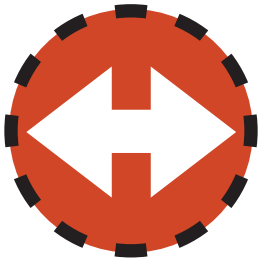
Measuring the Health of the Mountain: A Report on Mount Tamalpais' Natural Resources (2016)
(Chapter 12 excerpts)

ONE TAM

COHO SALMON, *Oncorhynchus kisutch*
STEELHEAD, *O. mykiss*
THREE-SPINED STICKLEBACK, *Gasterosteus aculeatus*

COHO SALMON IN LAGUNITAS CREEK

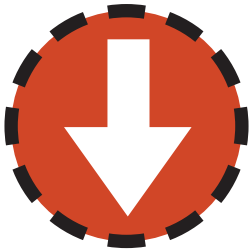


Condition: Significant Concern

Trend: No Change

Confidence: Moderate

COHO SALMON IN REDWOOD CREEK



Condition: Significant Concern

Trend: Declining

Confidence: Moderate

STEELHEAD TROUT

Condition: Significant Concern

Trend: No Change

Confidence: Moderate

THREE-SPINED STICKLEBACK

Condition: Good

Trend: No Change

Confidence: Low

WHY IS THIS RESOURCE INCLUDED?

Spending part of their lives in freshwater streams and part in the ocean, anadromous fish are good indicators of riparian habitat and watershed hydrology as well as ocean health. Anadromous fish are also an important food source for many species, as well as a source of marine-derived nutrients for aquatic and riparian communities. Endangered coho salmon and threatened steelhead trout live in Redwood and Lagunitas creeks in the One Tam area of focus. These iconic and charismatic species are compelling tools for public engagement and environmental education. Threespine stickleback, found in most of the streams in the One Tam area of focus, are also a charismatic native species, easy to recognize, and conducive to citizen science monitoring.

The land management agencies on Mt. Tam and their partners have been monitoring coho salmon and steelhead populations for decades, counting adult spawners, estimating summer fry, and (since 2006) monitoring smolts heading to the ocean. Steelhead have proved to be more difficult to monitor than coho, primarily because they tend to migrate to and from the ocean in late winter, when stream flows can be high. As a result, there remains a fair amount of uncertainty about the condition and trends of our local steelhead populations. Even less is known about the tiny threespine stickleback, which is caught incidentally during salmonid surveys and has not been the object of monitoring efforts. For stickleback, at least, there's an opportunity for the public to help increase our understanding of this local native fish.

OVERALL CONDITION

Coho Salmon (Lagunitas Creek): Listed as a federally threatened species in 1996 and as endangered in 2005, the Lagunitas Creek coho population reached a low point in 2008 when fewer than 60 adult fish returned from the ocean. Coho numbers have rebounded in recent years, but remain far below the 1,300 adults considered necessary to keep the population safe from extinction. Lagunitas Creek is now home to the southernmost stable population of wild coho salmon in the world, while remnant populations as far south as Santa Cruz are being augmented with hatchery fish.

Coho Salmon (Redwood Creek): Currently coho salmon are in steep decline and are at risk of being lost from the Redwood Creek Watershed. As in Lagunitas Creek, Redwood Creek coho salmon reached a low point in 2007—2008 when only four adult fish were observed. However, unlike their northern neighbors, Redwood Creek coho have not rebounded. In an effort to save the population, the California Department of Fish and Wildlife (CDFW) collected juvenile coho in 2014 and 2015 to be raised at the Warm Springs Hatchery and returned as adults starting in 2016—2017. Four mature males and three mature females from nearby Olema Creek were also planted in Redwood Creek in 2015—2016. Additional fish rescues are planned for 2016.

Steelhead Trout: Far more resilient than coho, and with more flexible habitat needs and lifecycles, steelhead trout appear to be relatively widespread in the streams of the One Tam area of focus. They have suffered, however, from the same anthropogenic impacts that have plagued coho, namely dam construction, stream channel alteration, and development. Steelhead trout along the central California coast were listed by the federal government as a threatened species in 2005.

Stickleback: Found throughout coastal drainages in North America, Europe, and northern Asia, the threespine stickleback appears to be abundant and widespread in the One Tam area of focus.

DESIRED CONDITIONS

Coho Salmon (Lagunitas and Redwood Creeks): Pacific salmon have evolved many mechanisms to persist in highly variable freshwater and marine environments, including high fecundity and recolonization of nearby streams should those populations be extirpated. Unfortunately, adjacent coho populations are too small to repopulate Lagunitas Creek in the event of a local catastrophe, so the Lagunitas Creek population will need to be large enough to persist indefinitely on its own. The creek's aquatic habitats will also need to support the diverse life histories of coho salmon (sometimes called "the portfolio effect"), which can provide resilience in a highly variable environment. The desired conditions for the Lagunitas Creek and Redwood Creek coho populations are therefore described below in terms of numerical targets for each coho life stage, as well as critical habitat conditions that support those life stages.

Steelhead Trout: Living in both estuarine and stream habitats that vary in depth, velocity, temperature, and shelter, steelhead are not as dependent on stream habitat conditions for survival as coho are. To persist indefinitely, steelhead should occupy more locations in the Mt. Tam area of focus and should migrate to the ocean in numbers sufficient to allow a viable number of adult steelhead to return each year and spawn.

Stickleback: A lack of stickleback in suitable, accessible stream habitats may be evidence of water quality or other

problems. For example, sticklebacks are currently being used as indicators of both hydrocarbon and hormone-disrupting chemical pollution. Locating places lacking stickleback can assist in identifying areas of past or ongoing environmental degradation. The desired condition for threespine stickleback is therefore their presence in suitable, accessible water bodies in the One Tam area of focus.

STRESSORS

Historic Hydrological Changes and Habitat Loss: Dam construction and loss of hydrologic connectivity between estuarine and stream habitats, and between creeks and floodplains, have affected the ability of anadromous fish to migrate between freshwater habitats and the ocean. Historic logging increased the amount of fine sediment that entered local streams, which smothered fish eggs and gravel nest sites (also known as "redds"). Removal of large woody debris and the reduction and modification of riparian and stream areas have all reduced the amount of habitat available to these species.

Current Hydrological Changes and Habitat Loss: Loss of spawning and rearing habitat continues to be a challenge to anadromous fish in the One Tam area of focus. Although much of their stream habitat in this area is on protected, open space lands, water withdrawals and extreme hydrologic and climatic events may still take a toll. Additionally, coarse sediment is being retained in reservoirs, which results in a finer, more mobile streambed that is not replenished. This, in turn, leads to channel incision and a loss of floodplain connectivity downstream. Reservoirs may also retain large woody debris and affect hydrological and geomorphic processes needed to support downstream salmonid habitat.

Ocean and Estuarine-related Factors: Anthropogenic changes are not limited to freshwater environments. Marine overharvesting of salmonids as well as their prey (e.g., sardines) reduces salmonid survival. Changes to ocean food webs related to climate change are also increasing threats to these species. Quality and quantity of estuarine habitats are also likely affecting Redwood Creek coho salmon, though recent restoration at Muir Beach has been aimed at improving habitat conditions there.

Invasive Species: The potential invasion of exotic mollusks such as the New Zealand mud snail (*Potamopyrgus antipodarum*) could cause changes to benthic macroinvertebrate communities and impact the salmonids' diet. The spread of invasive Japanese knotweed (*Fallopia japonica*), periwinkle (*Vinca* spp.), and invasive ivy species could suppress native riparian vegetation and insect production, and could also alter streambank dynamics.

Climate Change: Coho salmon in the One Tam area of focus are at the southern edge of their global distribution and are highly vulnerable to increases in water temperatures resulting from climate change. Longer droughts and more intense rainfall, as predicted by climate change models, would negatively impact all the species considered here. For example, longer or more intense droughts mean lower baseflows to sustain creek spawning and rearing habitats. Increased frequency, intensity, and/or duration of flood events can increase sedimentation of spawning gravel and wash salmonids downstream in the absence of suitable refugia. Finally, as described above, disruptions in the ocean food web could impact all anadromous fish species.

METRICS AND GOALS

COHO Salmon (Lagunitas Creek)

Metric	Condition Goal(s)	Status
Metric 1 Coho salmon adult escapement (adult spawners and redds)	The number of adult coho salmon spawners in Lagunitas Creek must be 1,300 to be considered for downlisting from federally endangered to federally threatened, and 2,600 for delisting as defined by National Marine Fisheries Service (NMFS) recovery goals. The target numbers must be sustained for nine consecutive years to meet the standard per the NMFS 2012 recovery plan. Lagunitas Creek is one of 28 populations that would need to achieve specific population goals before coho in the Central California Coast Ecologically Significant Unit could be downlisted or delisted.	

Metric 2 Outmigrant coho salmon smolts	An average of 52,000 coho salmon smolts in Lagunitas Creek over nine years (three generations), with 5% marine survival based on nine years of data. This number of coho salmon smolts and marine survival rate would result in 2,600 adults and meet the adult recovery goal. This metric is also a useful way to look at overwintering survival of juvenile coho salmon and provide an indicator of watershed health.	
Metric 3 Juvenile coho salmon counts	An estimated 120,000 individual coho salmon fry in the Lagunitas Creek watershed based on a maximum density of three coho per meter and accessible habitat of 40 kilometers of stream.	
Metric 4 Wood loading	Wood loading will meet established criteria for the forest type: 300 cubic meters per hectare in redwood channels, and 100 cubic meters per hectare in hardwood channels.	

COHO Salmon (Redwood Creek)

Metric	Condition Goal(s)	Status
Metric 1 Coho salmon adult escapement (adult spawners and redds)	The number of adult coho salmon spawners in Redwood Creek must be 136 for downlisting from federally endangered to federally threatened, and 272 for delisting as defined by recovery goals. The target numbers must be sustained for nine consecutive years to meet the standard per the NMFS 2012 recovery plan. Redwood Creek is one of 28 populations that would need to achieve specific population goals before coho in the Central California Coast Ecologically Significant Unit could be downlisted or delisted.	
Metric 2 Outmigrant coho salmon smolts	An average of 14,000 coho salmon smolts in Redwood Creek over nine years (three generations), with 2% marine survival based on 10 years of data. This is the number of coho salmon smolts needed to meet the adult recovery goal for delisting. This metric is also a useful way to look at overwintering survival of juvenile coho salmon and provide an indicator of watershed health.	
Metric 3 Juvenile coho salmon counts	An estimated 27,000 juvenile coho salmon fry in Redwood Creek based on a maximum density of three coho per meter and accessible habitat of 9 kilometers of stream.	
Metric 4 Wood loading	The 2012 coho recovery plan identifies wood frequency recovery actions in Redwood Creek. For stream sections with bankfull widths less than 10 meters, wood loading should be 6—11 key pieces per 100 meters, while for sections with bankfull widths greater than 10 meters, wood loading would be 1.3—4 key pieces per 100 meters. This wood loading goal differs from the goal in Lagunitas Creek because Lagunitas Creek has its own wood loading target.	

Steelhead Trout

Metric	Condition Goal(s)	Status
Metric 1 Steelhead adult escapement (spawners and redds)	The number of adult steelhead spawners must be 38—78 in Redwood Creek and 2,600 in Lagunitas Creek in order for them to be taken off the endangered species list. The target numbers must be sustained for eight consecutive years (typically two generations) to meet the standard per the NMFS draft recovery plan.	
Metric 2 Stream occupancy	Increased distance of occupied stream habitat over existing conditions (currently approximately 52 miles)	
Metric 3 Outmigrant steelhead trout smolts	An average of 26,000 steelhead smolts in Lagunitas Creek over eight years (two generations), with 10% marine survival based on eight years of data. This number of steelhead smolts and marine survival rate would result in 2,600 adults and meet the draft adult recovery goal. In Redwood Creek, 780 steelhead smolts and 10% marine survival would result in 78 adult steelhead trout and meet the draft recovery goal.	

Threespine Stickleback

Metric	Condition Goal(s)	Status
Metric 1 Presence in suitable water bodies	Stickleback should occupy all suitable habitats within the One Tam area of focus.	

INFORMATION GAPS

Monitoring Data: Current monitoring targets coho salmon, but surveys could be expanded to build a more robust dataset for steelhead trout and threespine stickleback.

Fish Migration and Habitat: The timing and magnitude of salmonid movements between streams using Passive Integrated Transponder (PIT) tag technology would provide valuable information on habitat needs during multiple life stages. Expanding existing PIT tagging to steelhead trout would provide data on steelhead trout smolt emigration prior to the start of smolt trapping.

Pool Habitat: The availability of pool habitats was identified as an important metric for coho salmon. However, there is not consensus on what defines these habitats, how different kinds of pools are classified, or what the ideal frequency of pools along a stream should be. Developing site-specific criteria for pool frequencies using appropriate data (e.g., geomorphic, sediment loading, pool scour potential, roughness, large woody debris loading, etc.) would allow us to measure this important aspect of salmonid habitat health in the future.