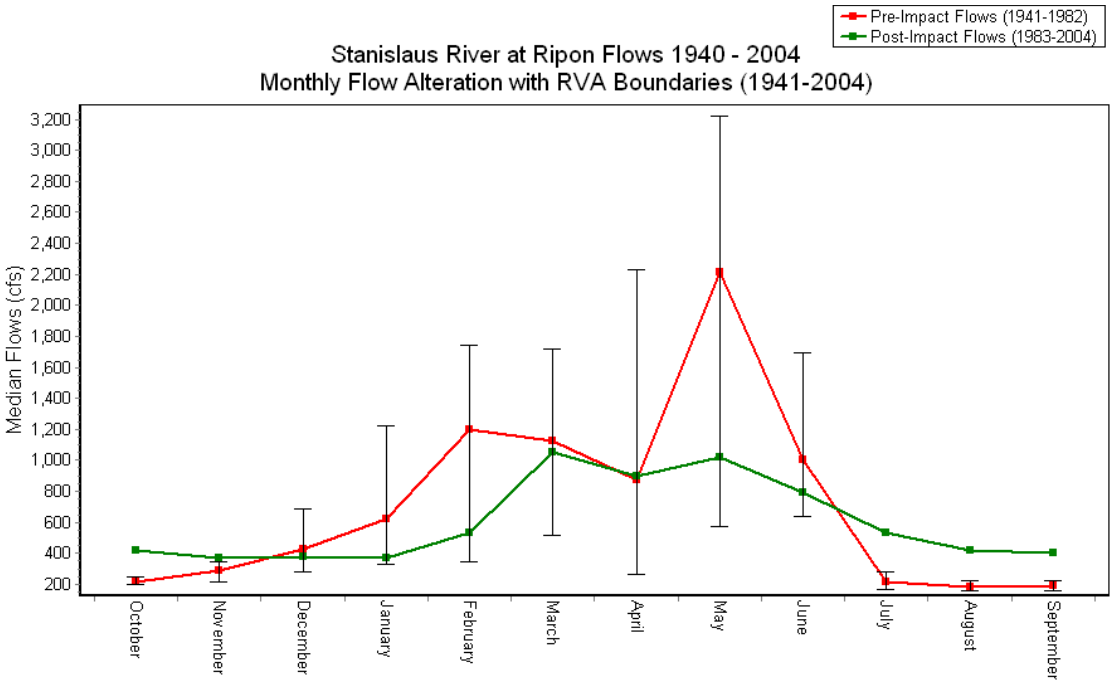


Figure 3-24 Stanislaus River at Ripon monthly flows comparing pre-New Melones Dam (1941-1982) to post New Melones (1983-2004) flows. The vertical lines represent range of variability analysis boundaries.

Water Temperature

Water temperatures in tailwater reaches in the area currently designated as critical habitat are cooler during the summer and warmer during the winter than what occurred historically. This moderation in water temperatures is due to the volume of water stored in each reservoir dampening the seasonal variation in inflow water temperatures. Historically when Chinook and steelhead had access higher into the watersheds the area currently used for spawning and rearing of Chinook salmon and steelhead was less suitable because of higher water temperatures during the summer and fall. During winter and spring water temperatures were cooler in the currently accessible habitat than what occurs now within the tailwater influenced reaches.

The change in temperature regime experienced by Chinook and steelhead may have changed the life history of the fish. For example warmer temperatures during the spring run and steelhead egg incubation period may result in earlier emergence than occurred historically. Current water temperature conditions throughout the year for each of the rivers is shown in Figure 3-25 through Figure 3-31.

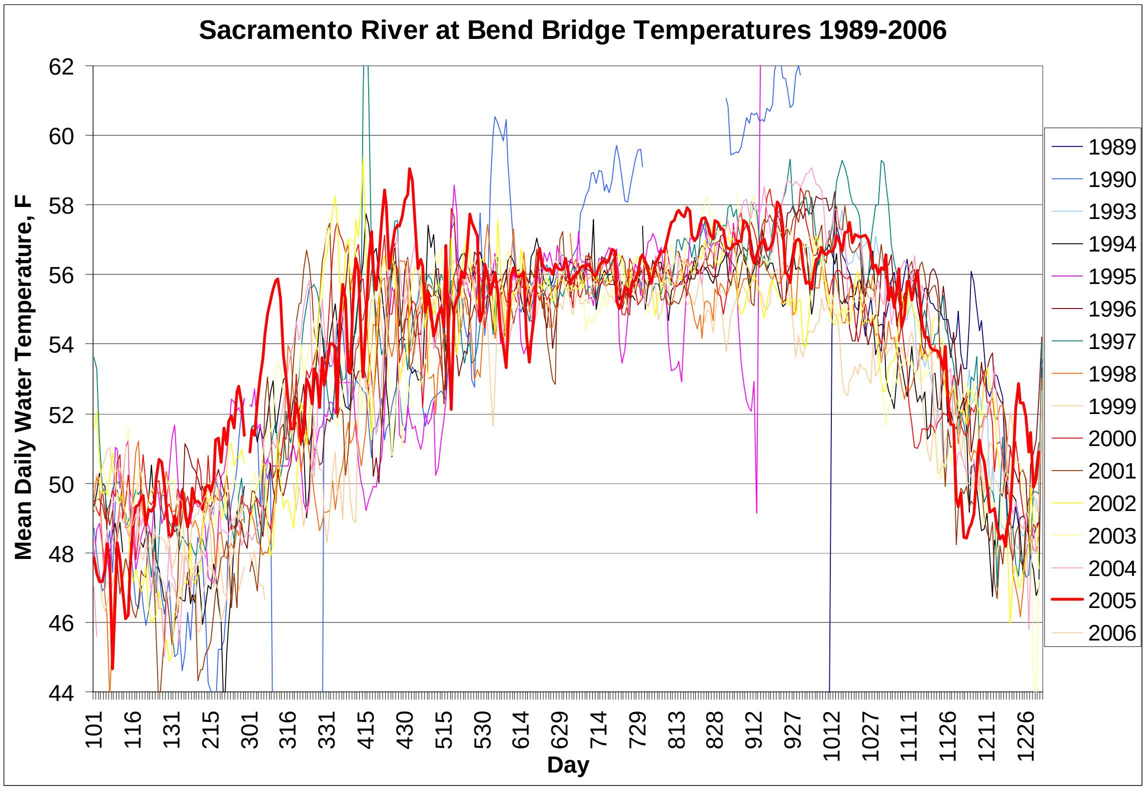


Figure 3-25 Sacramento River at Bend Bridge mean daily water temperatures 1998 – 2006.

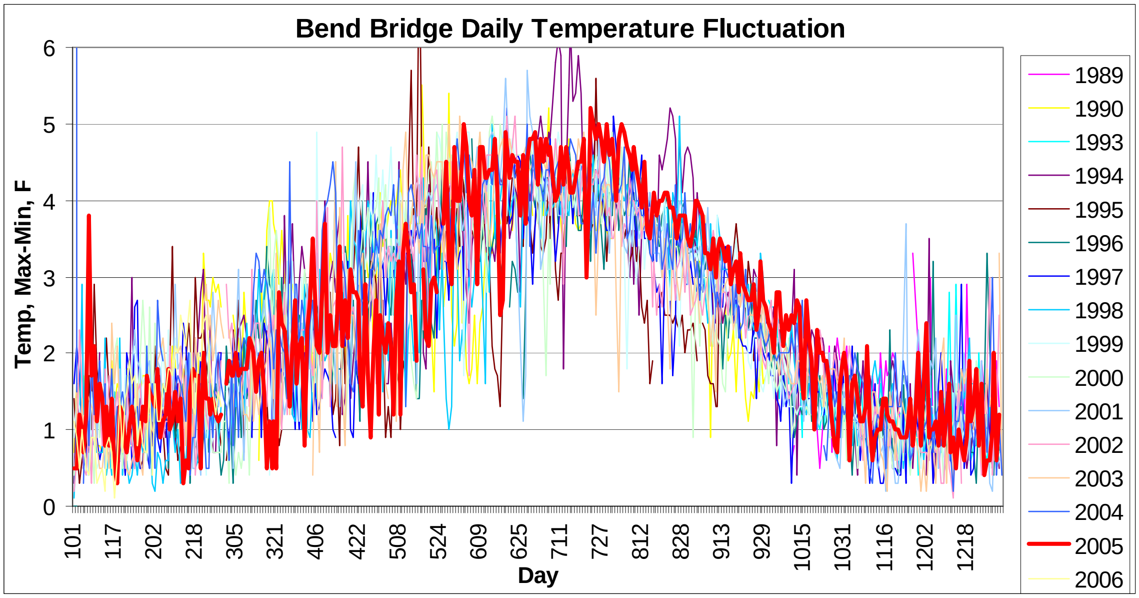


Figure 3-26 Sacramento River at Bend Bridge daily water temperature fluctuation (daily high temperature minus daily low temperature).

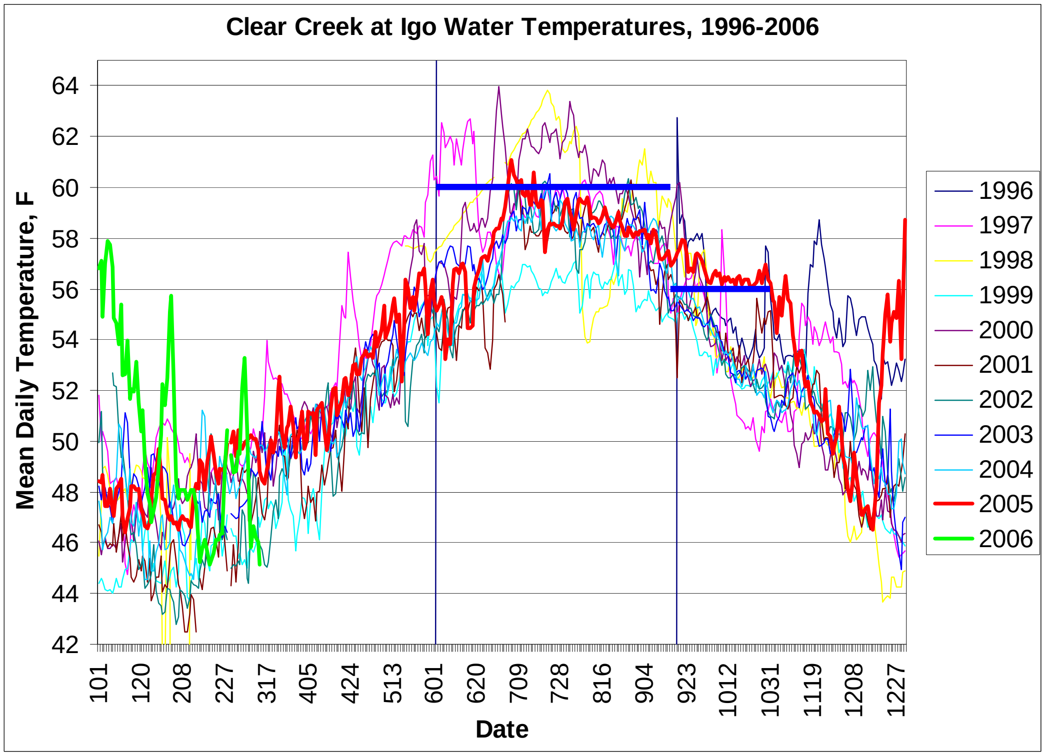


Figure 3-27 Clear Creek at Igo mean daily water temperatures 1996 – 2006.

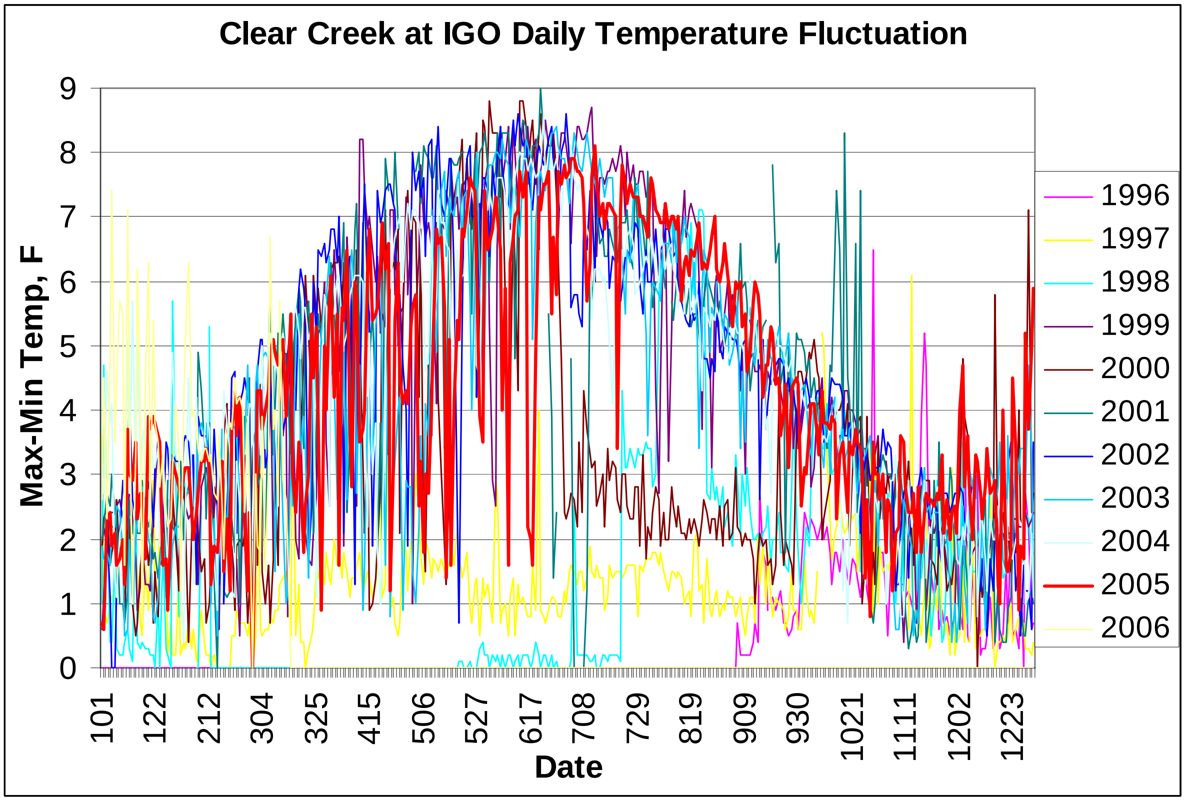


Figure 3-28 Clear Creek at Igo daily water temperature fluctuation (maximum daily minimum daily temperature).

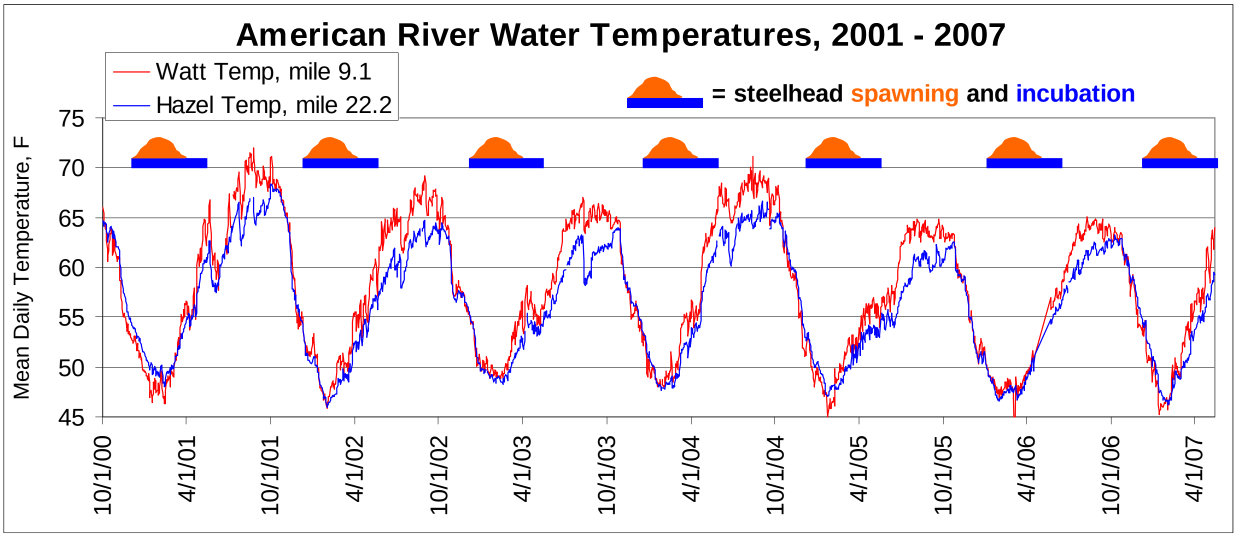


Figure 3-29 American River mean daily water temperatures, 2000 – 2007 at Hazel Avenue and Watt Avenue.

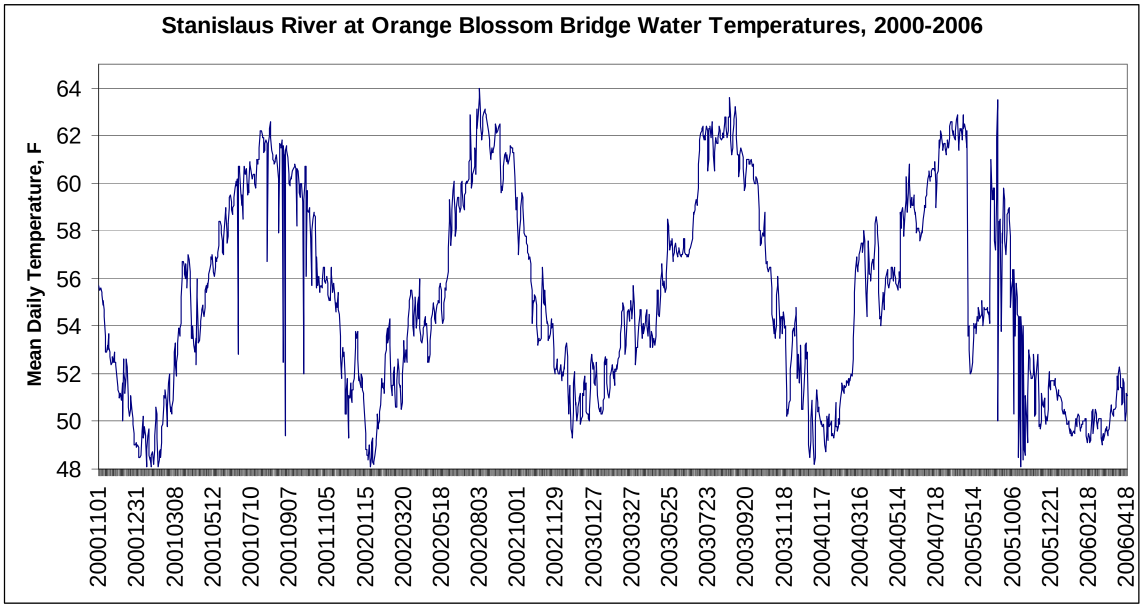


Figure 3-30 Stanislaus River at Orange Blossom Bridge water temperatures, 2001 – 2005. Note: some gaps in data exist.

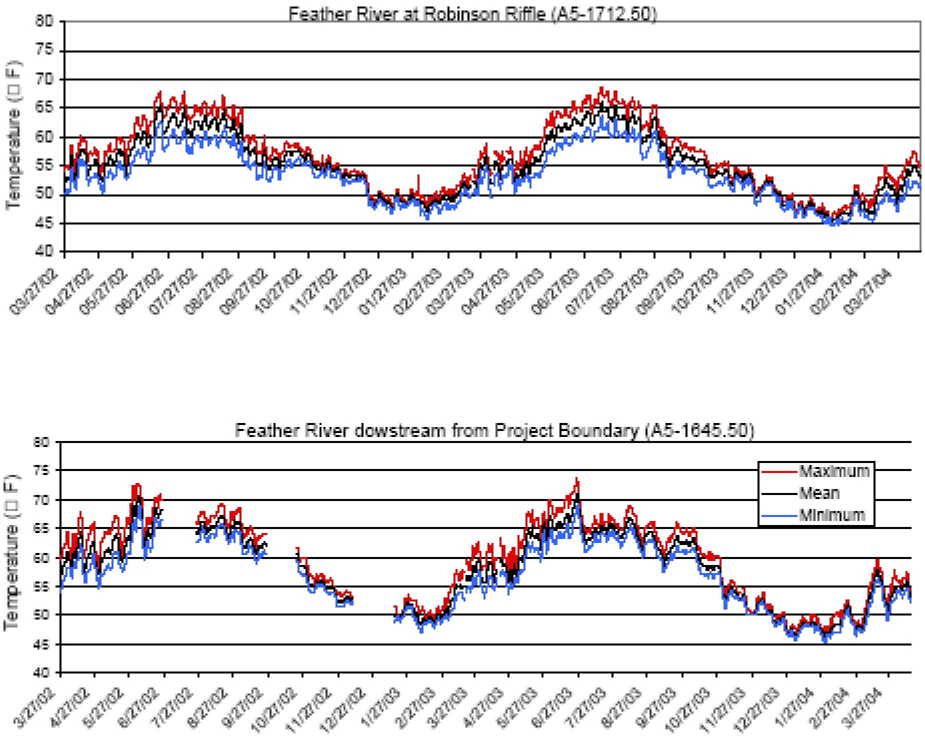


Figure 3-31 Feather River water temperatures, 2002 – 2004.

Effect of Cool Summer Time Dam Releases on Steelhead Habitat

The critical habitat of the Sacramento River below Keswick Dam is managed for cool water during the summer to protect winter-run Chinook salmon. This area was historically warmer and was not as suitable for juvenile steelhead during the summer. Prior to dam construction most trout probably reared further upstream, above the Shasta Lake area. The cool water provided over the summer downstream of Shasta Dam for winter-run Chinook salmon has been implicated in potentially decreasing the steelhead population due to an increase in the resident trout population (Cramer 2006). A similar situation occurs in the Stanislaus River downstream of Goodwin Dam and Clear Creek downstream of Whiskeytown Dam where cool water releases are maintained throughout the summer and resident rainbow trout populations are high. The larger resident trout populations may potentially compete with juvenile steelhead, reducing the juvenile steelhead population. The existence of the large, stable areas of habitat conditions in the dam tailwaters may promote residualism of the anadromous trout. The Cantara chemical spill occurred July 14, 1991 in the upper Sacramento River five miles upstream of the city of Dunsmuir. An estimated 309,000 trout were killed by the spill in an approximately thirty mile reach of the river, upstream of Shasta Lake (Hankin and McCanne 2000). Scale analysis and genetic analysis indicated 83-96% of these fish were wild (non-hatchery produced) trout. This population size amounts to 10,300 trout per mile (two trout per linear foot of river). This may be the best estimate of trout population size in any part of the Sacramento River. The population has since recovered to a similar density of trout in this reach. Water temperatures in this reach of the river are probably not much changed (or potentially higher due to Lake Siskiyou) compared to historic temperatures. The high trout population in this reach is probably similar to what existed in the upper Sacramento River historically in the presence of steelhead. Therefore we expect that the high resident trout population supported by cool water downstream of Central Valley Dams such as Keswick, Goodwin, and Whiskeytown is not a major factor in decreasing the anadromous populations in those systems. In any event the resident fish do produce anadromous individuals and maintain a supply of fish for the anadromous population.

San Joaquin River Flows

San Joaquin River flows in the critical habitat from the Merced River downstream are managed for one life history type of Chinook salmon. Flows are managed for fall-run Chinook salmon to enter the river in October, spawn in November, and incubate and rear in the river until late spring. Since 2000, flows are increased and delta exports decreased from generally mid-April to mid-May to aid emigration of the large (~75-100 mm) Chinook salmon juveniles out of the river and improve survival through the Delta to the estuary as part of the Vernalis Adaptive Management Program (VAMP). Flows prior to April 15 are managed for in-river rearing of Chinook and steelhead with no pulses, other than that provided by brief tributary inflows, to aid emigration of yearling Chinook, Chinook fry, or steelhead from the system. Little data on steelhead in the San Joaquin system exists so it is assumed that the flows that are managed for fall-run Chinook will adequately support the steelhead life history. Data from the Stanislaus River weir shows that the adult steelhead population in the Stanislaus is very low compared to the large resident rainbow trout population that is evident when snorkeling the river.

Predation

Species that prey on steelhead and Chinook salmon in the critical habitat of the project area include striped bass, Sacramento pikeminnow, smallmouth bass, trout, largemouth bass, seagulls, mergansers, cormorants, river otters, herons, sea lions, and seals. Striped bass, smallmouth bass, and largemouth bass are the introduced species that prey on salmonids and probably represent the greatest change (increase) in predation that has been experienced in the critical habitat compared to historical conditions.

Tucker et al (1998) found salmonids present in pikeminnow and striped bass stomachs at Red Bluff Diversion Dam. Salmonids outweighed other food in striped bass stomachs by a three to one margin. Reese and Harvey (2002) studied interactions between steelhead and Sacramento pikeminnows in laboratory streams. They found that growth of dominant steelhead was unaffected by presence of pikeminnow in water 15-18 ºC while at 20-23 ºC growth of dominant steelhead was reduced by over 50% in trials with steelhead alone compared to trials of steelhead with pikeminnows.

Merz (1994) measured striped bass predation on salmonids and estimated that striped bass consumed 11%-28% of the estimated Mokelumne River natural Chinook salmon production in 1993 at the Woodbridge Dam afterbay.

Connor et al (2003) describe a relationship in the Snake River where emigrating juvenile Chinook salmon survival generally increased with increasing flow and decreased with increasing temperature. They postulate that the clearer water and lower water velocities during lower flows increase the time the fish are exposed to predators while moving downstream and that higher water temperatures disrupt downstream movement exacerbating predation. A similar relationship is possible in the Central Valley rivers.

Consideration of Variable Ocean Conditions

Salmon and steelhead spend the majority of their lives in the ocean. Therefore, conditions in the ocean exert a major influence on the growth and survival of these fish from the time they leave the critical habitat in the Action Area (freshwater) until they return as adults to reproduce. Mantua et al (1997) described a recurring pattern of ocean-atmosphere climate variability centered over the mid-latitude North Pacific basin. Over the past century, the amplitude of this climate pattern has varied irregularly at interannual-to-interdecadal time scales. They refer to this pattern as the Pacific Decadal Oscillation (PDO). Major changes in northeast Pacific marine ecosystems have been correlated with phase changes in the PDO; warm eras have seen enhanced coastal ocean biological productivity in Alaska and inhibited productivity off the west coast of the contiguous United States, while cold PDO eras have seen the opposite north-south pattern of marine ecosystem productivity.

Another pattern, called the *El Niño/Southern Oscillation (ENSO),* occurs on a shorter time scale of six to eighteen months compared to 20 to 30 years for the PDO. The same general pattern is evident with warm periods showing inhibited productivity along the Pacific coast offshore of California and enhanced ocean biological productivity in Alaska.

Sierra snowpack and streamflow are also correlated with ENSO and PDO. During the warm phases lower snowpack and streamflows occur and during cool phases above average snowpack and streamflows occur (Mantua et al, 1997).

During the cooler phases of ENSO and PDO, California salmonid populations generally experience increased marine survival. In addition, higher streamflows tend to occur during the cooler phases, enhancing freshwater production and providing the opportunity for more diverse life history types of juvenile salmonids. The inverse effects on California salmonid populations tend to occur during warm cycles. These alternating patterns of productivity, not caused by water operations, can mask and override most changes in populations that occur due to water operations. Therefore, any effects need to be considered in light of variable and difficult to quantify ocean conditions and climate variability.

Mitigation Hatchery Steelhead Effects on Wild Steelhead

Kostow and Zhou (2006) investestigated the effect of a hatchery program for summer steelhead on the productivity of a wild winter steelhead population in the Clackamas River, Oregon. They found that when high numbers of hatchery summer steelhead adults were present the production of wild winter steelhead smolts and adults was significantly decreased. Large releases of hatchery smolts also contributed to the decrease in adult productivity. They concluded that over the duration of the hatchery program the number of hatchery steelhead in the basin regularly caused the total number of steelhead to exceed carrying capacity, triggering density-dependent mechanisms that impacted the wild population.

Levin and Williams (2002) tested the hypothesis that hatchery-reared steelhead released into the Snake River Basin negatively affect the survival of wild Snake River steelhead and Chinook salmon. They demonstrated that the survival of wild Chinook salmon is negatively associated with hatchery releases of steelhead but observed no relationship between survival of wild steelhead and steelhead hatchery releases. Steelhead Straying and Genetic Introgression

- The lack of distinction between San Joaquin and Sacramento steelhead populations suggests either a common origin or genetic exchange between the basins. Findings of a recent genetic study on Central Valley (CV) steelhead populations (Nielson et al. 2003) indicate that:Feather River steelhead populations (natural and FRFH-produced populations) are more similar to populations from streams in the same general geographic location—i.e., Clear Creek, Battle Creek, upper Sacramento River, Coleman National Fish Hatchery, and Cottonwood, Mill, Deer, and Antelope creeks.
- Feather River steelhead populations are not closely linked to Nimbus Hatchery and American River populations.
- Feather River steelhead population’s closest relative is the FRFH-produced steelhead and both are distinct from other Central Valley steelhead populations.
- There are no data on the potential effects (e.g., reduced fitness) of inbreeding or outbreeding of FRFH-produced steelhead.

These data suggest that there appears to be considerable genetic diversity within the CV steelhead populations and that, although fish from the San Joaquin and Sacramento River basins cannot be distinguished genetically, there is still significant local genetic structure to CV steelhead populations. For example, Feather River and FRFH-produced steelhead are closely related, as are American River and Nimbus Hatchery fish. American River steelhead stocks are greatly influenced by Eel River transplants used to rebuild the run after Nimbus and Folsom Dams were built.

Estimates of straying rates only exist for Chinook salmon produced at the FRFH. However, general principles and the potential effects of straying are also applicable for steelhead. However, based on available genetic data, the effects of hatcheries that rear steelhead appear to be restricted to the population on hatchery streams (DWR 2004a). These findings suggest that, although ongoing operations may impact the genetic composition of the naturally spawning steelhead population in these rivers, hatchery effects appear to be localized. It should be noted that genetic data for steelhead are limited (DWR 2004a).

Summary of the Environmental Baseline

Environmental baseline, as defined in 50 CFR 402.02, “includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process”. The prior information in this chapter provides the status of steelhead in the action area which has resulted from the past and present impacts of activities in the action area.

The majority of Central Valley steelhead are restricted to non-historical spawning and rearing habitat below dams within the action area. Populations of steelhead occur outside the action area (Yuba River, Deer Creek, Mill Creek, Antelope Creek), but the abundance of these populations is unknown. Existing spawning and rearing habitat within the action area can sustain steelhead at the current population level. Monitoring data indicates that much of the anadromous form of the species is hatchery supported. There remains a strong resident component that interacts with and produces anadromous individuals (Zimmerman et al. 2008).

Chapter 4 describes the factors that affect the species and critical habitat in the action area. A large factor affecting the listed salmonids is the loss of spawning and rearing habitat upstream of impassable dams. High water temperatures in these lower elevations are a stressor to adult and juvenile life stages. The factors that affect the survival are high temperatures, low flows, limited spawning and rearing habitat, blocked or delayed passage, unscreened diversions, and flow fluctuations.

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