Habitat Enhancement in The Salmon Creek Estuary

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Cover photo

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Photo by Brian Cluer

Introduction

The purpose of the Salmon Creek Estuary Habitat Structures Project (Project) is to improve aquatic habitat in the lower Salmon Creek estuary (above photo) through installation of large wood structures and floating willow rafts. The instream habitat structures will provide refuge areas for salmonids and other aquatic species during high flows and cover from predation during low flow periods. Funds have been provided by the State Coastal Conservancy, California Department of Fish and Game (CDFG), Redwood Empire Chapter of Trout Unlimited (RETU), and The Nature Conservancy and NOAA Community-Based Restoration Program for permitting and design, transportation of project materials, construction, and monitoring.

Project work included installing 12 boulder/rootwad clusters in a 1,000-foot reach immediately upstream of the mouth of Salmon Creek. Floating willow mats were constructed by volunteers and attached to the structures in the late spring to provide additional shade and cover for juvenile salmonids.

Project Background

The estuary habitat improvement project is part of a larger effort to address the decline of salmonid runs and implement an integrated, effective restoration strategy in Salmon Creek

(figure 1), a tributary to the Pacific Ocean in western Sonoma County, California,. Salmon Creek, like many of California's coastal streams, has lost its coho salmon *(Oncorhynchus kisutch)* run in the last 10 years and is left with a dwindling steelhead trout *(Oncorhynchus mykiss)* population. Restoration efforts have been spearheaded by the Salmon Creek Watershed Council (SCWC), Occidental Arts and Ecology Center's WATER Institute (OAEC), Gold Ridge Resource Conservation District (GRRCD), Sonoma County Agricultural Land Preservation and Open Space District, Bodega Land Trust, Trout Unlimited, State Parks, private landowners, consultants, and regulatory agencies.

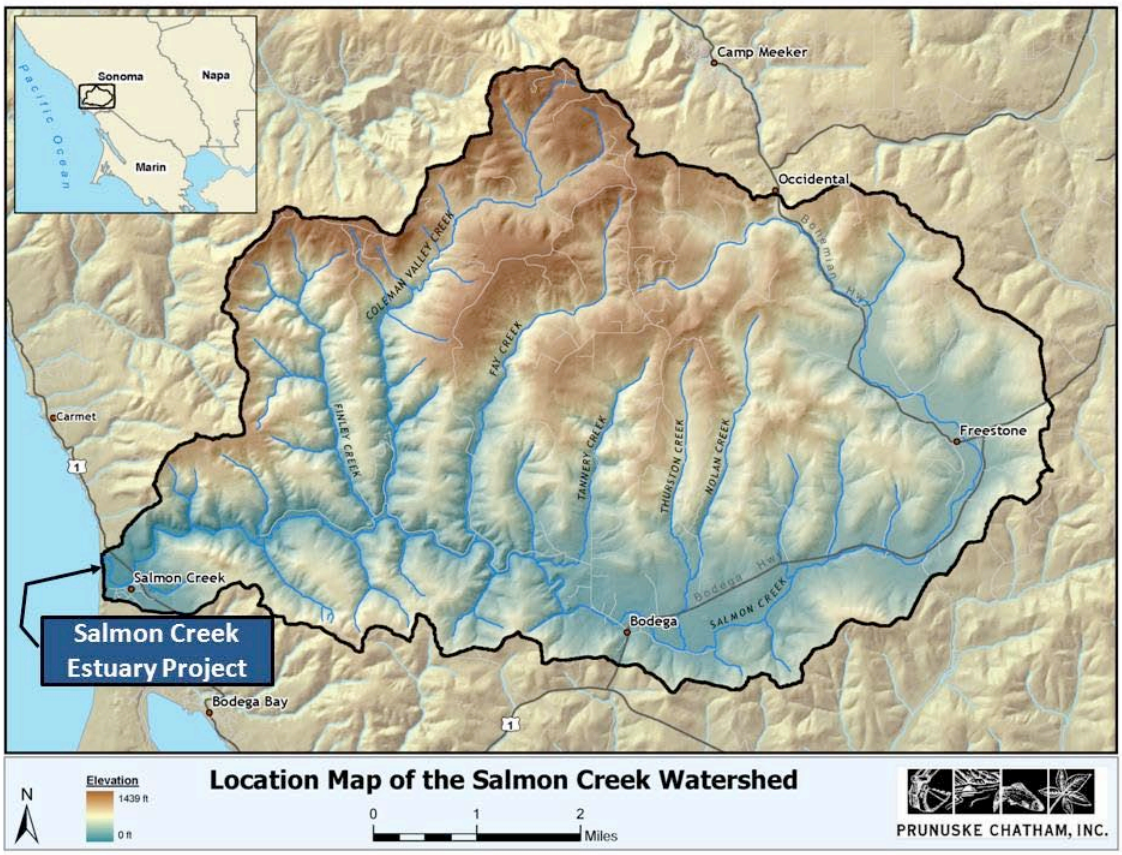

Figure 1. Location of Project area. The Salmon Creek Estuary is approximately 1 mile north of Bodega Bay, Sonoma County, California.

Research indicates that estuaries play a critical role in the life cycle of salmonids in the small coastal streams of northern California. Multiple studies indicate a direct relationship between the rapid growth of juveniles that occurs in coastal estuaries, which results in greater size upon entry to the ocean, and higher rates of marine survival and return. Important habitat features in estuaries for anadromous fish and other aquatic species include side channels, substrate complexity, and adequate woody debris for cover.

Estuarine habitat is particularly important in systems like Salmon Creek where upstream habitat is degraded or absent during the summer and early fall. In areas with poor summer rearing habitat or during drought years, juveniles will emigrate downstream seeking supportive habitat. If suitable habitat in the estuarine lagoon is unavailable, or of poor quality, the portion of the annual production of juveniles and smolts within the estuary may perish.

In 2006 the *Salmon Creek Estuary Study Results and Enhancement Recommendations* was completed by Prunuske Chatham, Inc. (PCI) for SCWC and OAEC. The objective of the studies conducted for the report was to evaluate how the estuary is functioning as related to salmonid habitat needs. Data was collected over a two year period to document hydrodynamics and water quality relationships, including topography, water surface elevations, temperature, dissolved oxygen, and salinity. Biotic monitoring of the estuary to document fish use was conducted over the same period. In addition, historical information was gathered and oral history interviews were conducted, to evaluate changes to the estuarine system over the previous 100+ years.

The following findings from the *Salmon Creek Estuary Study Results and Enhancement Recommendations* report *(PCI 2006)* outline the need for a large wood project in the estuary:

- Many juvenile steelhead trout (likely in the thousands) migrate from the upper watershed to the Salmon Creek lagoon in the late summer/early fall and congregate near the mouth where the water remains mixed and cool.
- During drought years, a large complement of the watershed's annual salmonid production may become trapped in the shallow, open area due to upstream channel disconnection and inhospitable water quality conditions in other areas of the estuary.
- Predation by pelagic birds reduces fish populations in this critical habitat, with up to 100% predation occurring during drought years.
- Changes to estuary conditions over the last 80 years, such as siltation and disconnection of tidal channels, reductions in summer inflows from upstream water use, and removal of in-stream habitat such as large woody debris have severely degraded the quality of habitat in the lower lagoon.
- Lack of shelter elements, including deep water and large wood features, creates conditions where salmonids are particularly vulnerable to predation, especially during drought years.

Large wood structures have been installed in the estuaries of the Mattole River in 2002 and 2007 and the Carmel River in 2006 to provide habitat complexity and cover. Monitoring of the Mattole River structures since installation indicates high utilization by juvenile salmonids and lower water temperatures. The structure installed in the Carmel River lagoon was immediately utilized by juvenile steelhead.

Project Goals

The following are the four goals of the Project and the reasoning behind the goals:

1. **Provide critical, protective habitat and shelter for juvenile salmonids that have migrated to the Salmon Creek estuary to complete the rearing cycle before entering the ocean.** Beneficial water quality is found in the reach near the mouth along the beach. Juvenile and adult steelhead were found to cluster in this reach in the late summer and early fall in anticipation of the sand bar breaching. Low water depths and lack of cover contribute to high predation of smolts, with nearly total mortality of the watershed's annual smolt production likely occurring in drought years.
2. **Increase the annual production and survival of salmonid smolts from the Salmon Creek watershed and ultimately the number of returning adults.** Providing necessary cover and territorial feeding habitat will reduce predation and increase the number of estuary-reared smolts entering the ocean. The result, it is hoped, will be an increase in the number of adult returns. Estuary-reared smolts tend to be significantly larger than their tributary-reared cousins, and consequently larger percentages of estuary-reared smolts survive in the ocean and return to spawn.
3. **Expand and improve upon the estuary LWD habitat-enhancement work done in the Mattole and Carmel Rivers' lagoon/estuary systems.** The Salmon Creek estuary provides an ideal location to utilize the knowledge gained from these recent habitat development projects and to implement a larger-scale project that will increase the regional restoration experience and success in this historically ignored, critical coastal habitat.
4. **Promote education and awareness of salmonid issues and the estuarine environment in a highly visible and public location.** The Salmon Creek estuary is located within Sonoma Coast State Park and is adjacent to one of the most heavily visited beaches in northern California. The project will provide a unique opportunity to educate the public about the sensitive resources that occur in the area, including the species that are the subject of this consultation. Further, the project will utilize local volunteers to build seasonal, floating willow rafts for additional cover and habitat improvement.

PROJECT PROCESS

Funding

Project proponents began seeking funding for this project in early 2006 while the *Salmon Creek Estuary Study Results and Enhancement Recommendations* report *(PCI 2006*) was being finalized. Ultimately, it took more than two years, multiple meetings with funders and regulatory agency staff, and several rounds of funding applications to secure the three grants from different agencies (State Coastal Conservancy, California Dept of Fish and Game, and TNC/NOAA's Community Based Habitat Restoration Program) that were needed to design,

permit, construct, and monitor the project. Full construction funding was secured for the project by July 2008.

Permitting

The permitting process was grueling. Permitting for the project took two years and ended up delaying the construction, as complexities with the project surfaced related to special-status species protections, coastal zone permitting, and non-standard construction season requirements in the estuarine environment. Initially the construction was scheduled for February/March 2009. Due to unforeseen delays in the U.S. Fish and Wildlife Service (USFWS) Section 7 consultation process, requests for extensive revisions to the Project's Biological Assessment (BA) related to tidewater goby *(Eucyclogobius newberryi)* impacts, and the State of California's December 2008 stop-work-order limiting the use of project planning funds to finalize other permits, the Salmon Creek Estuary Habitat Structures Project was unable to go to construction in spring of 2009.

Additional consultation and permit requirements progressed through the 2009 California budget crisis, and it was expected that construction would occur in spring 2010. However, the USFWS consultation process and agreement on project details relating to impacts to tidewater goby and brown pelican *(Pelecanus occidentalis)* continued to stall the permitting process. Several other state and federal required ecological permits (i.e. Regional Water Quality Control Board, California Department of Fish and Game, NOAA Fisheries, and Army Corps of Engineers) could not be completed until the USFWS Biological Opinion (BO) was finalized. In addition, State Coastal Commission permits (a 1-2 month Coastal Development Permit consultation process) need to be secured after all other state and federal permits are acquired.

The USFWS consultation process held up permit and NEPA finalization such that construction could not occur in the February-March 2010 construction window. Multiple requests for refinements to the tidewater goby monitoring plan in the BA were requested by USFWS through November 2009. Final internal approval of the USFWS BO was not completed until February 26, 2010. The California Department of Fish and Game and the Regional Water Quality Control Board fast tracked their permit process after receiving the BO. However, the three-week NEPA process timeline could not be adjusted. NOAA Fisheries Service determined that the project action is consistent with the Coastal Zone Management Act (CZMA), and the State Coastal Commission permit was secured through the federal agency nexus. All permits and NEPA were finally secured summer 2010.

Large Wood Structure Construction and Installation

Once permits were in place the construction and installation planning began. Allowable installation periods were set by fisheries agency staff to limit potential impacts to salmonids and tidewater goby. The two installation windows were October and February-March. Several additional challenges included timing the installation to occur in-between storm events when low water stages occur and scheduling the specialized excavator capable of handling the size and weight of the structures. It was decided to pre-fabricate the structures on site in late fall 2010 so that they were ready for installation in early 2011.

Twelve boulder/rootwad clusters were fabricated on the Salmon Creek staging area sandbar in early December 2010. These clusters consisted of 3-4 boulders (1-2 tons each) and 1-4 large redwood or fir rootwads cabled and pinned together (see photos below). The cluster dimensions ranged from 6'-14' in diameter and 4'-6' high.

Photos by Lauren Hammack

The structures were installed in the Salmon Creek estuary on February 14th and 15th, 2011. Several challenges arose in setting a date. There were conflicting needs to wait for ideal site conditions (low flows, open mouth, low estuary water surface, no rain) to be present and to reserve/schedule the equipment necessary for the install (only one excavator of size needed in the area). Mid-February had been tentatively scheduled for the install. As the day approached conditions in the estuary were changing daily. It was decided to go forward with February 14th, as the equipment was available, heavy rains were forecast for later in the week, and our NOAA-TNC project manager, Boze Hancock, was slated to be in town. Unfortunately, site conditions were not ideal. The estuary water level was high; forcing changes in structure placement locations. As planned, the four large, single-rootwad clusters were placed in the estuary

narrows and three complex clusters were placed near the mouth below the beach parking lot (see photos).

Photos by Jim Coleman and Brock Dolman

Then came the unknown – transporting structures 100 feet out into the middle of the estuary, across saturated sand, in water depths up to 2-3 feet. Rubber construction mats were tied together and laid out as a track in the water to the preferred placement site. A cluster was hooked up and the excavator was driven out on the mats. Slight settling occurred but nothing alarming. The rootwad cluster was set and the excavator backed up and out of the estuary (see photos below).

Photos by Jennifer Michaud and Brock Dolman

Additional attempts to transport clusters out to the center of the estuary were made. Each time the excavator sank into the sand. Apparently the first trip out sent enough vibrations through the sand and clays along the shore that they, in essence, liquefied. Given the situation, it was decided to place the remaining structure material up at the narrows and at the lower section near the mouth.

The final distribution of the clusters is 6 in the narrows reach, 1 in the center, and 5 near the mouth (Figure 2). All were placed in locations that historically have been the deep channel areas. After placing the clusters, several logs, some with boulders attached, were added to create more complexity and link clusters together. The use of logs was originally intended as a primary structure element, but upon placement it was concluded that they did not add significantly to the structure function as the placement angles were limited by access. Thus, only 3 logs were added.

Photos by Brock Dolman

A large storm occurred the day after installation and the site has weathered many high flow events this spring. Baseline topographic surveys around the structures and as-built location mapping were completed after the initial storm event. The bolts and cables have been checked and tightened since installation. All remaining materials have been cleaned up and removed from the project area.

Figure 2. Final locations of large wood structures in the Salmon Creek estuary.

Willow Mat Construction

In April of 2011, Doug Gore of Dragon Fly Stream Enhancement led Redwood Empire Trout Unlimited (RETU) members, AmeriCorps and local watershed volunteers in constructing willow *(Salix spp.)* mat habitat structures in the Salmon Creek Estuary for the benefit of juvenile Coho Salmon and Steelhead. The willow mat structures were constructed on the beach, walked out to the Large Wood Structures described above, and secured using hemp twine. See photos below illustrating the procedure. The project biologist was on hand to make sure no salmonids or tidewater goby were harmed in the process.

For the most part the mats stayed in place through the summer, even after withstanding several late spring/early summer storms and high flows.

Photos by Brian Hines

Effectiveness Monitoring

Prior to project implementation a monitoring plan was developed and two primary objectives of the project were quantified for formal evaluation. The two primary objectives were:

1. Increase cover by at least 350 m^3 in the project area by 2010, and

2. Increase juvenile steelhead survivorship to 25% between July and mid-October in project site (during dry springs and summer) by 2011.

Additional monitoring data collected includes evaluating changes to estuary bed levels adjacent to the structures (i.e. measuring scour or deposition) and documenting fish presence and utilization of the structures. USFWS required evaluating the impact of structures on tidewater goby concentrations.

The construction delay to 2011 resulted in the two year post-installation monitoring program shifting to be pre-project and 1 year post-project monitoring. In both 2010 and 2011 the Salmon Creek lagoon levels remained high throughout the summer and fall. Under these conditions juvenile salmonids have access to good habitat in the upper watershed and the entire estuary, and thus are not clustered in the lower estuary where the structures were installed.

Construction biological monitoring was conducted during installation activities. Hand seining and snorkeling by agency-approved biologists occurred at each structure site immediately prior to installation. No fish were collected in the open estuary during the installation process. However, sampling of the overhanging banks in the narrows netted 17 tidewater gobies. This was the first time many of us have seen this endangered species that caused project delays. See photos below.

Upper left photo of juvenile steelhead smolt by Jennifer Michaud. Top right and bottom two photos, including tidewater goby in lower left, by Brock Dolman.

Biologic monitoring

Pre-construction biological data was collected in October 2010. Seine and snorkel sampling activities documented the utilization of the lower estuary by steelhead and other native fish. Seine pulls in the vicinity of the proposed structure locations netted over 100 steelhead smolts awaiting the lagoon's breaching (see photo above). No tidewater gobies were sampled.

Late spring and early summer rains produced an extremely wet hydrologic year in 2011, with streamflows remaining strong throughout the summer. The Salmon Creek estuary closed late this year and lagoon water levels were high all season. Although no detailed water quality measurements were collected, it is likely that freshwater inflows were sufficient to maintain excellent habitat conditions throughout the watershed and estuary, so salmonids were not restricted to the project area as they have been in past drought years.

On August 8, 2011, the early-season monitoring of the Salmon Creek estuary was completed by Michael Fawcett, private consultant, and Jennifer Michaud, Sr. Wildlife Biologist with Prunuske Chatham, Inc. (PCI). Water levels were moderately deep around the structures (5 to 7 feet), with the structures all partially visible. Monitoring was completed utilizing underwater snorkel observations. The survey was completed with each diver equipped with a mask, snorkel, wetsuit, and underwater flashlight. The estuary was surveyed from the downstream end to the upstream end of the project limits. Each habitat structure was surveyed. Between structures, open water and shoreline habitats were surveyed for comparison.

Observations of species utilization of the installed structures were limited due to poor water quality conditions and depths of the structures. Throughout the estuary, filamentous algae and *Ruppia* was abundant. All of the structures were in relatively deep water (approximately 5'). The most abundant and widespread species observed was threespine stickleback *(Gasterosteus aculeatus)*, especially around the structures. No tidewater gobies were observed around the structures. Thousands of gobies were observed along the shoreline in shallow water (approximately 12"), with concentrations greatest where aquatic vegetation is present. Small schools of shiner surf perch *(Hyperposopon ellipticum)* were observed; however, these were

not restricted to the structures. Due to their cryptic coloration, water depths, and poor water quality conditions, an accurate determination of salmonid usage around the structures could not be made.

The late-season monitoring was completed on November 3, 2011. Water depths had increased since the August sampling, with depths ranging from 7 to 10 feet and all structures fully submerged. Water visibility was poor, and thick filamentous algae around the structures further hindered fish observations. No fish were observed around the structures except for threespine stickleback schooling around the downstream cluster. Between the structures, in shallower water, mysids (shrimp-like crustaceans) were prevalent and a few tidewater goby were observed.

Topographic monitoring

Topographic baseline monitoring data was collected one week after the structures were installed. The structure locations and dimensions were surveyed, and the estuary bed immediately adjacent to and surrounding the structures was documented. A repeat survey was conducted in August 2011 to evaluate channel bed changes after high flows and evaluate structure stability. Preliminary analyses of the topographic survey data shows varying pockets of scour and fill around the structures. Depths in some locations increased by up to a foot, while commensurate aggradation amounts occurred in other locations. The structures appear to have been stable except for the single structure placed in the center of the estuary – this one appears to have rotated and shifted downstream.

Monitoring Results

The following is the analysis of the effectiveness of the project based on one year of monitoring:

1. **Increase cover by at least 350 m^3 (12,360 ft^3) in the project area.**
   The project provides 360 m^2 (3,872 ft^2) of cover in the project area, with water depths ranging from 1 to 3 meters (3 to 10 feet). The volume of complex shelter habitat provided by the project's wood structures is at least 360 m^3 (11,616 ft^3) and up to 1,080 m^3 (38,720 ft^3), depending on lagoon depth.

2. **Increase juvenile steelhead survivorship to 25% between July and mid-October in project site (during dry springs and summer).**
   Summer lagoon depths were much greater than in dry years (the target enhancement conditions) and water quality and habitat conditions throughout the watershed and lagoon were high. Biotic monitoring of the project area was inconclusive. Water depths hindered seine work, and poor visual conditions around the structures limited the effectiveness of snorkeling to track fish utilization. This survivorship parameter is only applicable in drought years.

Need for the large wood structures is most critical during drought years when available habitat for salmonids is limited to the reach adjacent to the beach bar and water levels are extremely low (1'-5'). During wet hydrologic years, such as 2011, the entire lagoon area is available and

water depths are supportive (6'-10'+). The lack of visual observations of salmonids around the structures in summer/fall 2011 should not be taken as an indication of ineffectiveness, as the juveniles are likely utilizing the more typical tidal-channel edge habitat in the upper estuary.

The table below summarizes the structures installed in the Salmon Creek estuary in 2011 and, generally, how the bed had adjusted adjacent to each structure at the end of one season of high flows. In actuality, each structure had areas of scour and fill in different locations around it. It is expected that patterns of scour and fill will vary annually depending on flood events, storm and tidal swells, and sediment delivery.

Structure (upstrm. to dwnstrm.)	Dimensions	Area	Group effective area*	Group effective length *	# of rootwads	# of logs	Average Bed Adjustment
#		Sq. Feet	Sq. Feet	Feet			
1	5x7	35	48	9	2		no change
2	10x14	140	525	35	1		scour
3	5x12	60			2		scour
4a	12x12	140	675	50	1		scour
4b	7x7	49			2		scour
4c	15x20	300			5	2	scour
5	12x14	168	224	16	3		fill
6	12x14	168	2400	120	4		fill
7	11x12	132			3		no change
8	11x15	165			4		no change
9	11x12	132			3		no change
10	7x30	210			2	1	scour

* effective refers to habitat area at edge of or between structures that is protected by proximity or willow rafts

Conclusions and Lessons Learned

There are many challenges associated with the funding, permitting, and installation of large wood structures for habitat improvement in coastal estuary/lagoon systems. Estuary enhancement projects are a relatively new realm for the California salmonid habitat restoration program, and thus there are not standard practices or understood associated costs and ecological impacts that come after years of implementation trials. Feedback we received from grant review committees indicated that they considered this project "experimental" and felt that the costs were high compared to large wood structure installations in upland waterways. The permitting process, size of the structures, material requirements, and installation equipment needs and challenges contribute to these higher costs.

Recent research on the utilization of coastal estuary/lagoons by salmonids is highlighting the importance in their anadromous lifecycle, and how the degradation of the estuaries has likely contributed to the decline of coho and steelhead populations. Little is known, however, about the population dynamics of, and interrelationships between, salmonids and other species in the estuaries. For example, the project was stalled in the permitting phase due to concerns that juvenile salmonids prey on tidewater goby, a federally-listed endangered species, and that promoting salmonid survival would have a negative impact on tidewater goby populations in the Salmon Creek estuary. Providing salmonids cover habitat to escape predation by pisciverous birds also brought up concerns that the project would deprive Brown Pelicans of a food source. Luckily, the Brown Pelican was delisted in December 2010 and we narrowly escaped having to quantify and mitigate those potential impacts. As in almost any habitat restoration project that seeks to improve specific habitat conditions for a particular species (often due to funding opportunities), the needs of other species come into question and perceived conflicts arise. For habitat enhancement project proponents the requirement to prove no long-term take to other listed species utilizing the same area is onerous and costly. Especially when there are few, or no, biotic studies that address the regulatory concerns. It highlights some problems inherent in the ESA regulation procedures – managing based on individual species versus balanced ecosystem dynamics or structure. In this project, researching and addressing these concerns added significantly to time and money spent during the planning and permitting phase, the construction project was delayed a year, and the effectiveness monitoring period was cut in half.

Constructing the large wood structures and their installation in the estuary environment also poses several challenges. Producing structures large enough to cover an area that provides significant habitat improvements requires a lot of very large wood and rootwads. Preferred wood type is redwood for its longevity, though other conifers such as Douglas fir can be substituted and may provide better habitat due to their more complex root balls. Sources for large rootwads are typically limited, and securing the volume needed for estuary projects may be problematic depending upon the project location. In watersheds with active timber harvesting activities material is likely more readily available. However, projects in more urbanized regions will need to set aside additional funds for purchasing and trucking wood materials in from distant supplies.

Unlike wood structures installed along channel margins in upland creeks, estuary structures cannot be anchored to secure trees along the bank or buried in floodplain banks. Thus, they must be attached to boulders or, perhaps, cabled and anchored deep into the bed sediments. The wood's buoyancy and the pressure forces of the flood flows must be overcome if the

structures are to remain in place. If not sufficiently weighted there is risk that the wood will float downstream out of the estuary or be rafted to shore. For example, each 6 foot diameter rootwad required 4 to 6 tons of rock for stability. Also, unlike wood installation in creeks, the estuary cannot easily be dewatered, and thus the boulders need to be attached to the wood prior to installation and moved as a unit into place. The weight of the wood and boulder complexes quickly overwhelms the capabilities of widely available heavy equipment.

Timing the installation is tricky, as previously mentioned. Periods of time when impacts to estuarine species will be minimal occur primarily during the winter high flow season in California. To place the structures safely out in the open water areas, the estuary must be open and have had sufficient flows to scour and drain the mouth, and incoming streamflows must be low (i.e. in-between storm events). There is no way to predict when a good window of opportunity will arise, and thus there must be a high level of flexibility in the access, equipment availability, and the contractor's schedule. Even if the timing is right, the potential for getting the heavy equipment stuck in the soft sediments of the estuary is high. In this project we used rubber construction mats to provide a flat, supported surface for the excavator tracks. Even with the mats, the excavator sank into the sand. However, they worked well in the drier wetland areas to protect the native vegetation. Steel plates may have worked better for going across the sand.

Ultimately the project was a success – 12 large wood structures were installed in the estuary, providing at least 3,800 square feet of complex habitat in the lower Salmon Creek estuary for juvenile salmonids to seek shelter in during drought years. Several years will be needed to fully document the effectiveness of the structure design and their utilization by the various fish species found in the estuary. This project taught the team that working in estuaries requires an abundance of patience, flexibility, perseverance, and support.

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Community Participants and Supporters
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Resources

Books and Reports –

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Salmon Creek Water Conservation Plan, OAEC WATER Institute, Prunuske Chatham, Inc. and Virginia Porter (2010). Available at www.oaecwater.org/salmon-creek-water-conservation/plan

Organizations Who Conduct Habitat Restoration In the Watershed -

Bodega Land Trust – www.bodeganet.com/landtrust/

California State Parks - www.parks.ca.gov/

Dragon Fly Stream Enhancement – Doug Gore (707) 527-2900 or trouthab@sonic.net

Gold Ridge Resource Conservation District – www.goldridgercd.org

LandPaths - www.landpaths.org/

Occidental Arts & Ecology Center's WATER Institute – www.oaecwater.org

Pacific Watershed Associates - www.pacificwatershed.com/

Prunuske Chatham Inc. – www.pcz.com

Redwood Empire Trout Unlimited – www.redwoodempiretu.org/

Salmon Creek Watershed Council – www.salmoncreekwater.org

Sonoma County Agricultural Preservation and Open Space District - www.sonomaopenspace.org/

Sonoma Land Trust - www.sonomalandtrust.org/