Six-foot drop over Glennbrook Gulch Dam prior to removal. Photo by Ross Taylor.

California Fish Passage Forum

Barrier Removal Effectiveness Monitoring

Glennbrook Gulch Dam Removal Project

By Leah Mahan, NOAA

Background

The Albion River, a 43-square mile coastal river in Mendocino County, California, is identified as a high priority watershed for the recovery of State and Federally endangered Central California Coast (CCC) coho salmon and North Central Coast (NCC) steelhead. Glenbrook Gulch is a small tributary to the lower Albion River with a drainage area of about 1.5 square miles. In 2007, an earthen dam located 1,400 feet up Glenbrook Gulch (see photo above) was identified by Ross Taylor and Associates (RTA) during an inventory of stream crossings throughout the Mendocino District of California State Parks (RTA 2007) as a complete barrier due to a 6–7 foot drop over the spillway. Pre-project fisheries surveys indicated that no fish were present in the upstream channel or the pond created by the dam.

Project Purpose

The purpose of the project was to restore fish passage to Glenbrook Gulch by removing the earthen dam and allowing unimpeded passage for all life stages of other salmonids. California State Parks worked collaboratively with the California Geological Survey to design the dam removal project. Funding was acquired for the project in 2009 from the NOAA Restoration Center and the California Department of Fish and Wildlife. The Glenbrook Gulch dam was removed in September 2010 by California State Parks and local contractors, and the gravel and sediments stored upstream of the dam were left in place and allowed to re-distribute downstream naturally. During the summer of 2011, the California Conservation Corps placed 23 instream large woody debris (LWD) structures and rock weirs to improve salmonid rearing habitat and to retain mobilized substrate. Monitoring was led by RTA with help from Trout Unlimited during some monitoring events. Funding for project monitoring activities was provided by the NOAA Restoration Center.

Monitoring Timeline

Project Monitoring was conducted during the winter of 2009–10 through the summer of 2015. Removal of the dam occurred in September 2010. Monitoring is ongoing and will continue through the summer of 2016.

- Pre- and post-project channel longitudinal profiles and cross sections were collected upstream and downstream of the dam removal site between 2010 and 2013.
- Pre- and post-project pebble counts were conducted upstream and downstream of the dam removal site between 2010 and 2013.
- Spawner surveys were conducted each winter between 2009 and 2016 Juvenile salmonid surveys were conducted each July between 2009 and 2016.

PROJECT AT-A-GLANCE

Project Title: Glenbrook Gulch Dam Removal Project

Project Applicant: California Department of Parks and Recreation, Sonoma-Mendocino Coast District

Partners: NOAA Restoration Center, California Department of Fish and Wildlife, California Conservation Corps, California Geological Survey, Ross Taylor and Associates, Trout Unlimited Mendocino Redwood Company

Project funding provided by: NOAA Restoration Center, California Department of Fish and Wildlife

Groups Conducting Monitoring: Ross Taylor and Associates, Trout Unlimited, NOAA Restoration Center

Barrier Removal Completion Date: September, 2010

Project Location: Latitude: 39.264338, Longitude: -123.670131

Ecological Value: The Albion River, where Glenbrook Gulch is located, supports State and Federally endangered CCC Coho and Federally threatened NCC Steelhead steelhead.

Monitoring Purpose

We wanted to evaluate the rate and extent of juvenile and adult salmonid re-colonization of the previously blocked habitat in Glenbrook Gulch, and measure channel gradient and habitat changes upstream and downstream of the dam associated with stored sediment re-distribution after dam removal.

Monitoring Methods

Channel Longitudinal Profiles and Cross Sections

Between 2010 and 2013, a total of five channel longitudinal profile and cross-section surveys encompassing 2,350 ft. of channel were completed in conjunction with the Glenbrook Gulch dam removal project. About 1,100 ft. of channel was surveyed upstream of the dam location, and 2,250 ft. was surveyed downstream. The five channel profile surveys included one pre-project survey in 2010, one record survey immediately after construction in 2010, and three post-project surveys, in 2011, 2012 and 2013. In addition, five Glenbrook Gulch cross-sections were established and surveyed each summer between 2010 and 2013.

Pebble counts

Glenbrook Gulch's channel bed substrate was characterized between 2010 and 2013 using the Wolman Pebble Count method (Wolman 1954) as described by Harrelson et al. (1994). Pebble counts were made along five transects, with three transects located downstream of the dam removal project site. At each transect, 100 measurements were taken.

Winter spawner surveys

Spawner surveys were conducted for seven consecutive years starting during the winter of 2009–2010 and continuing through the winter of 2015–2016. Spawning survey methodology was consistent with Part IV of the California Stream Habitat Restoration Manual (Flosi et. al 2010), except mark-recapture on carcasses with hog rings and flagging was not conducted. Three surveys were typically conducted each winter and were timed to occur after storms had elevated stream flow to levels conducive for adult fish migration.

Summer juvenile fish distribution sampling

Juvenile Distribution Sampling was conducted with a backpack electrofishing unit and followed the NOAA guidelines for sampling ESA-listed salmonids (NOAA 2000). In 2014, dip nets were used to sample the pools.

Monitoring Results/Discussion

Physical and biological monitoring was conducted at Glenbrook Gulch between 2010 and 2016 to evaluate the fisheries and stream channel response to dam removal. The project aimed to restore coho salmon and steelhead access to blocked habitat, and improve spawning and rearing habitat for these species throughout Glenbrook Gulch. In addition, the project aimed to restore natural sediment transport upstream and downstream of the dam.

Based on the results of the biological and physical monitoring completed during the last six years, the Glenbrook Gulch Dam Removal Project has accomplished its intended purpose. The opened habitat has been recolonized by juvenile steelhead/coastal rainbow trout, and adult and juvenile coho salmon (Figure 6). Spawning and rearing habitat throughout Glenbrook Gulch has been improved. The distance of salmonid distribution upstream of the dam removal project has increased every year since dam removal (Figure 7), and has exceeded the estimated amount of habitat that would be opened when the project was proposed. Through biological monitoring, we learned that Glenbrook Gulch, including the newly opened habitat upstream of the dam removal site, is also serving as important non-natal rearing habitat for coho salmon. Natural redistribution of stored sediment upstream of the dam, coupled with installation of habitat structures downstream, provided a more diverse substrate size and configuration, and improved spawning and rearing conditions for coho salmon and steelhead.

The physical channel characteristics in Glenbrook Gulch, based on longitudinal profile, cross section and pebble count data, changed after dam removal. The 2011, 2012, and 2013 post-project channel profile surveys revealed that the channel head-cut was within the expected extent, and was eventually controlled by a LWD jam 600' upstream of the dam site that was exposed as the stored sediments behind the former dam location began to evacuate. After three post-project winters, the head-cut had not moved upstream of the LWD jam (Figure 1).

Table 1. Funding by source and dollar amount for the Glennbrook Gulch Dam Removal design, implementation, and monitoring effort.

Design/Construction Monitoring	$33,000	
California Geological Survey (CGS)	$16,500	Interagency Contract/Services
NOAA Restoration Center	$16,500	Grant funding for CGS design and construction monitoring
Implementation	$218,272	
NOAA Restoration Center	$60,858	Grant funding for dam removal
California Department of Fish and Wildlife	$157,414	Grant funding for dam removal, adjacent road decommissioning, LWD placement
Pre- and post- project monitoring	$124,084	
NOAA Restoration Center	$116,739	RTA via NOAA Fish Passage Monitoring Contract
NOAA Restoration Center/Trout Unlimited	$7,345	RTA via NOAA/TU Partnership
Total Cost of Design, Implementation and Monitoring	$342,389	

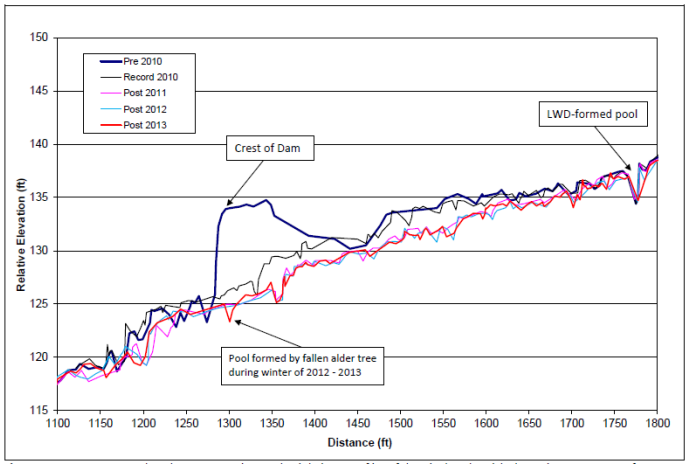

Figure 1. Pre-project, record, and post-project longitudinal thalweg profiles of the Glennbrook Gulch channel, 1,100 to 1,800 feet.

Pebble counts, longitudinal profile surveys, and direct observation by RTA confirmed the re-distribution of stored sediments downstream of the dam site in the 3 years following removal. The channel immediately upstream and downstream of the dam was initially aggraded with sediment, but has since down-cut (Figure 1). The habitat structures installed in 2011 have trapped spawning sized substrate throughout the reach downstream of the former dam site. Pebble counts between 2010 and 2013 documented a shift to smaller size particles downstream of the project site over time, providing for better spawning habitat, as evidenced by adult coho salmon utilization. Prior to dam removal, the channel downstream of the dam was dominated by bedrock and there were several chutes and jumps that could impede salmonid movement during low flows. By 2014, channel adjustments and aggradation from sediment transport downstream of the dam resulted in reduction of these drops, and made them much more passable. For example, what had once been an 18-inch drop near the confluence of Kaisen Gulch and Glenbrook Gulch, and the upstream bedrock chute was backwatered due to substrate deposition.

A pool was formed by the LWD jam located 600 ft. upstream of the dam, and this pool was immediately occupied by juvenile steelhead within weeks of dam removal. Also, in most of the years sampled after dam removal, juvenile salmonids were observed rearing in this LWD formed pool during July sampling. In the winter of 2012-2013, within the head-cut immediately upstream of the project, an alder tree fell across the channel, and on subsequent storms this tree captured additional wood and scoured a pool. The 2013 biological sampling found fourteen age-0 coho salmon rearing in this newly formed pool. Two of the three coho salmon redds observed upstream of the dam site since removal (in winter 2012-2013 and 2014-2015), were constructed in newly exposed or deposited substrate resulting from the project. In 2015, a coho salmon redd was found in substrate that had collected near a habitat structure installed downstream of the dam site as part of the 2011 in-stream restoration. These observations underscore the importance of in-stream features such as wood and boulders for creating spawning and rearing habitat.

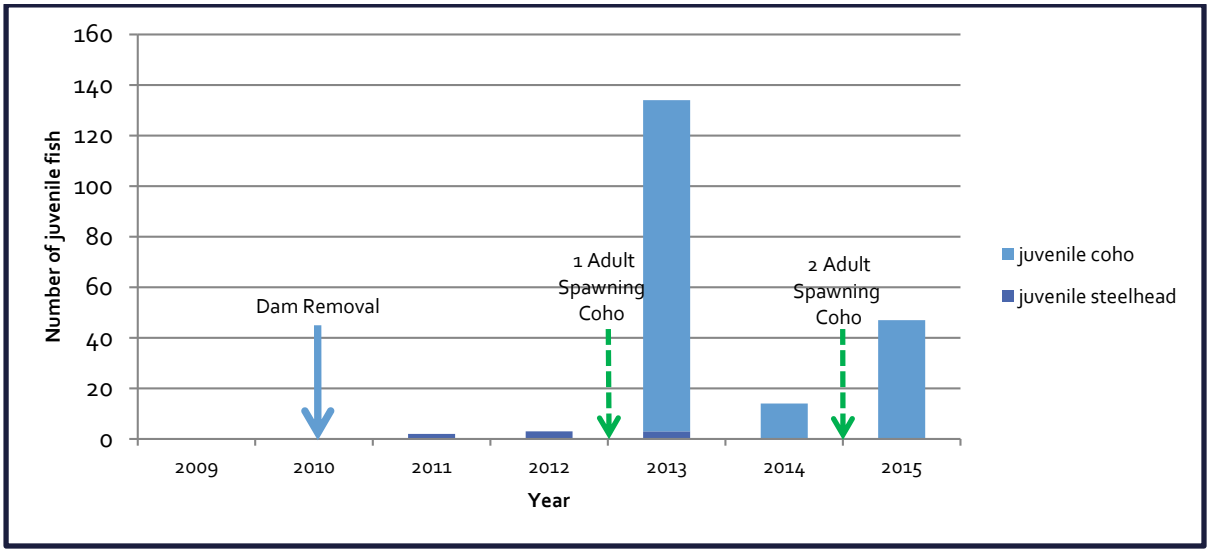

Figure 2. Number of juvenile coho and steelhead, and occurrence of spawning adults, upstream of Glennbrook Gulch Dam before and after removal.

Recolonization of the newly opened habitat was first accomplished by juvenile steelhead/coastal rainbow trout immediately following dam removal. Each year after project implementation, through the summer of 2013, steelhead/coastal rainbow trout were found further upstream than the previous year(s). Coho salmon adults returned to Glenbrook Gulch in the third and fifth winters after dam removal, and both times established redds upstream of the dam removal site in newly configured gravels. Abundant numbers of juvenile coho salmon were documented throughout Glenbrook Gulch each summer after spawning fish were observed the previous winter (2013 and 2015). To date, juvenile steelhead/coastal rainbow trout have recolonized 1,250 ft. of habitat upstream of the dam site, and juvenile coho salmon have recolonized 1,750 ft. upstream of the dam site. To date, adult coho salmon have spawned up to 2,200 ft. upstream of the former dam site (Figure 3). Two of the three coho salmon cohorts have re-established in the Glenbrook Gulch watershed as of July 2015.

During the first, second and fourth winters following dam removal (2010-2011,2011–2012, and 2013–2014), there was very little rainfall during December and January, and may have resulted in insufficient flows for adult coho salmon movement into Glenbrook Gulch. This observed absence of spawning activity in Glenbrook Gulch could have also been related to depressed Mendocino Coast adult coho salmon populations in general during these years. The winters of 2012–2013 and 2014–2015, when spawners returned, had frequent rain events during the period of coho salmon migration

that likely provided several opportunities for adult coho salmon to migrate into coastal rivers along the Mendocino Coast and access smaller tributaries for spawning.

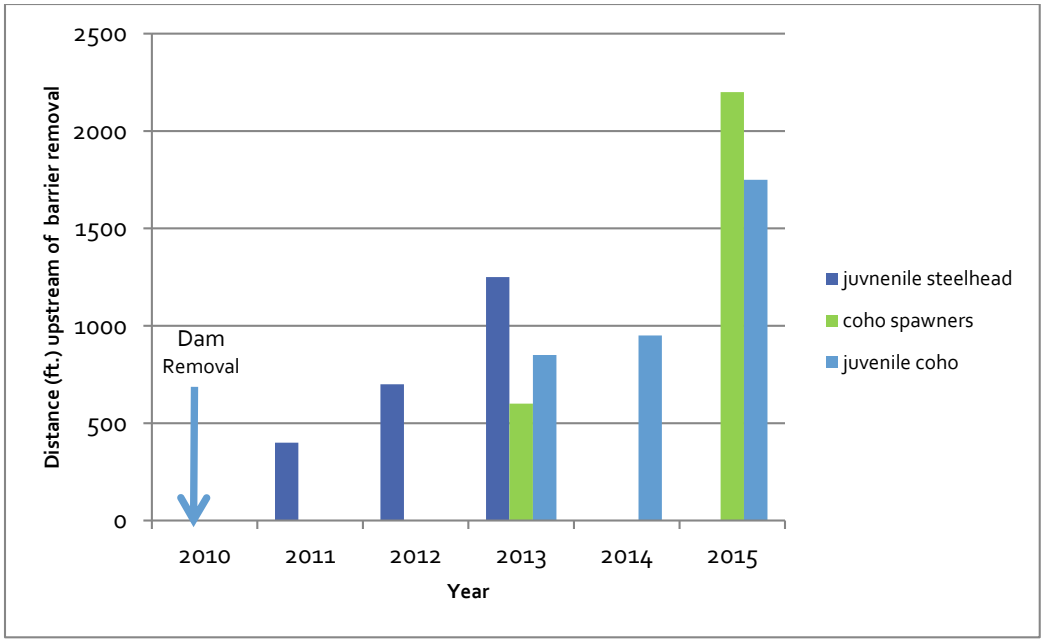

Figure 3. Distance (ft.) of juvenile and adult salmon and steelhead recolonization above the Glenbrook Gulch dam removal site after barrier removal in 2010.

One major challenge to achieving long-term viability of Glenbrook Gulch's coho salmon population is adequate over-summering streamflow; an issue facing many coastal northern California watersheds. The severity of several consecutive dry years has caused reaches of Glenbrook Gulch to either dry up or be reduced to isolated pools; resulting in direct mortality of juvenile coho salmon or significantly reducing growth rates and condition factors. The flow issue was further exacerbated in 2014 by a marijuana grow at the headwaters of Glenbrook Gulch upstream of the dam removal site. Glenbrook gulch was dry for long stretches, and algal growth was prevalent in pools exposed to the sun. RTA was unable to determine the extent of salmonid distribution in 2014 past 900 ft. upstream of the dam due to the active illegal marijuana grow on State Park lands. From observations at the furthest extent of the survey, RTA was unsure whether Glenbrook Gulch had surface flow and could support fish upstream of this location in 2014. A marijuana grow was also found in 2010 in the Glenbrook Gulch watershed, which likely resulted in summer low flow and reduced habitat as well. In two of the six years sampled (2010 and 2014), illegal marijuana growing was discovered within the watershed. This issue is prevalent throughout the north coast of California and is likely reducing available summer habitat for salmonids.

Although adult coho salmon did not spawn in Glenbrook Gulch until the third winter after project implementation ten juvenile coho salmon were found throughout the lower 900 ft. of Glenbrook Gulch (up to 500 ft. downstream of the dam site) in 2011, one year after dam removal. It is likely that these fish entered Glenbrook Gulch from the Albion River because no adult coho salmon or completed redds were observed in Glenbrook Gulch during the 2010-2011 spawner surveys. This demonstrates the importance of these small coastal tributaries for non-natal rearing, and documents juvenile coho salmon movement into Glenbrook Gulch from other parts of the Albion River.

In the past, fish passage restoration projects were primarily focused on achieving adult passage to upstream habitat, and design standards and measures of success were focused on how the project would accommodate adult returns. More recently, juvenile passage has gained higher importance and most fish passage projects are designed to meet both juvenile and adult passage needs, wherever possible. Glenbrook Gulch studies shed light on the role this and many other small coastal tributaries play in spawning, juvenile rearing, AND non-natal rearing of coho salmon. Current fish passage efforts should consider all three of these life cycle needs in the context of the local river basin when prioritizing, funding and implementing projects.

This project aimed to open 0.66 miles of habitat for coho and steelhead and restore channel function, gravel quality and habitat complexity. The project addressed important recovery actions for both of these listed species. To date, it has opened 0.68 miles for coho salmon and 0.23 miles for steelhead. The upstream extent of recolonization is likely limited by water availability and spawner access. Each year, juvenile salmon have moved further upstream of the dam removal site (Figure 7). Future monitoring will observe further recolonization and habitat utilization in the Glenbrook Gulch watershed.

Another major benefit of the project is that it restored habitat complexity downstream of the dam. Sediments released from the dam removal were sorted and trapped in habitat structures downstream, which improved spawning and rearing habitat, and passability in lower Glenbrook Gulch. These are all important actions that address the limiting life stages of both coho salmon and steelhead. Results show that the restored habitat was utilized by all life stages of each of these species.

Planning/Implementation Considerations for Future Projects

- Winter and summer streamflow for access to, and out of spawning and rearing habitat is should be considered as part of evaluating project priority and expectations.
- Projects should consider juvenile natal and non-natal summer and winter rearing habitat in addition to adult spawning habitat when prioritizing, implementing and monitoring fish passage projects.

- Channel controlling features such as large wood and boulders upstream of barrier removals can minimize headcut and provide habitat for recolonizing fish.
- Barrier-related sediments can be beneficial to downstream habitat if they contain properly sized gravels and are trapped and sorted by downstream habitat complexity.
- Consider pairing barrier removal projects with restoration of downstream habitat complexity where possible.

Monitoring Considerations for Future Projects

- Summer drought conditions, or lack of winter flow during spawning season can limit monitoring data and fish presence after barrier removal in California. If possible, monitoring should be planned for at least two years pre-project and three years post project to span environmental variability over time.
- Coupling winter spawner surveys with juvenile distribution surveys is invaluable for observing how salmonids are utilizing the habitat throughout their life cycle.
- Monitoring professionals should record visual observations about the watershed or the fish, in addition to quantitative data. These visual observations, such as what RTA provided, can be used to put together more of a long-term understanding than if the data were compiled on its own.
- It is beneficial to hire salmonid monitoring professionals for spawner and juvenile surveys as they will notice and understand more of what they observe.
- It is important to establish a consistent project benchmark so that all topographic surveys can be compared to one another.

Pond upstream of former Glennbrook Gulch Dam prior to removal. Photo by Ross Taylor.