



Coho Salmon Monitoring in Redwood Creek

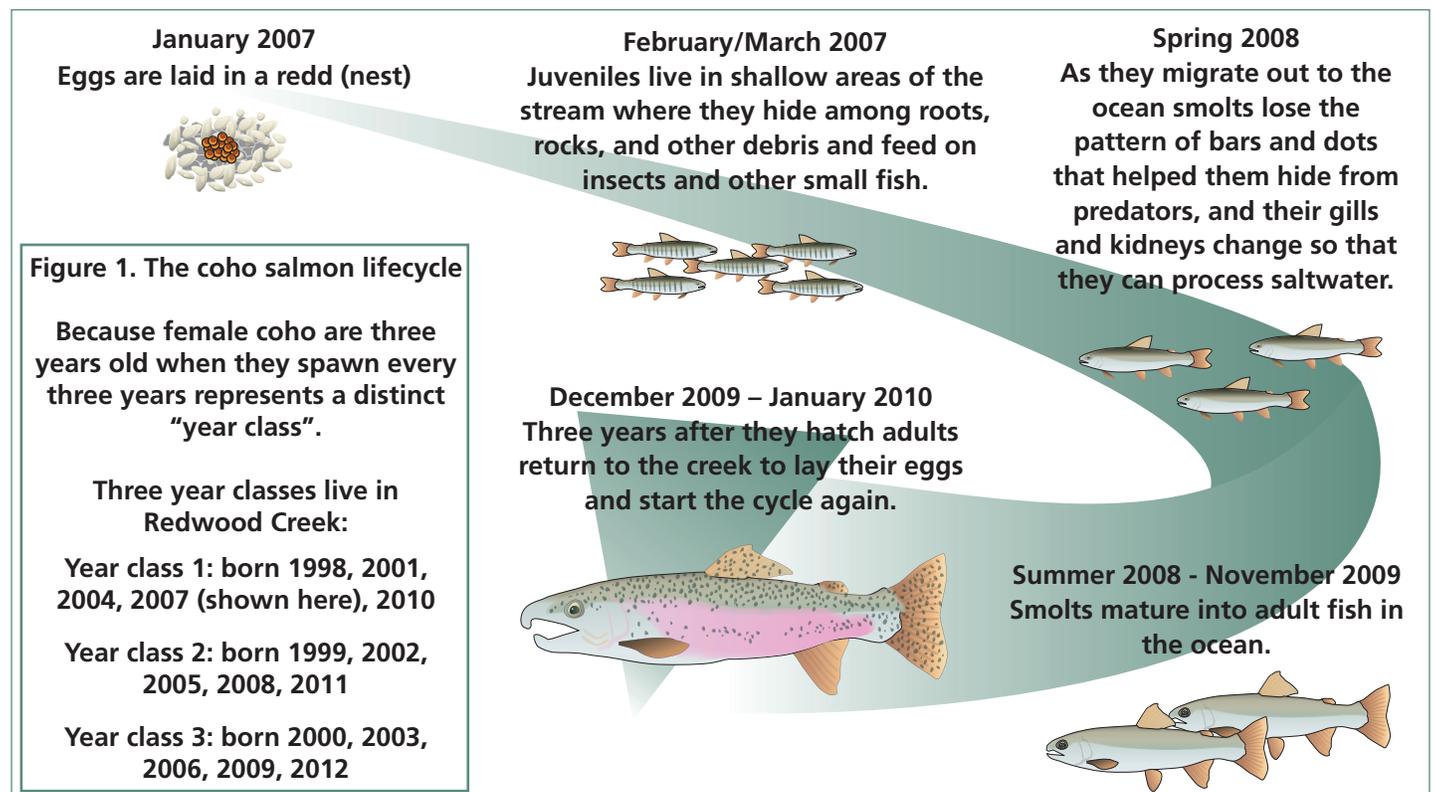
Importance: *Coho salmon use several of the coastal streams within the Golden Gate National Recreational Area and Point Reyes National Seashore throughout their lifecycle. Because coho are an endangered species, the National Park Service (NPS) is responsible for monitoring and protecting these populations.*

In the winter, coho salmon (*Oncorhynchus kisutch*) lay their eggs in shallow gravel nests (redds) in freshwater streams. After nearly six weeks as eggs, and six more weeks as tiny egg-sac fry, juveniles emerge in the spring, holding close to shallow, shady near-shore areas where they live among tree roots, woody debris, and rocks.

These juveniles stay in the stream until the following spring when they “smolt”, or undergo a series of physiological changes that enable them to live in saltwater. Smolts migrate out to the ocean where they mature for another 18 months before they return as adults to their natal stream to spawn.

Unlike some other fish species, coho salmon only reproduce this one time before they die. The cycle of birth to death takes a total of three years and so fish born three years apart are considered part of the same cohort or “year class” (Figure 1).

Olema, Redwood, and Pine Gulch Creeks in Marin County all support populations of coho salmon; however, spawning stocks along the West Coast of the United States are only at about 1% of historical levels. Habitat loss from urbanization, dam construction, logging, water withdrawals, and stream channel alterations, along with over-harvest, climactic changes, and poor ocean productivity have all contributed to this population decline.



Monitoring Program: *NPS monitors coho salmon throughout their entire lifecycle to track population trends and evaluate the effects of restoration activities.*

In 1997, NPS staff and volunteers began monitoring coho salmon in Redwood, Olema, Pine Gulch, and Cheda Creeks. The Marin Municipal Water District surveys Lagunitas Creek, Devil's Gulch, and San Geronimo Creek. The Salmon Protection and Watershed Network monitors tributaries of San Geronimo Creek. Combined, these efforts have provided critical information about the coho salmon populations in these watersheds.

The NPS monitoring program is designed to address the following questions:

- What are the trends in coho abundance and distribution during their different life stages?
- Have the size and health of these fish changed over time?
- Is the park meeting their mandate for salmon habitat protection?
- How are habitat restoration efforts affecting coho recovery?

Year-round monitoring captures coho population dynamics at each stage (see below) and over time. For example, comparing the number of juvenile fish in a given year with how many smolts migrate to the ocean the next provides an estimate of juvenile survival rates. How many of these smolts return 18 months later as spawners gives a measure of ocean productivity and survival. Finally, counting the numbers of redds produced by these spawners indicates their level of reproductive success.



Summer Juvenile Survey

From July to October, scientists and volunteers use snorkel surveys to count juvenile coho hiding under vegetation and stream banks. These surveys give an estimate of the number and location of juveniles in the stream. This estimate is then calibrated by electrofishing—a technique that uses electricity to temporarily stun the fish allowing for safe capture and release. Some of these fish are weighed and measured to determine their health, which is directly related to habitat quality and food availability.



Winter Spawner Survey

Between November and February, returning coho salmon adults (spawners) and redds (nests) are counted. This information can then be combined with data from other years to help illuminate long-term trends in distribution, abundance, and size of spawning coho salmon.



Spring Smolt Trapping

From March to June, temporary traps capture a sample of salmon smolts migrating out to sea. Biologists and volunteers count, weigh, and measure the fish before releasing them. This information is used to estimate the number and size of smolts in the stream, and can be compared across multiple years to track the size and condition of each year class. The size of migrating coho is especially important because larger smolts have a better chance of surviving to adulthood out in the ocean.

Status and Trends: *Each of the three year classes in Redwood Creek show distinct population patterns. The 2007 and 2008 seasons have shown a marked decline from previous years.*

Redwood Creek

Redwood Creek begins in Mt. Tamalpais State Park, then passes through the redwood forest at Muir Woods National Monument before emptying into the Pacific Ocean at Muir Beach. Spawners migrate into the creek after heavy winter rains breach the sandbars between the creek and the ocean at Muir Beach.

Large-scale weather and ocean patterns largely determine how many coho will return to spawn. Between 1999 and 2005, all three year classes in Redwood Creek increased after an El Niño event improved ocean productivity. A period of reduced nutrient upwelling in 2005-2006 led to the dramatic coho population declines since.

Year class 1 - born 1998, 2001, 2004, 2007

The number of spawners has been relatively steady over the past four generations—from a high of about 106 in 2001 to 51 in 2007. As would be expected, with fewer spawners the number of redds also declined in 2007. Despite the decrease in egg production, a mild winter allowed many of the young fish that hatched (about 7,832) to survive.

This same mild, dry winter led to low summer stream flows, which shrank smolt habitat and dropped their numbers from 2,481 in 2004 to only around 520 in 2007. The average smolt length (110.6 mm) was higher than previous years, indicating those that did survive had adequate food (see Habitat Matters).

Year class 2 - born 1999, 2002, 2005, 2008

Highly variable, this year class had the highest

Habitat Matters

Because coho require both high quality ocean and freshwater stream habitats, they are excellent indicators of watershed health. Coho only thrive when the amount of nutrients and food available at sea is high, and when their stream habitat is cool (below 70° F/21° C) with unobstructed water flow, high levels of dissolved oxygen, and a diversity of habitats such as riffles, deep pools, and backwater areas.

Monitoring has shown that good quality stream habitat is especially important for young coho as overly strong currents can wash unprotected eggs and juveniles away (see Year Class 3) and larger smolts—those that have had adequate food and shelter—are more likely to survive to adulthood (Figure 2).

The NPS restoration project at Muir Beach (see below) will create side channels and other protected areas outside of the main stream channel to shelter vulnerable juveniles and smolts and increase their chances of survival.

spawner count in survey history in 2004-2005 with nearly twice as many spawners (198) and redds as the previous generation. The returning 2007-2008 spawner year class also began with a sizeable juvenile population of about 8,594 in 2005, and an all time high smolt estimate of 3,253 in 2006.

Despite these record numbers, no adult coho spawners or redds were found in Redwood Creek in the winter of 2007-2008. Fortunately, enough juvenile coho were found in the summer of 2008 to indicate that at least two successful redds had been created.

Redwood Creek was not the only place that saw a precipitous drop in coho numbers in 2007. There

Restoring Redwood Creek at Muir Beach

The creeks and wetlands that feed into Muir Beach have been altered over the years to the point where critical habitat for federally listed coho salmon, steelhead trout, and California red-legged frogs has been lost. Starting in 2009, NPS will begin restoring Muir Beach to create a functional, self-sustaining ecosystem and improve visitor access. The project will realign the stream and restore dunes and native vegetation. It will also increase off-channel refuges like floodplains and backwater areas, including the addition of large woody material to provide cover for aquatic life and create deep pools. For more information on this project please see <http://www.nps.gov/goga/naturescience/muir-beach.htm>.

was a 73% reduction in returning coho spawners across the California and Oregon coasts. Even so, a return rate in Redwood Creek similar to other places along the coast would have brought back about 20-25 adults. The remarkable decline seen in Redwood Creek is likely because the smolt in 2006 were smaller than average, and would have had a harder time surviving the poor ocean conditions present along the coast that year (See Habitat Matters and Figure 2).

Year class 3 - born 2000, 2003, 2006, 2009

Only about 30 spawners returned to Redwood Creek in the winter of 2005-2006. Historically the

smallest cohort, year class 3 was hit hard when high winter stream flows during the 1996-97 El Niño event decreased juvenile survival (Habitat Matters). The resulting population dip continues to be reflected in low spawner and juvenile numbers.

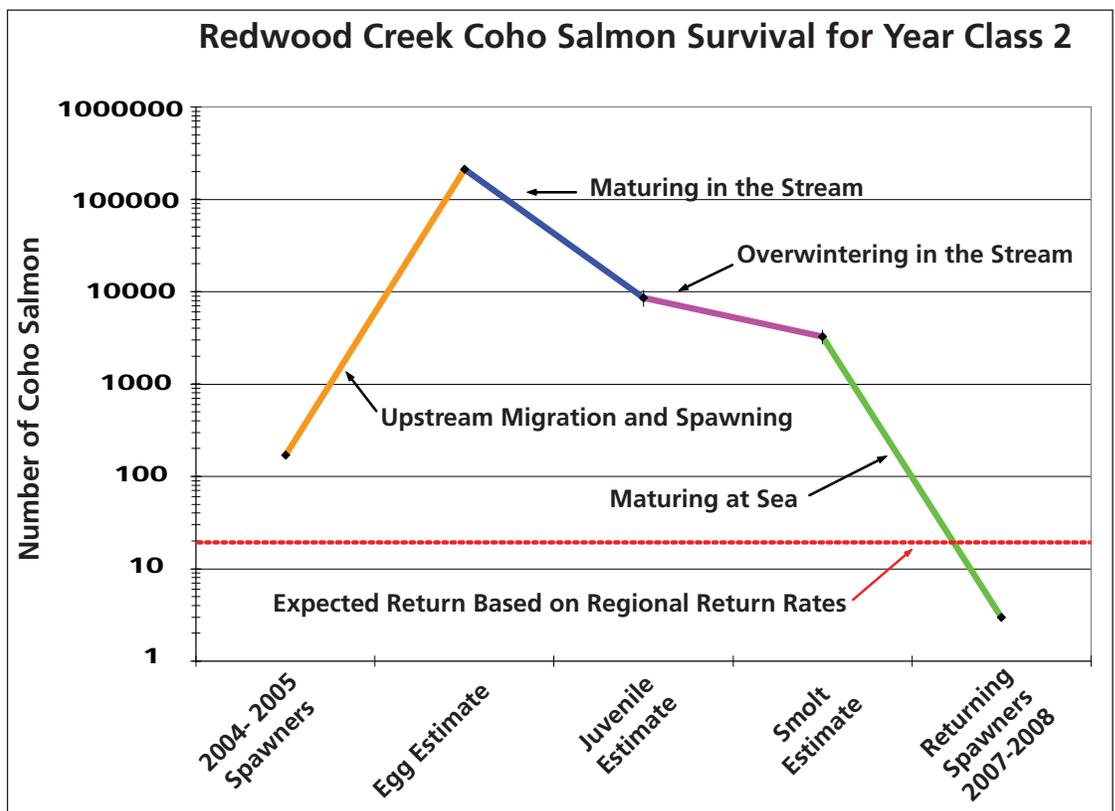
Juvenile monitoring for this year class only began in 2006 with an estimated 1,050 young that later became about 520 smolts in 2007. This is the lowest recorded smolt estimate for Redwood Creek, but reflects a high winter survival rate of about 49.5%.

Figure 2

The green line on the far right of the graph shows the dramatic decrease in the number of returning coho spawners in the winter of 2007-2008. Ninety seven percent fewer coho returned to the creek than in the previous generation of this year class, while the region as a whole saw a significant, yet less dramatic, 73% decline.

This larger than average drop for Redwood Creek illustrates how stream and ocean habitat quality affect coho survival. Monitoring has shown that a lack of refuge habitat in Redwood Creek

caused the smolts to expend time and energy hanging on to their position in the stream rather than on feeding. As a result, these smolts were much smaller in 2006 than in previous years, and they were also smaller than the regional average. To make matters worse, ocean nutrient upwelling was delayed that year so the already undersized smolts found little food once at sea.



Additional Resources:

Carlisle, S., M. Reichmuth, E. Brown, S.C. Del Real and B.J. Ketcham. 2008. Long-term Coho Salmon and Steelhead Trout Monitoring in Coastal Marin County 2007 Annual Monitoring Progress Report. National Park Service, San Francisco Bay Area Inventory and Monitoring Program, Point Reyes Station, CA. prepared for the California Department of Fish and Game P0530415.

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