WASHINGTON STATE
RECREATION AND CONSERVATION OFFICE
Salmon Recovery
Funding Board

Reach-Scale Effectiveness Monitoring Program

Large Woody Debris Catalog

March 2011




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Prepared by

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1 INTRODUCTION

The installation of large woody debris (LWD) has been actively used as a stream restoration method throughout the Pacific Northwest to improve habitat conditions for salmon and steelhead, as well as other species. While thorough evaluation of the physical and biological responses to different installation techniques is still lacking for many regions, channel types, and biota (Roni et al. 2005), documentation of the effectiveness of some LWD projects can be found in scientific (Reich et al. 2003; Roni 2003; Kail et al. 2007) and organization/agency (Binns 1999) literature. However, information on the cost and specific approaches of LWD projects is often missing in the scientific literature. A collection of this type of information, combined with quantitative effectiveness monitoring results, may serve as a useful reference for project sponsors who are looking to implement effective projects for their specific habitat or waterway.

The Washington State Salmon Recovery Funding Board's (SRFB) Reach-Scale Effectiveness Monitoring Program has the goal of assessing whether projects have been successful in attaining their salmon recovery objectives and the success rate of different categories of restoration actions. Information collected between 2004 and 2010 as part of this Program includes data from 12 LWD projects implemented across the state using a variety of methods. These projects were also implemented across a range of stream and river sizes, from 1.3 meters to 34 meters wetted width. Data collected for each project included changes in channel form, as well as fish use in specific areas of the sample reach. These data were compared with the amount of wood placed at the sub-reach level to determine if there were correlations between the placement of wood, increases in pool depth, and the numbers of fish observed at the sub-reach level.

The data were summarized in project pages for each restoration site (see Appendix A). Information on stream size was included to allow readers looking for information that could inform their project design to identify projects that addressed similar habitat objectives and scales. In addition, the number of pieces of wood installed, the cost of the wood, and the project cost were included to help project sponsors determine if the approach used would be financially feasible for their situation.

1.1 LARGE WOODY DEBRIS PLACEMENT IN THE PACIFIC NORTHWEST

Wood plays a large role in stream channel complexity and function in the Pacific Northwest. Many of the functions wood plays in the streams are important for salmon habitat (IMST 2010). These include dissipation of stream flow energy; sorting of sediment; streambank protection and stabilization; pool, riffle and gravel bar formation; cover and refugia for aquatic organisms; habitat diversity due to increased channel complexity; and redirection of flow (Meehan et al. 1977; Bisson et al. 1987; Sedell et al. 1988; Maser et al. 1988; Gregory et al. 1991; Hicks et al. 1991; Reeves et al. 1993; Montgomery et al. 1995; Beechie and Sibley 1997; Bilby and Bisson 1998; McIntosh et al. 2000).

Historically, many streams in the Pacific Northwest were forested. Logjams within larger systems could be as long as 2 kilometers (Collins et al. 2002). Logging operations and faulty understanding of salmonid habitat needs led to removal of many of these logjams from many of the Pacific coast watersheds (Reich et al. 2003). Additional clearing and land conversion further reduced woody debris presence and recruitment in streams.

Where wood played a large role in directing flow and influencing channel complexity, the loss of its input into these systems resulted in simpler channel forms with fewer pools. In extreme cases, the loss of storing mechanisms for river substrate resulted in significant loss of the stream bed material, with the channel being scoured to bedrock (Roni et al. 2006). Such situations dramatically altered the biological function of the river, reducing spawning and prey habitat.

From a review of relevant scientific literature, it is clear that the restoration effectiveness regarding the use of in-stream wood placement to improve salmonid habitat varies considerably across projects. Studies such as Cederholm et al. (1997), Solazzi et al. (2000), Roni and Quinn (2001), and Roni (2003) demonstrated increases in juvenile coho salmon (Oncorhynchus kisutch) abundance following wood placement. In the Pacific Northwest, it could be argued that any wood placement is likely to better mimic the natural condition as rivers and streams in this area in general had high historical wood loads. The change over time in landscape and use, however, means that simply adding wood may not be enough. As the landscape has changed, additional factors such as adjacent land-use, erosion potential, and channelized systems have come into play when considering how wood placement will affect a river segment or system. Urban areas have still further factors to consider such as safety, pollution, and lack of additional recruitment or unsuitable substrates. Costs of implementation vary widely as well. A stream on harvested timber land will generally contain fewer design constraints, allowing placement to mimic natural jams and not requiring extensive engineering design to meet hazard prevention requirements. Urban settings or areas near infrastructure, by contrast, will generally require extensive engineering to prevent damage to bridges and avoid flooding impacts. In addition, in an urban setting additional wood recruitment often does not occur and thus placed wood functions as static structures. These immovable structures perform differently than "natural" logjams, which are expected to expand and contract and move downstream as streams and rivers shift through time.

While in-stream wood placement has been occurring for many decades as a method of restoration, monitoring the success of these structures has only been done over a broad scale within the last 10 to 20 years. Assessing the success of the restoration provides insight into how structures perform and why results might not be as dramatic as expected.

Cost evaluations for restoration activities compared to their relative success allow project sponsors, funding agencies, and regulating agencies to better assess the effectiveness of funding allocation. A 1988/1989 report evaluating in-stream fish habitat restoration structures in Klamath River tributaries investigated cost/fish for multiple in-stream structure designs. The results of this study showed that different structures and installation methods had significantly different costs per unit metric (Olson and West 1989).

1.2 MONITORING METHODS

The purpose of this catalogue is to present monitoring results from a variety of wood placement projects. The monitoring methods for the included projects follow the SRFB Restoration Effectiveness Monitoring Protocols, which utilize a Before-After/Control-Treatment (BACI) design. In most instances for this catalogue, only the before/after data is presented for the treatment reach, however analyses were conducted using the full BACI design and SRFB protocols. Projects were monitored before implementation, within 1 year of implementation, and then 3, 5, and 10 years post-implementation. No 10-year monitoring has occurred yet. The first Year 10 monitoring will occur in 2014.

Reaches were set up before project implementation using equally spaced transects upstream and downstream of a centrally located "x" site (see Figure 1). Wetted width, substrate, depth, and LWD counts were collected along the reach. Each transect (the distance between lettered locations) was divided into 10 equal distances and a thalweg depth measurement was taken at each of these subdivisions. Substrate and width information was collected at each transect and at the halfway point between them. LWD was counted and assigned to size classes for each transect. Fish counts (via snorkel survey or electro-fishing) were summed for each transect. Fish were recorded by species and length. Post-implementation, placed wood was tagged and Global Positioning System (GPS) coordinates taken for each placement location.

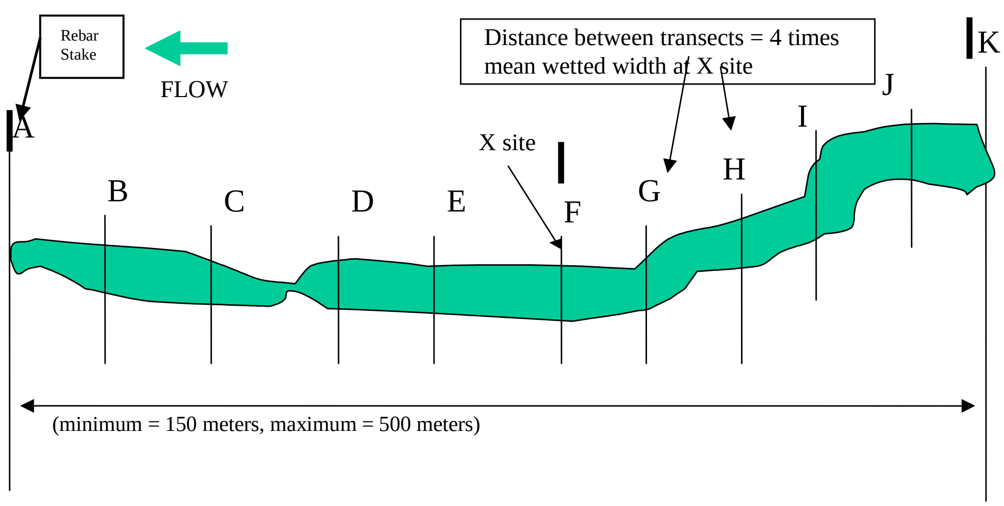

Figure 1. Diagram of Reach Layout

1.3 DISCUSSION

As other researchers (Roni and Quinn 2001) have found, effectiveness of the LWD structures was highly variable. Direction of change in monitored fish abundance varied across sites. Half (six) of the projects showed an increase in fish abundance over baseline as of the most recent monitoring action. Four projects showed a decrease in abundance and for two projects, the change in fish abundance was not able to be determined (Table 1). While project cost was not always indicative of increased fish abundance, projects over $400,000 all had increased abundance post-implementation. Most projects included additional restoration actions. For example, the most expensive project, 07-1803, included road decommissioning, channel bank reconstruction, and riparian planting in addition to LWD placement.

Table 1. LWD Project Monitoring Results for Reported Fish Species Abundance Change between Pre-Implementation Monitoring (Year 0) and the Most Recent Post-Project Monitoring Year: increase (↓), decrease (↑) or not able to be determined (--)

Project #	Most Recent Survey Year	Project Cost	Species	Change in Abundance
02-1444	Y5	$32,942	coho	↓
02-1463	Y5	$236,946	coho	↓
02-1515	Y1	$489,147	chinook	--
02-1561	Y5	$983,853	chinook	--
04-1209	Y1	$925,810	coho	↑
04-1338	Y1	$900,000	coho	↑
04-1448	Y5	$348,430	Steelhead	↓
04-1575	Y5	$378,940	Steelhead	↑
04-1589	Y3	$1,066,351	Steelhead	↑
04-1660	Y1	$892,993	chinook	↑
05-1533	Y3	$105,537	coho	↓
07-1803	Y1	$1,180,386	Steelhead	↑

Change in pool depth was estimated using the thalweg profile data and the residual pool depth calculations. Table 2 shows the direction of change in residual pool depth between the Year 0 values and the most recent post-implementation year (Year Code) surveyed. The "0" value is for the site where monitoring data were not collected in Year 0. The asterisk (*) indicates a site where the change in direction is from the Year 1 data due to the Year 0 data being in a dry channel.

Table 2. Change in Residual Pool Depth from Pre- to Post-Implementation

Project #	Year Code	Reach Length (m)	Channel size	Mean Residual Pool Depth (cm)	Change in Depth
02-1444	5	150	small	7.8	↑
02-1463	5	180	med	18.7	↑
02-1515	1	360	med	21.8	0
02-1561	5	360	med	20.5	↑*
04-1209	1	250	med	7.9	↓
04-1338	3	220	med	7.3	↓

Table 2. Change in Residual Pool Depth from Pre- to Post-Implementation (continued)

Project #	Year Code	Reach Length (m)	Channel size	Mean Residual Pool Depth (cm)	Change in Depth
04-1448	5	320	large	53.8	↑
04-1575	5	500	large	23.1	↑
04-1589	3	500	large	9.3	↓
04-1660	1	500	large	27.8	↓
05-1533	3	300	med	0.6	↓
07-1803	1	500	large	10.6	↓

Wood placement was not always maintained within the treatment reach. Some structures were installed without artificial anchoring methods; however, the majority of the LWD placement was installed with cables and anchoring with the intent that the wood would remain in place. When wood did move, it may have provided habitat and structural functions at its new location; however, once it was out of the treatment reach, effects were not able to be documented. Table 3 is a summary table of the wood quantity for the sites before and after treatment. Sites with more than one year of post-implementation monitoring show the change in wood quantity over time.

Table 3. Reach Characteristics and Wood Placement by Year for Each Project

Project #	Station	Year Code	Reach Length (m)	Wetted Width (m)	Bankfull Width Class (m)	# Pieces LWD	Pieces/100 meters
02-1444	IMPACT	0	150	1.19	0 to 6	0	0.00
02-1444	IMPACT	1	150	1.18	0 to 6	18	12.00
02-1444	IMPACT	3	150	1.18	0 to 6	16	10.67
02-1444	IMPACT	5	150	1.50	0 to 6	15	10.00
02-1463	IMPACT	0	180	5.25	6 to 30	32	17.78
02-1463	IMPACT	1	180	4.81	6 to 30	56	31.11
02-1463	IMPACT	3	180	5.44	6 to 30	84	46.67
02-1463	IMPACT	5	180	10.43	6 to 30	22	12.22
02-1515	CONTROL	0	150	4.07	6 to 30	50	33.33
02-1515	CONTROL	1	150	4.69	6 to 30	86	57.33
02-1515	IMPACT	1	360	12.19	6 to 30	155	43.06
02-1561	IMPACT	1	318	14.79	6 to 30	165	51.89
02-1561	IMPACT	3	318	1.73	6 to 30	82	25.79
02-1561	IMPACT	5	360	9.01	6 to 30	74	20.56
04-1209	IMPACT	0	250	5.66	6 to 30	23	9.20
04-1209	IMPACT	1	250	7.30	6 to 30	75	30.00
04-1338	IMPACT	0	220	9.19	6 to 30	66	30.00
04-1338	IMPACT	1	220	9.15	6 to 30	499	226.82
04-1338	IMPACT	3	220	5.93	6 to 30	310	140.91
04-1448	IMPACT	0	320	23.67	30 to 100	66	20.63
04-1448	IMPACT	1	320	40.85	30 to 100	54	16.88
04-1448	IMPACT	3	320	42.05	30 to 100	96	30.00
04-1448	IMPACT	5	320	29.40	30 to 100	170	53.13
04-1575	IMPACT	0	500	25.87	6 to 30	8	1.60
04-1575	IMPACT	1	500	22.46	6 to 30	211	42.20

Table 3. Reach Characteristics and Wood Placement by Year for Each Project (continued)

Project #	Station	Year Code	Reach Length (m)	Wetted Width (m)	Bankfull Width Class (m)	# Pieces LWD	Pieces/100 meters
04-1575	IMPACT	3	500	22.26	6 to 30	249	49.80
04-1575	IMPACT	5	500	20.42	6 to 30	235	47.00
04-1589	IMPACT	0	500	17.66	30 to 100	169	33.80
04-1589	IMPACT	1	500	16.99	30 to 100	452	90.40
04-1589	IMPACT	3	500	24.08	30 to 100	191	38.20
04-1660	IMPACT	0	500	21.73	6 to 30	36	7.20
04-1660	IMPACT	1	500	34.07	6 to 30	288	57.60
05-1533	IMPACT	0	300	13.47	6 to 30	13	4.33
05-1533	IMPACT	1	300	15.23	6 to 30	50	16.67
05-1533	IMPACT	3	300	13.81	6 to 30	29	9.67
07-1803	IMPACT	0	500	28.91	30 to 100	36	7.20
07-1803	IMPACT	1	500	29.73	30 to 100	76	15.20

This report only analyzed wood within the bankfull channel. A number of the projects in the analysis included wood within the floodplain. Floodplain placement may be done to increase roughness during flooding events and thus provide low-flow refugia for rearing salmonids. Floodplain wood may also reduce floodplain erosion and aid in the creation and stabilization of new side-channels. The current monitoring methodology reported in this document is not applicable for evaluating the effectiveness of floodplain wood in many cases. However, additional data collected during the SRFB monitoring protocols may catch some lateral migration effects using side-channel data collected during the thalweg profile assessment.

In summary, the results from this analysis are mixed. Some projects have shown clear indication of woody debris placement and pool creation or scour depths, while for other projects the relationship is unclear. Similarly, for some projects, post-implementation surveys indicated a strong relationship between juvenile salmonid abundance and wood placement. For other projects, fish abundance decreased post-implementation or abundance distribution did not appear associated with wood. Many of these projects included additional restoration activities such as channel realignment, riparian planting, and floodplain connectivity. While these aspects are important for restoration objectives, it makes interpretation of wood placement impacts difficult to separate from the impacts of other actions. Additionally, where watersheds are impacted by additional factors, wood placement may not show any beneficial effects until other limiting factors are reduced or removed. Finally, this catalog only looked at 12 projects that varied across stream type, size, and impact level. Additional projects would aid in assessing the cost-benefit analysis of these projects.

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APPENDIX A

PROJECT PAGES FOR EACH RESTORATION SITE

02-1444 Little Skookum Valley, Phase 2 Restoration

02-1444 Little Skookum Valley, Phase II Restoration

Project location: Little Skookum Valley Creek, which is a tributary to Skookum Creek at RM 5, in Mason County

Average wetted width: 1.3 meters
Reach slope %: 2.2
Reach sinuosity: 1.52
Channel Type: Pool-Riffle/ Rosgen: E4b

Project components: LWD, livestock exclusion fencing, riparian plantings

Project Sponsors: Mason Conservation District and South Puget Sound Salmon Enhancement Group (SPSSEG)

Contact: Lance Wineka (SPSSEG)

Project design/oversight: Squaxin Island Tribe consulted with SPSSEG

Approximate cost of project: $32,942

Project Setting

Within the project area, Little Skookum Valley Creek is a small stream that runs through a vegetated corridor surrounded on both sides by agricultural lands. The habitat within this portion of the creek has been degraded due to lack of riparian cover and large woody debris, and excessive invasive plant cover. The dominant riparian vegetation is reed canary grass. Additionally, the source of future wood recruitment has been dramatically reduced through past human activities. Historically, coho salmon used the reach extensively, but loss of habitat complexity and the presence of invasive species have reduced use of the creek by salmonids.

Project Description

The Little Skookum Valley project was designed to improve stream habitat in Little Skookum Valley Creek for salmonids and other resident species, with coho salmon being the target species. The project included:

1. Installing LWD;
2. Constructing riparian livestock exclusion fencing; and
3. Planting the riparian buffer with appropriate native plants.

Project Sponsor and Design Information

This project is sponsored by the Mason County Conservation District and the South Puget Sound Salmon Enhancement Group (SPSSEG). The primary contact person is Lance Wineka of SPSSEG. The Squaxin Island Tribe consulted with SPSSEG on project design and oversight. The approximate cost of the project was $32,942.

LWD Summary

This project involved the placement of 7 artificial instream structures within Little Skookum Valley Creek. With an average wetted width of only 1.3 meters, the size of the wood had to be scaled appropriately for a small stream environment. During the first year of effectiveness monitoring following project implementation, all of the naturally occurring and artificially placed large woody debris within bankfull of the project reach were documented. The distribution of all LWD diameter in Year 1 was as follows:

- 61 percent were less than 12 inches in diameter
- 33 percent had a diameter between 12 and 24 inches
- 6 percent had a diameter greater than 24 inches

Table 1 illustrates the distribution of LWD placed in Little Skookum Valley Creek.

Table 1. Distribution of LWD (Natural and Place) throughout Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	0	0
B-C	0	0
C-D	0	2
D-E	0	2
E-F	0	0
F-G	0	2
G-H	0	0
H-I	0	1
I-J	0	6
J-K	0	5

Thalweg Profile

Figures 1 and 2 show the thalweg profile within the project reach of Little Skookum Valley Creek during monitoring events prior to the project (Year 0) and following project implementation (Year 5). Although the sampling took place at a similar time each year, variances in water levels can cause variations in depth between years. These figures also show the counts for juvenile coho salmon observed by transect. Coho in Year 0 are generally associated with pools in the thalweg profile (Figure 2). Pool depths are greater in Year 5 and remain deeper after adjusting for flow differences (Figure 3). It appears that wood may be increasing pool depths in some of the placement locations. No coho were observed during the Year 5 monitoring event; nor were any observed in the Year 1 or Year 3 surveys.

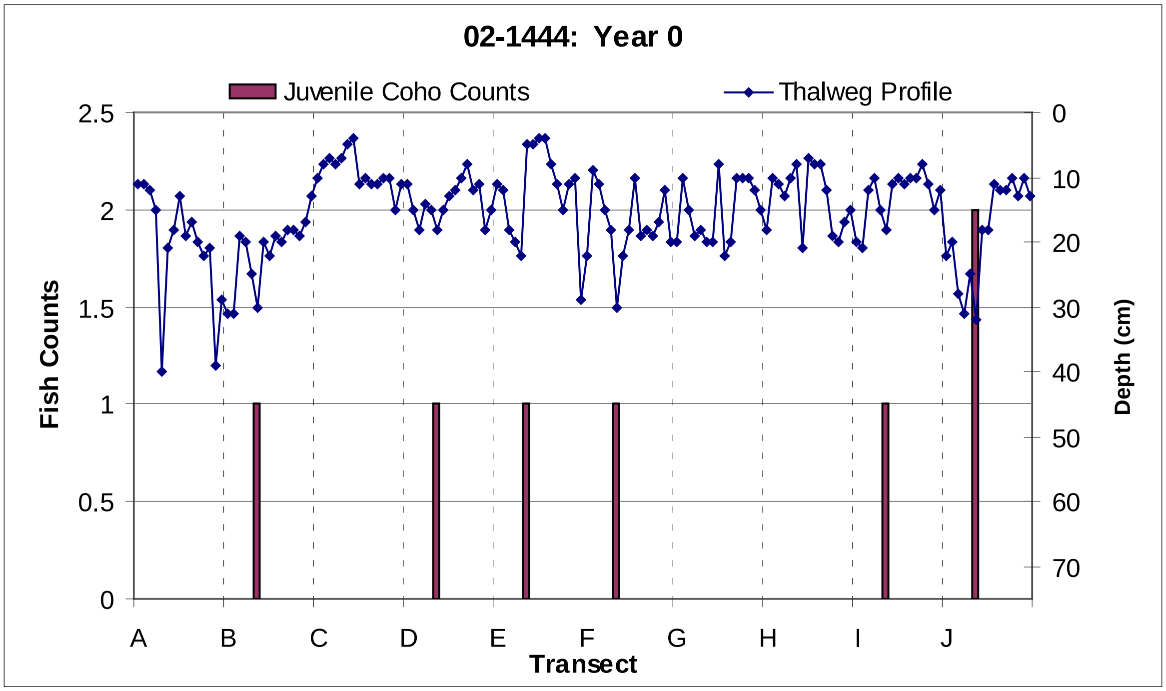

Figure 1. Thalweg Profile Cross Section and Coho Counts Pre-Project (Year 0)

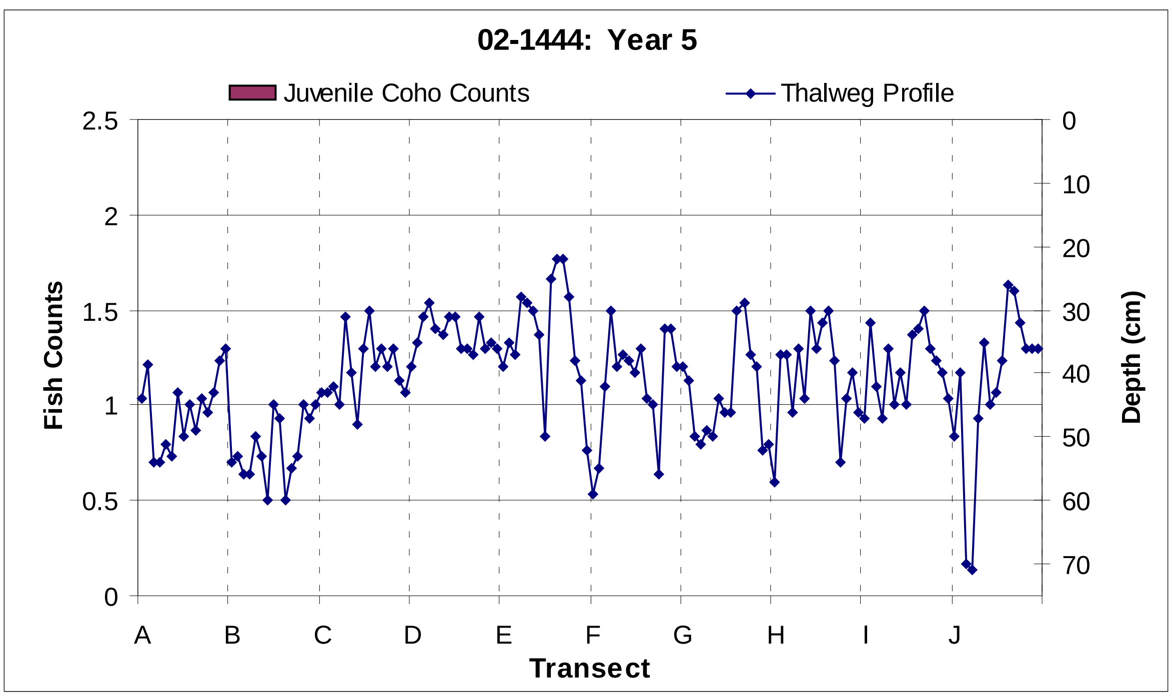

Figure 2. Thalweg Profile and Coho Counts in Five Years after Implementation (Year 5). No coho were observed.

02-1463 Salmon Creek Restoration

02-1463 Salmon Creek Restoration

Project location: Salmon Creek, within the Naselle River Basin, in Pacific County

Average wetted width: 6.5 meters
Reach slope (%): 0.63
Reach sinuosity: 1.2
Channel Type: Pool-riffle/ Rosgen: C4

Project components: LWD, Stream connectivity

Project Sponsors: Willapa Bay Fisheries Enhancement Group

Contact: Ron Craig
Approximate cost of project: $236,946

Project Setting

Approximately 6,500 feet of Salmon Creek were assessed to be lacking in sufficient large woody debris and sinuosity. The riparian zone is dominated by deciduous species including mature red alder and big leaf maple with few large coniferous trees capable of acting as key pieces within the stream. The proximity of an adjacent road had channeled parts of the stream and cut off the stream from the adjacent wetland. Decommissioning of the road was to be accomplished under a different project.

Project Description

This project was designed with the goal of improving salmonid spawning and rearing habitat within Salmon Creek. Chinook, chum, coho, cutthroat, and steelhead were all target species for this enhancement activity. The project included:

1. Re-grading the channel migration zone;
2. Reconnecting off-channel habitat; and
3. Placing LWD within the stream.

Road decommissioning activities were also conducted in the vicinity of this project.

Project Sponsor and Design Information

This project is sponsored by Willapa Bay Fisheries Enhancement Group, with Ron Craig as the primary contact person. Partners include the Campbell Group, DNR, and the Turnersville Horse Group.

LWD Summary

This project involved the placement of 13 artificial instream structures within Salmon Creek. Monitoring through Year 3 showed 12 of the 13 structures remained in place. The distribution of all LWD diameters in Year 1 was as follows:

- 35 percent were less than 12 inches in diameter.
- 47 percent had a diameter between 12 and 24 inches.
- 18 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of LWD by transect in the completed project in the year prior to and the first year after construction.

Table 1. Distribution of LWD (natural and placed) by Transect, Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	3	6
B-C	3	7
C-D	0	0
D-E	7	4
E-F	6	8
F-G	1	9
G-H	5	11
H-I	1	3
I-J	2	4
J-K	4	4

Thalweg Profile

Figures 1 and 2 show the thalweg profile within the project reach of Salmon Creek during monitoring events prior to the project (Year 0) and following project implementation (Year 5). By five years after implementation, pool depths have increased substantially, especially in transects A-B and E-F. These are transects that received wood treatment. These figures also show the counts for juvenile coho salmon observed by transect. The distribution of juvenile coho is similar both before and after the project, with slightly higher numbers of fish in the impact reach before the project. The distribution of juvenile coho is similar in both Year 0 and Year 5 survey data, with slightly higher numbers of fish in the impact reach before the project (Year 0). Juvenile coho appear to be correlated somewhat with pools in Year 0, while a slightly stronger correlation with the deeper pools may be present in Year 5.

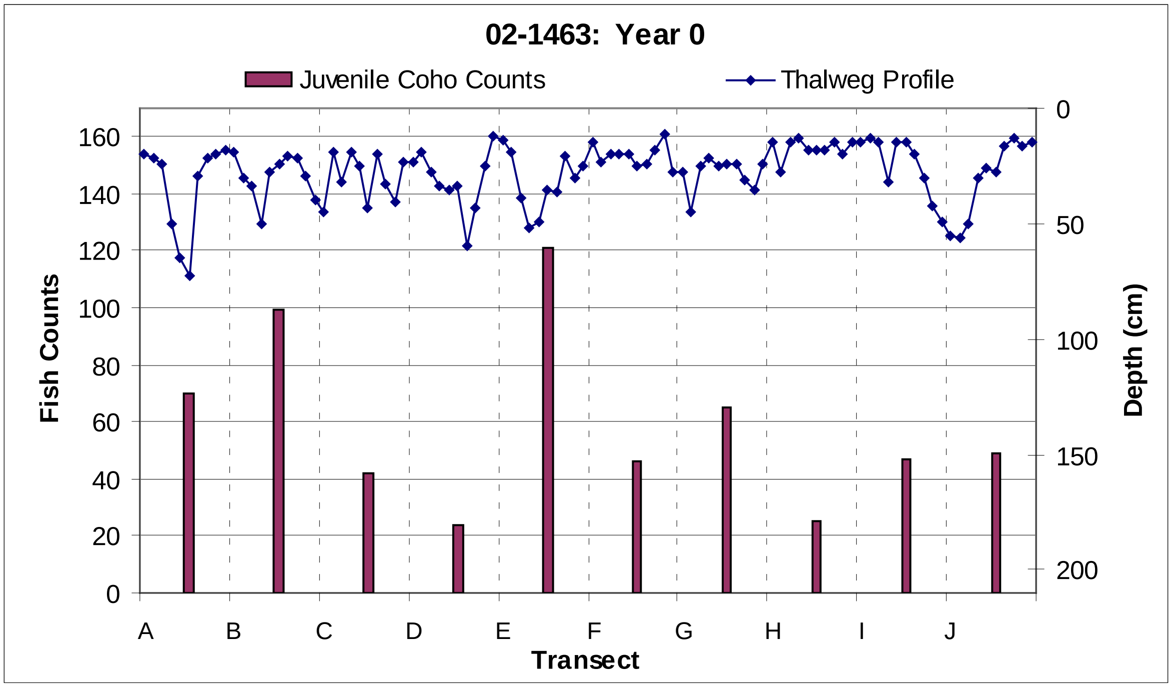

Figure 1. Thalweg Profile and Juvenile Coho Counts Pre-Project (Year 0)

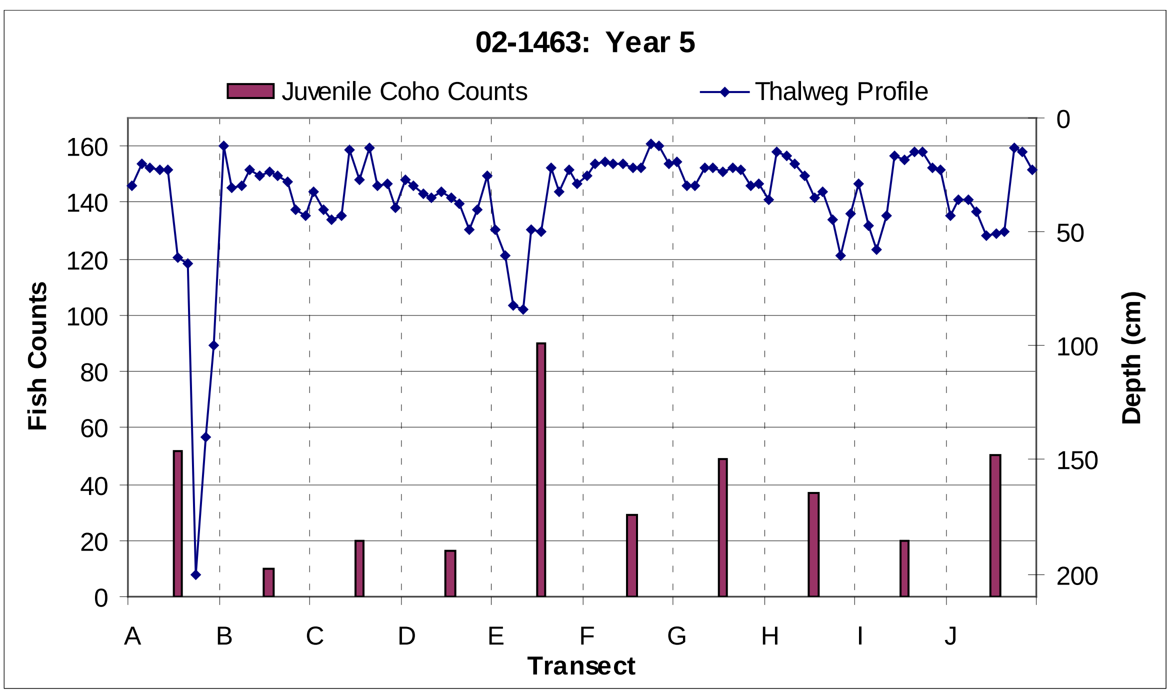

Figure 2. Thalweg Profile and Juvenile Coho Counts Five Years after Implementation (Year 5)

02-1515 Upper Trout Creek Restoration

02-1515 Upper Trout Creek Restoration

Project location: Trout Creek, within the Wind River Basin, in Skamania County.

Average wetted width: 12.5 meters
Reach slope (%): 1.1
Reach sinuosity: 1.1
Channel Type: Pool-riffle/ Rosgen: C4

Project components: LWD, riparian planting

Project Sponsor: Underwood Conservation District

Landowner: US Forest Service

Contacts: Brian Bair and Bengt Coffin

Approximate cost of project: $489,147

Project Setting

Trout Creek is a major tributary to the Wind River and is vital for the recovery of steelhead within the basin. Trout Creek provides a large quantity of spawning and rearing habitat for salmonid species. The Trout Creek watershed has historically supported approximately 20 percent of the entire Wind River's run of wild steelhead. Upper Trout Creek and tributaries were logged in 1948, and in the 1970s, logjams were thought to be migration barriers and were removed. These activities eliminated natural water velocity modification and sediment storage and instigated channel incision. As a result of logging, there was little shade provided to the stream, thus causing elevated water temperatures. Additionally, bankfull channel width-to-depth ratios became inappropriate, and bank erosion was occurring along a high percentage of the banks. Furthermore, the amount large woody debris (LWD) found in the stream was lower than target values. The Upper Trout Creek Rehabilitation Project was intended to improve habitat for wild steelhead by restoring riparian areas and channel stability in the Trout Creek drainage. Chinook salmon and cutthroat trout may benefit from this project as well.

Project Description

The Upper Trout Creek Rehabilitation Project was intended to improve habitat for wild steelhead by restoring riparian areas and channel stability in the Trout Creek drainage. This was accomplished by:

1. Placing LWD within the stream, and
2. Installing native plants within the riparian zone.

The target species for this project is steelhead; however, it is also expected to benefit Chinook salmon and cutthroat trout.

Project Sponsor and Design Information

The Underwood Conservation District sponsors this project and the USFS is the land owner. Brian Bair and Bengt Coffin are the primary contacts.

LWD Summary

The riparian understory was thinned and underplanted with conifer trees. Trees removed were used for construction of logjam revetments for bankstability and reducing the width to depth of the channel. An additional 1,600 trees were used to construct logjams as roughening elements. Six logjams were installed to stop channel downcutting.. The distribution of sizes for the total wood present in the project reach after construction was as follows:

- 39 percent were less than 12 inches in diameter.
- 34 percent had a diameter between 12 and 24 inches.
- 27 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of wood by transect across the project reach, post-construction.

Table 3. LWD Counts (Natural and Placed) by Transect for the Final Project Reach, Post-Implementation

Transect (Downstream to Upstream)	Number of LWD Pieces
	Year 1
A-B	16
B-C	17
C-D	41
D-E	56
E-F	2
F-G	1
G-H	2
H-I	1
I-J	19
J-K	0

Table 2 shows the distribution of wood in Year 0 and Year 1 in the control reach as a reference for wood load in un-modified areas of the system.

Table 4. LWD Counts by Transect for the Final Control Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 1	**Year 0**
A-B	4	0
B-C	2	0
C-D	3	1
D-E	2	2
E-F	3	1

Table 5. LWD Counts by Transect for the Final Control Reach (continued)

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 1	Year 0
F-G	12	1
G-H	16	6
H-I	14	0
I-J	9	2
J-K	21	4

In the two pre-implementation survey years, the monitoring reaches were located on Crater Creek (tributary to Trout Creek) and were 150 meters long; however, during project construction, the LWD was placed downstream of the sampling impact reach that had been established during baseline monitoring. Sampling reaches were revised in Year 1 to capture the placement of the wood. The Year 0 impact reach was changed to be the control reach, and a new impact reach was established on Trout Creek with a length of 360 m. There is no Year 0 data for the final impact reach, however information on the control conditions vs. the impact conditions can still be useful for interpreting results. The control reach is 150 meters long and the impact reach is 360 meters. Wetted widths differed between the two reaches as well; the wetted width for the control was 4.5 meters, and the wetted width for the project reach was 12.5 meters. These values should be taken into consideration when interpreting the comparative graphs.

Figures 1 and 2 show the depth profile and fish counts in the final control reach for Year 0 and Year 1 monitoring. Counts were much higher in the Year 1 monitoring data. Wood count also increased between the two years within the control reach. Wood increased the most in the upstream portion of the reach and fish were present in the four transects with the greatest wood counts, however the transect with the greatest increase in fish numbers had no increase in wood. Pool depths also appear to have increased some within the control reach.

Figure 3 shows the depth profile and fish counts in the impact reach for Year 1. The two transects (C-D and D-E) with the most wood also have the most fish present. A large amount of wood was also placed downstream of these transects, however, and no fish were observed. Very little wood was observed between E and I and no fish were observed in these transects. Pools appear to be deeper in this reach than in the control reach; however there is no pre-project data to determine if this reach naturally had deeper pools. One of the objectives of the project was to reduce the width/depth ratio in this stream. While the SRFB monitoring did not monitor bankfull measurements, wetted width and depth measurements for width and depth give a ratio of approximately 23. Subsequent monitoring years should show if the width to depth ratio in this stream is decreasing as designed.

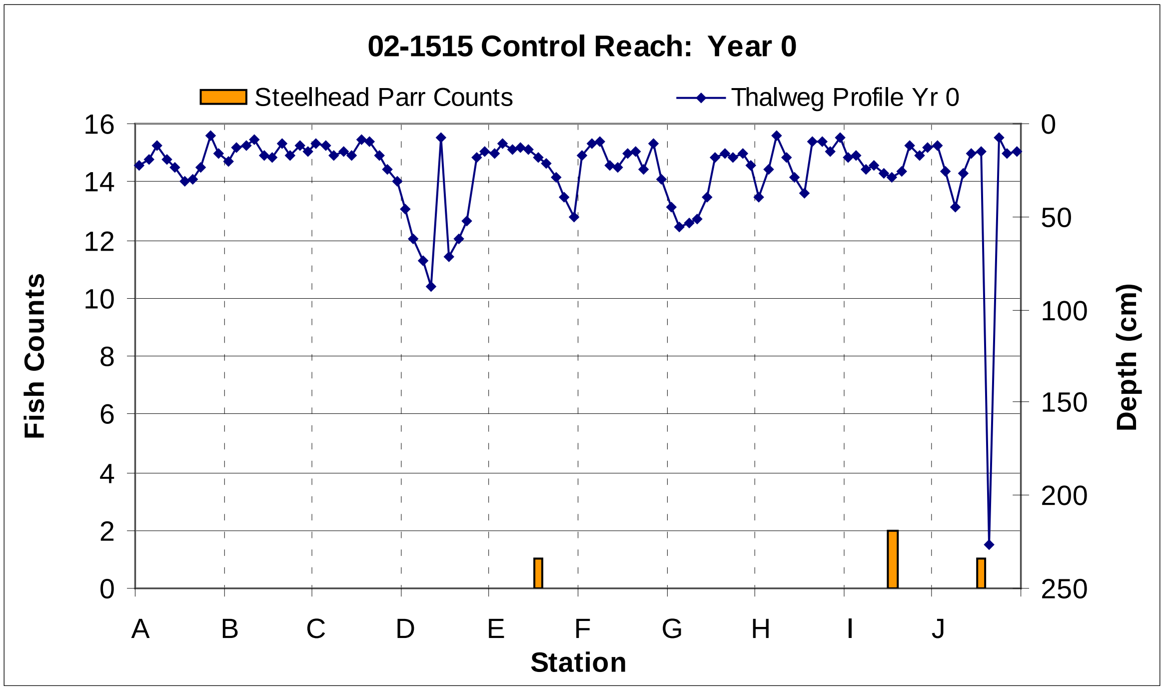

Figure 1. Thalweg Profile and Steelhead Parr Counts for the Final Control Reach Pre-Project (Year 0). The total reach length is 150 meters.

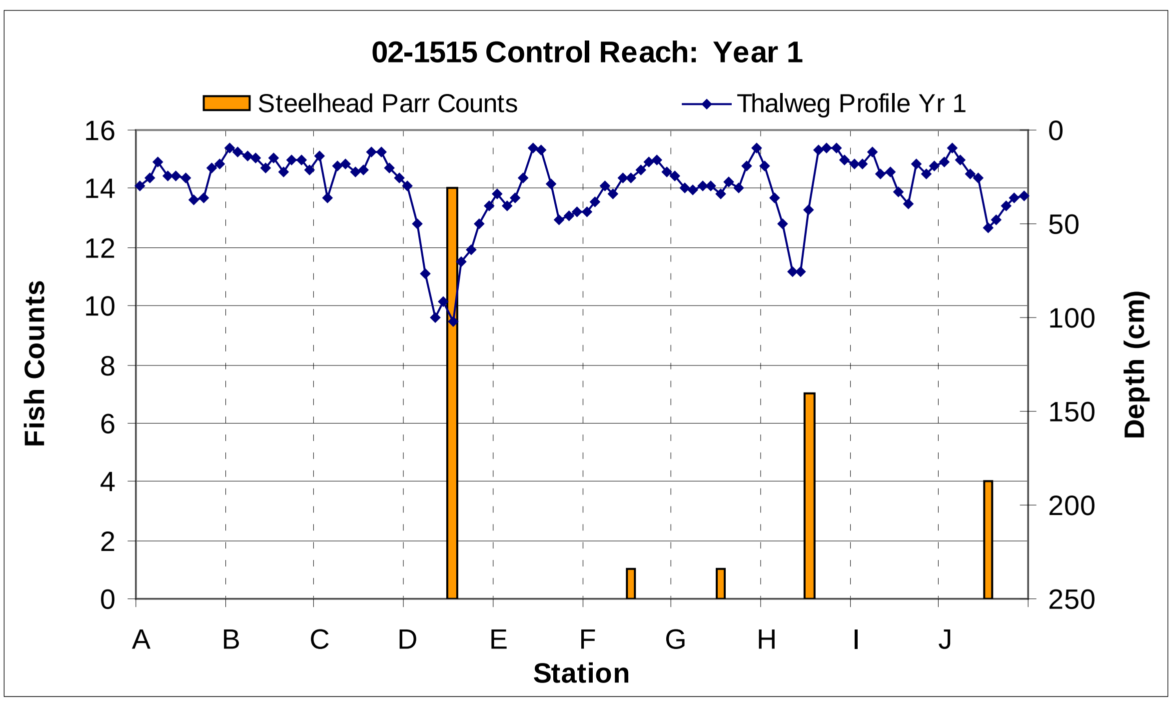

Figure 2. Thalweg Profile and Steelhead Parr Counts for the Final Control Reach Post-Project (Year 1). The total reach length is 150 meters.

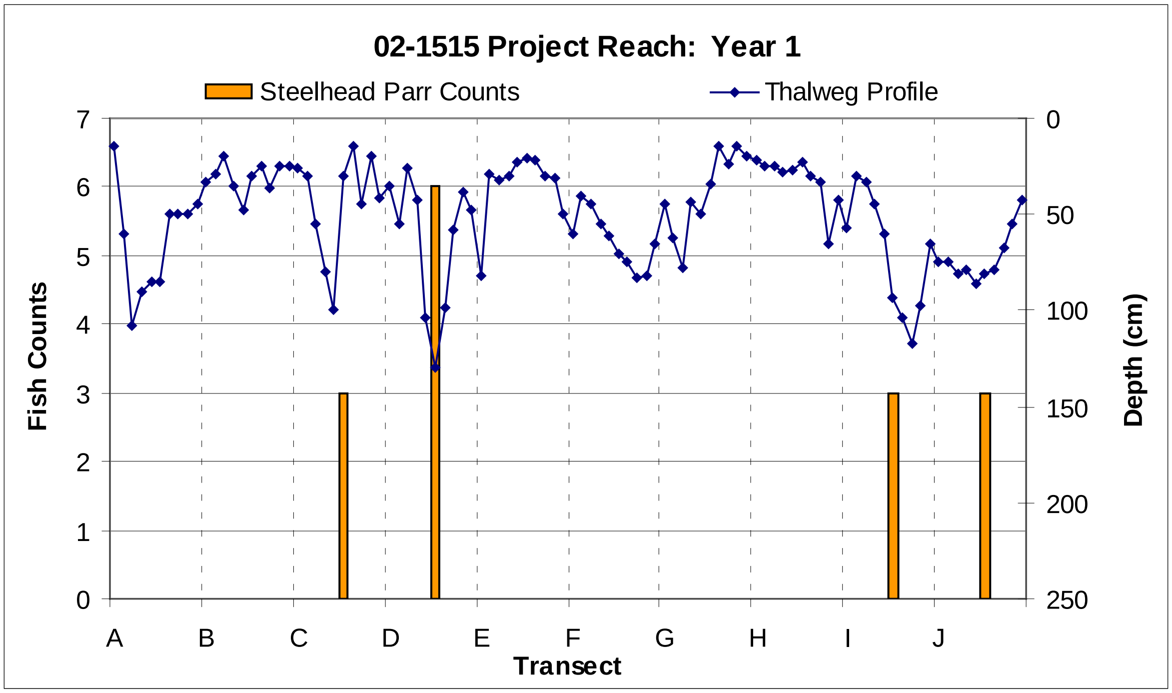

Figure 3. Thalweg Profile and Steelhead Parr Counts for the Final Control Reach Post-Project Implementation (Year 1). Total reach length is 360 meters.

02-1561 Edgewater Park Off-Channel Restoration

02-1561 Edgewater Park Off-Channel Restoration

Project location: Skagit River (WRIA 3), at Edgewater Park, in the City of Mount Vernon, Skagit County

Average wetted width: 6.5 meters
Reach slope (%): <0.1
Reach sinuosity: 1.2
Channel Type: Dune-Ripple/ Rosgen: C5

Project components: LWD, channel connectivity, riparian planting

Project Sponsor: City of Mt. Vernon

Landowner: City of Mount Vernon Park and Recreation Department

Contacts: Larry Otos, Curt Miller

Approximate cost of project: $983,853

Project Setting

Edgewater park is located on the west side of the Skagit River, within the floodplain. The surrounding area is flat agriculture and residential land. Over 22 miles of the river in this area are constrained by levees. At the park, the levee is set back, however historic off-channel habitat has been partially filled in over the years. The remaining slough acts as refuge however a depositional bar at the south end results in stranding as the river level recedes. The Skagit sustains multiple species of salmon. Due to the extensive levee system, off-channel habitat in the lower reaches is rare, including habitat features such as logjams.

Project Description

The Edgewater Park Off-Channel Restoration project was intended to create approximately 34 acres of restored off-channel sloughs and reconnect isolated habitat to the Skagit River. The primary target species for the project is Chinook salmon, however coho, chum, pink, and steelhead were also targeted in this restoration effort. This project included:

1. Constructing an off-channel slough and reconnecting isolated habitat to the river;
2. Replanting the riparian area; and
3. Installing LWD within the newly created channel.

Project Sponsors

The project is sponsored by the City of Mount Vernon Park and Recreation Department with primary contacts being Larry Otos and Curt Miller.

LWD Summary

This Project involved the placement of Artificial Instream structures (AIS) and individual LWD pieces within a reconstructed/excavated side-slough to the Skagit River. Between 10 and 15 AIS were constructed and multiple single-logs placed along the new channel (range is a result of difficulty in differentiation between individual structures in some areas). Numerous logs, including one large jam at the downstream end of the new channel, were placed above the channel within the floodplain. Wood retention throughout subsequent surveys was high, however some pieces were found to have been nearly completely buried in sand, and counting methods resulted in inconsistent tallies for within-bankfull wood vs. above-bankfull wood between years. The distribution of LWD diameters in Year 1 was as follows:

- 45 percent were less than 12 inches in diameter.
- 42 percent had a diameter between 12 and 24 inches.
- 13 percent had a diameter greater than 24 inches.

Table 1 illustrates the distribution of LWD placed in the newly constructed channel by transect.

Table 1. Distribution of LWD (Natural and Placed) throughout Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	0	6
B-C	1	86
C-D	5	40
D-E	2	1
E-F	7	0
F-G	0	0
G-H	0	0
H-I	5	6
I-J	0	15
J-K	3	54

Prior to project implementation, the site was a dry channel. LWD counts were conducted in what was assumed to be the reconstructed channel alignment. Construction locations varied somewhat from this predicted alignment. No fish were sampled in Year 0, as the channel was dry. In Year 1, the first year after implementation, the depth of the channel ranged between 30 cm and 80 cm, and there was use of the channel by juvenile Chinook. In subsequent surveys, the channel had mostly filled in with sand and snorkel surveys were not possible to conduct due to shallow water or dry channels. By Year 3, the channel was mostly dry at the time of the survey. In order to have enough water for surveying in Year 5, flows in the adjacent main channel had to be fairly high. No fish were observed during the snorkel survey in Year 5, however the high flows in the main channel resulted in high turbidity which limited visibility within the project reach.

Figure 1 shows the thalweg profile and fish counts for Year 1, soon after implementation. Figure 2 shows the change in thalweg profile depths over time.

Year 1 profile results show a relatively smooth depth transition from deeper to shallow moving upstream. By Year 3, pools had scoured near the upstream and downstream wood placements. By Year 5, the relative depths of these pools had increased, however submersion of the majority of the channel only occurred during storm events. Wood placement at the downstream and upstream ends of the reach appears to be successfully maintaining pools. The shallower pool between F and H, may be indicative of scouring actions from the LWD placement in transect H-I as well. The channel may perform as successful off-channel refugia during storm events; however its short inundation periods may limit its use as rearing habitat for juvenile salmonids.

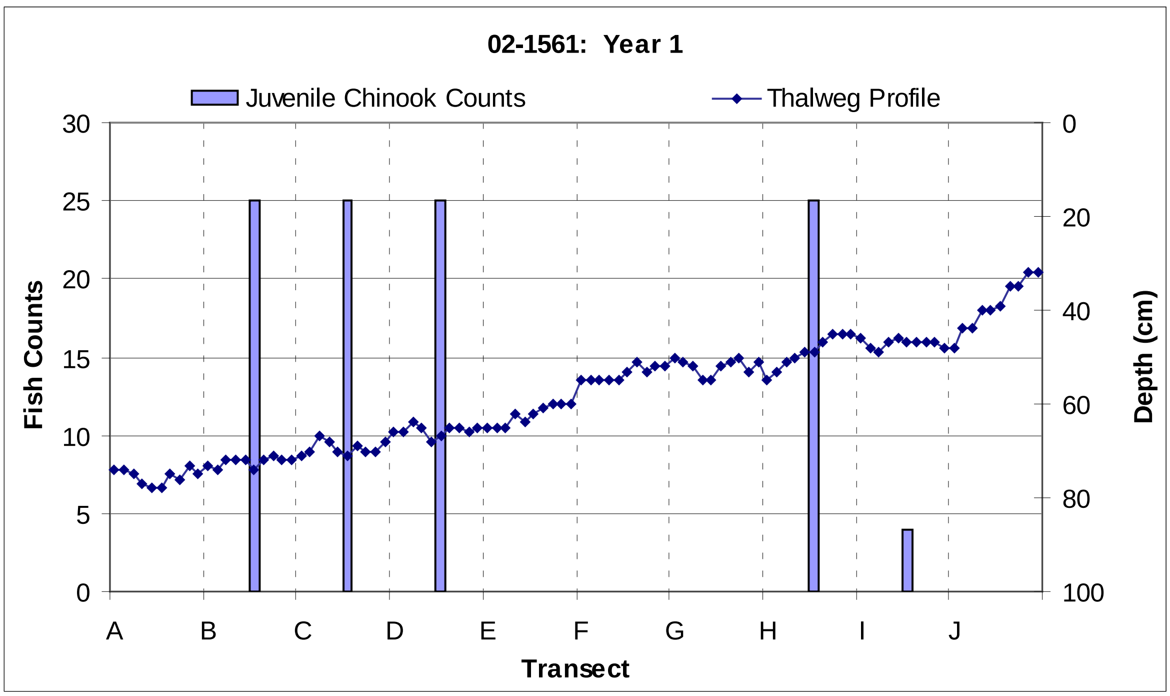

Figure 1. Thalweg Profile Cross Section and Juvenile Chinook Counts in Year 1. Reach length is 318 meters.

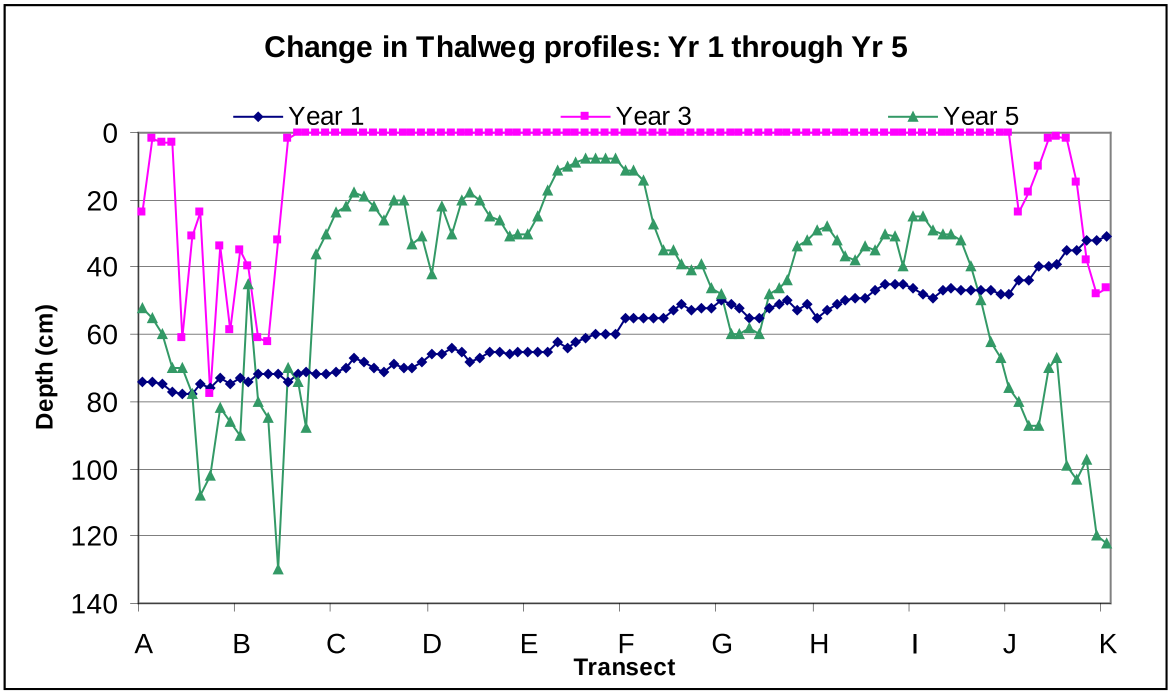

Figure 2. Change in Thalweg Profiles Between Monitoring Surveys. Reach length is 318 meters.

04-1209 Chico Creek Instream Habitat Restoration

04-1209 Chico Creek Instream Habitat Restoration

Project Location: Chico Creek, which flows to Dyes Inlet, in Kitsap County

Placement of LWD: 80 AIS were placed in newly aligned stream channel

Average wetted width: 6.5 meters
Reach slope %: 0.8
Reach sinuosity: 1.07
Channel Type: Pool-riffle/ Rosgen*: F4*

Project components: LWD, channel reconstruction, riparian planting

Project Sponsor: Kitsap County

Contact: Kathleen Peters

Approximate cost of project: $925,810

Project Description

The project is located near the mouth of Chico Creek before it flows into Dye's Inlet. Within the project area, Chico Creek runs through a manicured golf course. The upstream portions of the project are partially vegetated with mature trees while its riparian vegetation is open with manicured grass and minimal small shrubs for the majority of its length. The creek had been channelized and disconnected from its floodplain. A set of box culverts had been modified with downstream log weirs to better facilitate fish passage, however spacing issues created risk of undermining and an over-wide and shallow channel morphology. In addition, the log weirs are located in an area of historically high-quality spawning habitat.

Project Description

The goal of this project was to restore productive spawning habitat, provide high flow refuge, and facilitate upstream migration to an additional 16 miles of habitat in the upper watershed. Target species for this project included Chinook, coho, chum, steelhead, and cutthroat trout with chum being the primary target species. The project included:

1. Creating a more natural stream gradient, meander pattern, and floodplain dimension;
2. Enhancing the riparian zone with native conifer tree species and shrub vegetation; and
3. Installing LWD within the channel to provide in-stream habitat, maintain the meander, and stabilize bed material.

While chum were the primary target species, juvenile coho were used for effectiveness monitoring assessment as they spend more time rearing within the stream.

Project Sponsor and Design Information

This project is sponsored by Kitsap County. The primary contact person is Kathleen Peters.

LWD Summary

This project involved the placement of 80 instream structures within the reconstructed channel of Chico Creak. LWD was used as grade control, bank protection and roughening, as well as for habitat enhancement. During the first year of effectiveness monitoring following project implementation, all of the naturally occurring and artificially placed LWD within bankfull were documented. The distribution of sizes was as follows:

- 39 percent were less than 12 inches in diameter.
- 53 percent had a diameter between 12 and 24 inches.
- 8 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of LWD by transect within the project reach.

Table 1. Distribution of LWD (Natural and Placed) Throughout Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	0	0
B-C	0	0
C-D	0	2
D-E	0	2
E-F	0	0
F-G	0	2
G-H	0	0
H-I	0	1
I-J	0	6
J-K	0	5

Figures 1 and 2 illustrate the changes observed from before project implementation (Year 0) and after implementation (Year 1). At the time of monitoring, the log weirs downstream of the box culverts had not been removed. Large increases in both pool depth and counts of juvenile coho were observed in the first year after project implementation. Higher numbers of fish were also observed in the control reach in Year 1, however, which may indicate need for additional monitoring to detect significant changes in juvenile fish densities at this site. Existing pool locations were maintained in most instances, however size and channel characteristics shifted between the year 0 and year 1 surveys. High numbers of fish are generally observed in the vicinity of deeper pools, but the correlation is not exact.

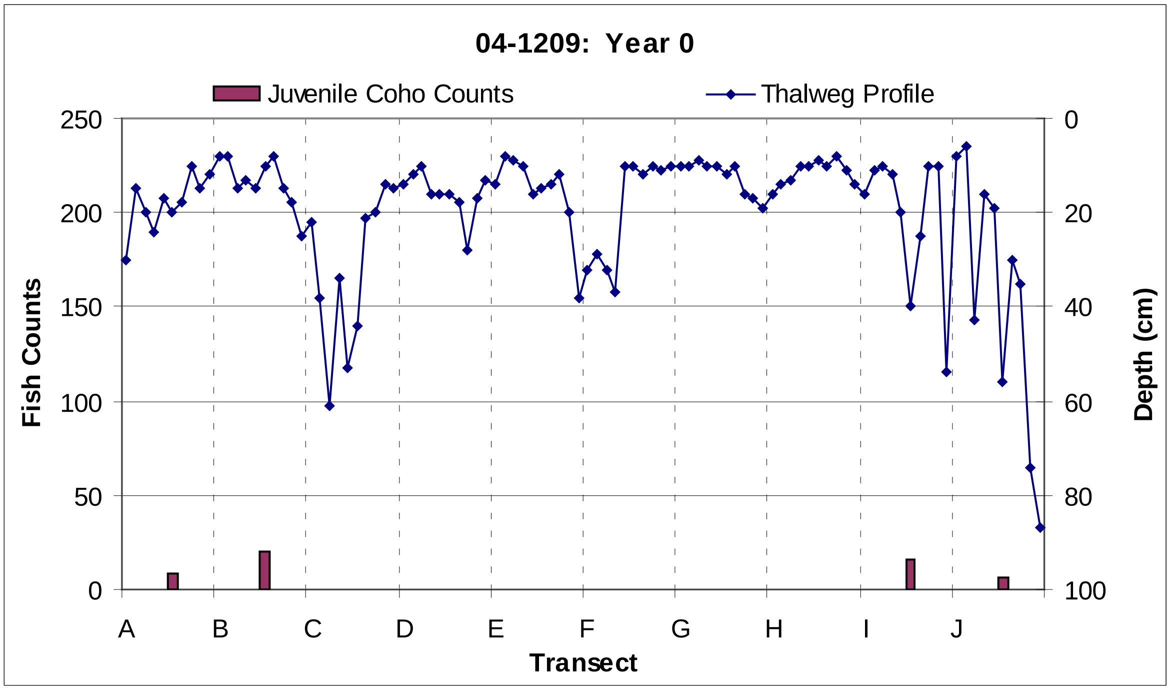

Figure 1. Thalweg Profile and Juvenile Coho Counts Pre-Project (Year 0)

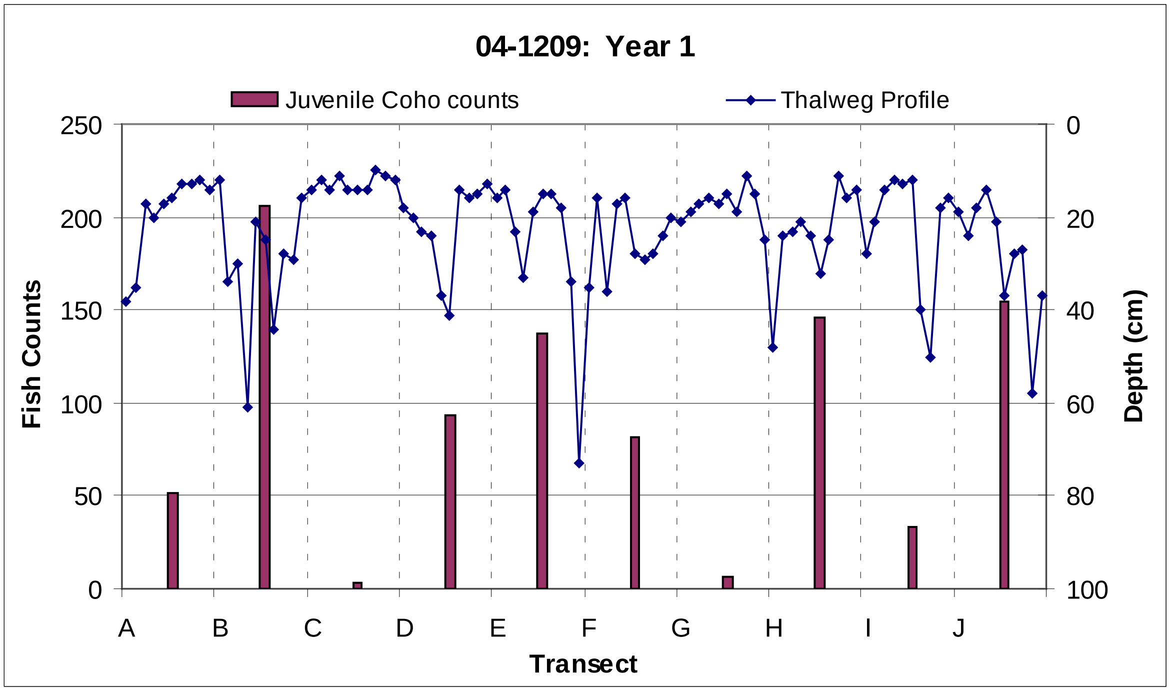

Figure 2. Thalweg and Juvenile Coho Counts Five Years After Implementation (Year 5)

04-1338 Lower Newaukum Restoration

04-1338 Lower Newaukum Restoration

Project location: Newaukum Creek near confluence with Green River in King County

Phased Placement of LWD: Phase 1 – Installation of 4 channel-spanning log jams. Phase 2 – Installation of 20 logs around existing log jams

Average wetted width: 9 meters

Project Sponsor: King County Department of Natural Resources and Parks (KC DNRP) Contact: Dan Eastman

Project design: KC DNRP

Approximate cost of project: Phase 1 $600K, Phase 2 $300K

Project Setting

The project is located in the lower 800 feet of Newaukum Creek before it enters the Green River. The stream channel and riparian corridor in the project area were degraded due to past anthropogenic disturbances. Large wood removal and channelization due to past instream activities and construction resulted in a simplified channel. Hydro-modification of the Green River may also have resulted in a steeper confluence for Newaukum Creek with the river. With little complexity or wood, sediment transport was high. The above factors contribute to isolation of the floodplain features, such as a 1,600 feet long channel that was only partially connected during extreme flow events, and thus posed a stranding risk. With few logjams, the low complexity of the stream and adjacent floodplain did not offer high-quality rearing and spawning opportunities for salmonids in this portion of the creek. Chinook spawn in Newaukum Creek in large numbers.

Project Description

This project aimed to restore in-stream roughness and hydraulic complexity and enhance the channel's connection with its floodplain in the lower portions of Newaukum Creek; thereby restoring dynamic, habitat-forming processes within the project reach. The target species for this project is Chinook however other salmonids are likely to benefit as well. The project included:

1. Restoring a historic meander;
2. Setting back a berm and naturalizing the restored floodplain area;
3. Placing several engineered LWD jams in the channel and floodplain to provide cover, spawning, and resting areas
4. Planting the riparian buffer with appropriate native plants.

Project Sponsor and Design Information

This project is sponsored by King County Department of Natural resources and Parks (KC DNRP). Design work was conducted by the project sponsor. The primary contact person is Dan Eastman.

LWD Summary

The project involved placement of wood in two phases. In Phase I, 4 channel spanning logjams were installed and the floodplain graded to enhance connectivity and function of approximately 12 acres of floodplain habitat. In Phase II, an additional 20 logs were installed around existing logjams. All wood, artificially placed and naturally occurring, was documented post-implementation. The size distribution was as follows:

- 88 percent were less than 12 inches in diameter.
- 10 percent had a diameter between 12 and 24 inches.
- 2 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of LWD by transect within the project reach.

Table 1. Distribution of LWD (Natural and Placed) Throughout Impact Reach

Transect (Downstream to Upstream)	Number of Instream Structures	
	Year 0	Year 1
A-B	3	5
B-C	1	132
C-D	1	87
D-E	2	100
E-F	3	19
F-G	45	79
G-H	3	24
H-I	3	29
I-J	2	11
J-K	3	13

Figures 1 and 2 show the thalweg profile and counts of juvenile coho by transect within the impact reach before project implementation (Year 0) and within the first year after implementation (Year 1). While Chinook is the target species, juveniles were not abundant during snorkel surveys. A total of 13 juvenile Chinook were observed in Year 0, while none were observed in Year 1. Within the first year of construction, the channel had developed side channels and multiple braided sections. This resulted in pools that were not as deep, but greater habitat complexity, which is likely a factor in the substantial increases in the counts of juvenile coho in the sample reach. Additional monitoring will provide information on long-term impacts of the large wood placement on channel profiles and fish distribution and abundance.

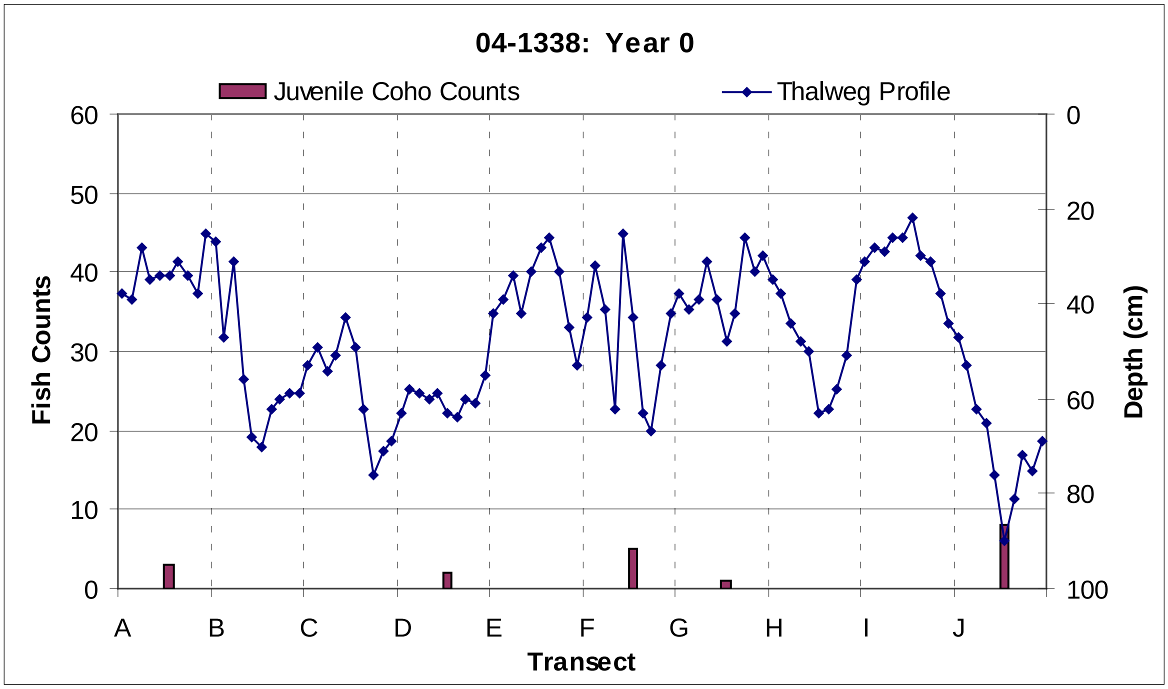

Figure 1. Thalweg Profile and Juvenile Coho Counts by Transect (Year 0)

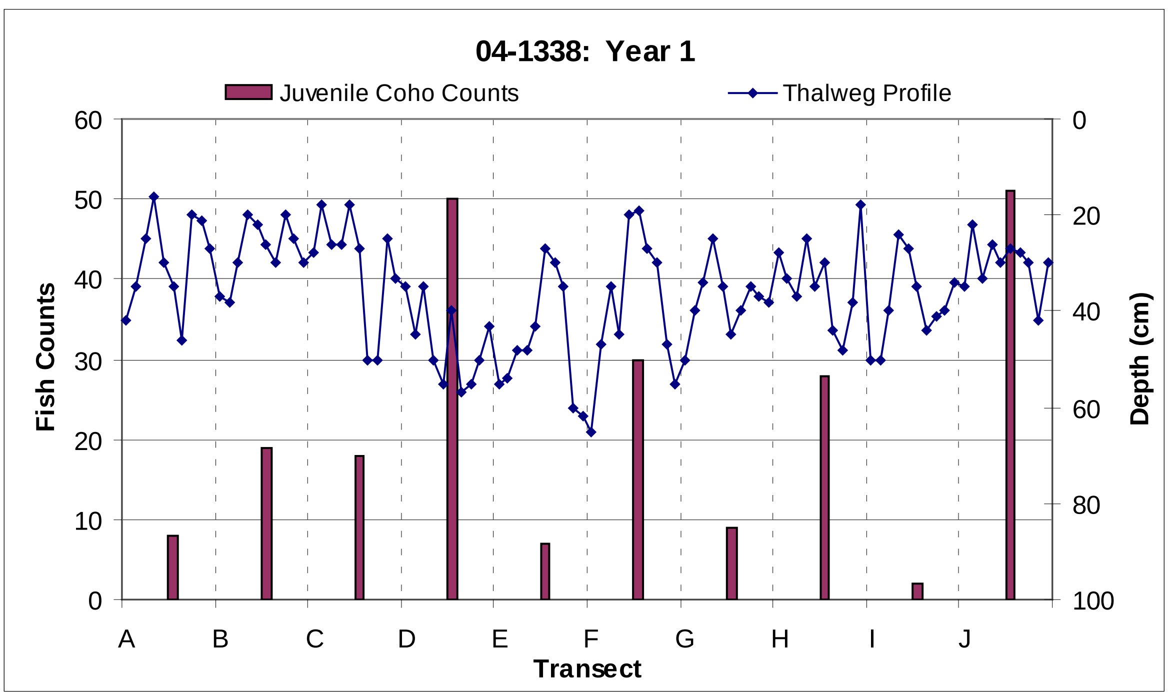

Figure 2. Thalweg Profile and Juvenile Coho Counts by Transect (Year 1)

04-1448 Grays River PUD Bar Habitat Enhancement Project

04-1448 Grays River PUD Bar Habitat Enhancement Project

Project location: On the Grays River in Wahkiakum County, west of Longview, Washington.

LWD placement: Installation of 1 LWD jam and 7 stone vane structures with wood incorporated

Average wetted width: 34 meters
Reach slope (%): 0.4
Reach sinuosity: 1.00
Channel Type: Pool-Riffle

Project Sponsor: Grays River Habitat Enhancement District & Lower Columbia Fish Recovery Board

Contact: Delvin Fredrickson

Approximate cost of project: $348,430

Project Setting

The project area includes approximately 0.2 mile of the lower Grays River around RM 11.8. River migration since 1999 had removed riparian cover and large wood was lacking in the project area. Within the 0.2 mile reach, two 500-feet riffles and 1 pool were present. Lack of riparian cover and high width-depth ratios resulted in high water temperatures such that the river was brought under a 305b listing.

Project Description

The Grays River PUD Bar Habitat Enhancement Project was designed to improve habitat complexity and channel stability, increase spawning opportunities, and increase the amount of hiding refugia for of fish. The project included:

1. Placing LWD and rock structures within the stream, and
2. Installing native plants within the riparian zone over a 5-acre area.

Project sponsor

This project is sponsored by the Grays River Habitat Enhancement District and the Lower Columbia Fish Recovery Board. Primary contact for the project is Delvin Fredrickson.

LWD Summary

This project involved placement of one logjam, one rock "W" vane, and six rock J-hook vanes. Wood was incorporated into the rock vanes. The aim of these placements was to create a series of 8 pool-riffle sequences. The log jam utilized cables and ecology blocks with wood rack design as well as whole trees and partial embedment in placement design. All wood was counted during monitoring surveys. A baseline assessment of the wood present at the site after project implementation was made. Wood and rock structures have remained fairly stable throughout the Year 5 surveys. The distribution of sizes of Year 1 LWD was as follows:

- 17 percent were less than 12 inches in diameter.
- 62 percent had a diameter between 12 and 24 inches.
- 21 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of LWD throughout the project reach.

Table 1. Distribution of LWD (Natural and Placed) Throughout Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	0	0
B-C	0	1
C-D	7	7
D-E	10	2
E-F	4	2
F-G	5	3
G-H	5	2
H-I	1	1
I-J	2	25
J-K	28	11

Figures 1 and 2 illustrate the changes in thalweg profiles and juvenile steelhead densities between Year 0 and Year 1 surveys. Chinook were only present in very low numbers throughout the surveys (two in Year 0 and five in Year 5). In the Year 5 surveys, northern pike minnow were observed in large numbers in transects E-F, F-G, and I-J. The presences of northern pike minnow corresponded fairly well to deeper pools with low juvenile steelhead counts. The location of the logjam corresponds with the creation of a pool downstream of transect J in the thalweg profile for Year 5. Juvenile steelhead numbers are only slightly higher in Year 5 than Year 0. It is likely that the pike minnow in the pools are impacting the steelhead abundance.

Flow in the impact reach has moved from the right bank to the left bank, and wood placed along the right bank is now providing cover in a seasonally flowing side channel. Wood continues to recruit to the large jam in the main channel.

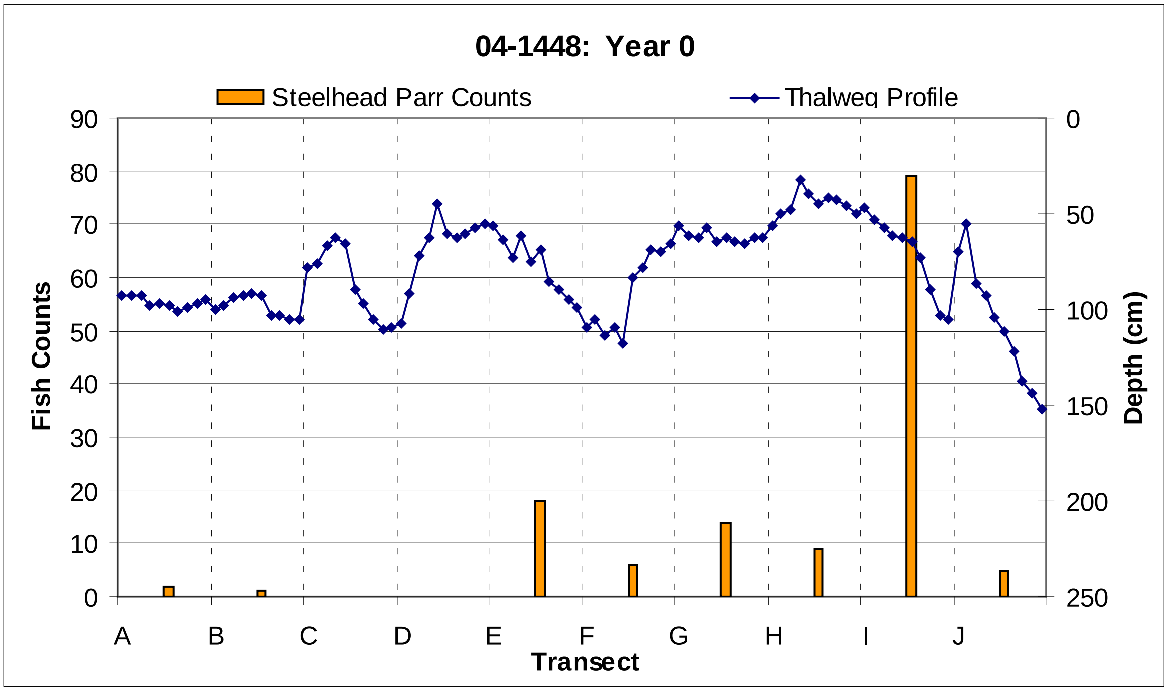

Figure 1. Thalweg Profile and Steelhead Parr Counts Pre-Project (Year 0)

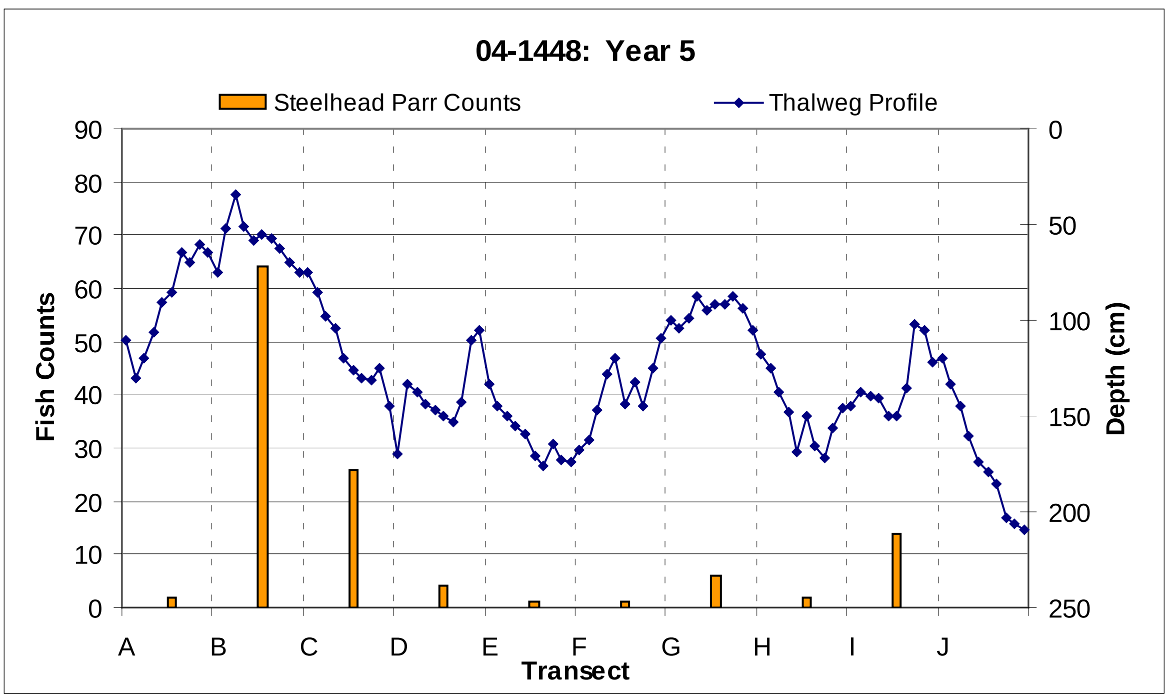

Figure 2. Thalweg Profile and Steelhead Parr Counts Five Years After Implementation (Year 5)

04-1575 Upper Washougal River LWD Placement Project

04-1575 Upper Washougal River LWD Placement Project

Project location: Washougal River in Skamania County.

Average wetted width: 23 meters
Reach slope (%): 1.0
Reach sinuosity: 1.02
Channel Type: Bedrock/Step-pool

Project components: LWD

Project Sponsor: Lower Columbia River Fish Enhancement Group

Contact: Tony Meyer

Approximate cost of project: $378,940

Project Setting

The upper Washougal River LWD Project addressed degraded floodplain conditions and functions identified by the Lead Entity and the WDFW as limiting salmon and steelhead production in the upper Washougal watershed. This project treated specific reaches of the mainstem Washougal River from RM 15 to approximately RM 22 that have become deeply incised in a bedrock channel due to log drives and catastrophic forest fires that occurred in the late 1800s and early 1900s.

Project Description

The Upper Washougal River LWD Placement Project was intended to decrease channel width and increase in-stream cover, spawning and rearing areas, pool depth, and sub-surface flows. This was accomplished by placing engineered log jams and log/boulder complexes within the river. The project directly benefits a primary population of ESA-listed summer steelhead, as well as contributing populations of ESA-listed Chinook and winter steelhead. Other species present in the project area include coho, resident cutthroat and rainbow trout, and mountain whitefish.

Project Sponsor

The project sponsor is the Lower Columbia Fish Enhancement Group and the primary contact is Tony Meyer.

LWD Summary

The project involved placement of engineered logjams and log/boulder complexes capable of withstanding peak peek flows. Six primary log structures were placed in Year 1 and all structures were found to be in place in Year 3. During the first year of effectiveness monitoring following project implementation, all of the naturally occurring and artificially placed LWD within bankfull were documented. The distribution of sizes was as follows:

- 50 percent were less than 12 inches in diameter.
- 50 percent had a diameter between 12 and 24 inches.
- 0 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of LWD by transect within the project reach.

Table 1. Distribution of LWD (Natural and Placed) Throughout Impact Reach

Transect (Downstream to Upstream)	Number of Instream Structures	
	Year 0	Year 1
A-B	2	46
B-C	0	1
C-D	1	68
D-E	2	32
E-F	0	0
F-G	1	28
G-H	0	1
H-I	1	35
I-J	0	0
J-K	1	0

A sharp decrease in steelhead density was observed in Year 3 as compared to Year1 and Year 0; however, a marked increased was noted in Year 5. Fish were present throughout the project reach in Year 5, though in lower densities between B and G than in the rest of the reach (Figures 1 and 2). The highest densities of fish were associated with transects where wood was either placed or where wood was placed in an adjacent transect, however high wood placement did not always result in high fish densities. Pools present in Year 0 were maintained throughout the post-implementation surveys. With the exception of the pool in transect I-J, these pools increased in residual depth. Addition pools were created in transect G-H and transect J-K.

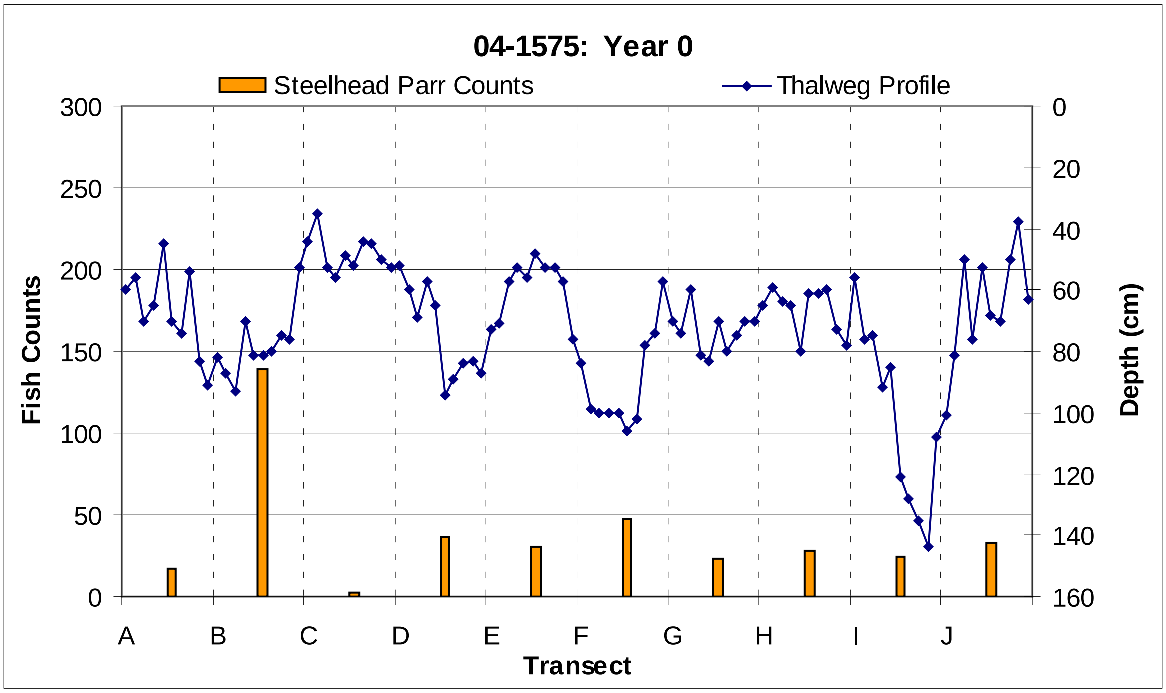

Figure 1. Thalweg Profile and Steelhead Parr Counts Pre-Project (Year 0)

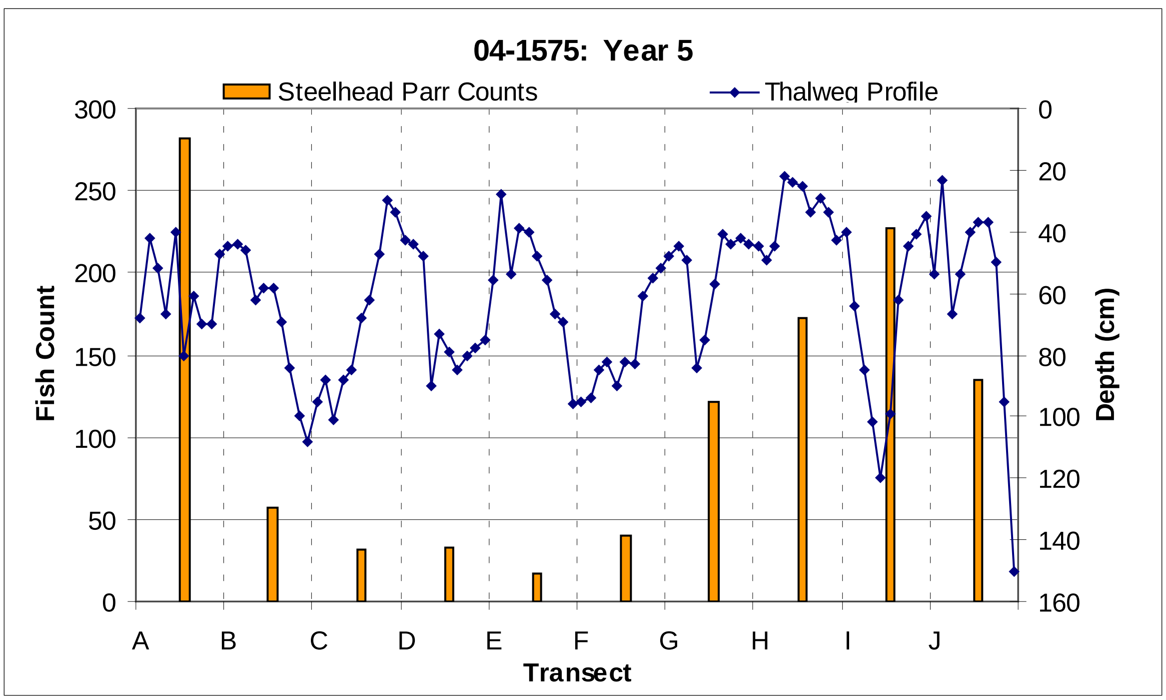

Figure 2. Thalweg Profile and Steelhead Parr Counts Five Years After Implementation (Year 5)

04-1589 Dungeness River Railroad Bridge Restoration Project

04-1589 Dungeness River Railroad Bridge Restoration Project

Project location: Clallam County, on the Dungeness River, at the end of the road in Railroad Bridge Park.

Average wetted width: 23 meters
Reach slope %: 1.4
Reach sinuosity: 116
Channel Type: Pool-Riffle/Braided

Project Sponsor: Jamestown S'Klallam Tribe

Contact: Byron Rot

Designed by: Herrera Environmental Consultants

Approximate cost of project: $ 1,066,351

Project Setting

The Dungeness River Railroad Bridge Restoration project is located upstream of some of the healthiest remaining salmonid habitat in the lower Dungeness River. Pre-project data showed that stable log jams were lacking in this reach of the river. As recently as the early 1980s, Clallam County regularly collected and burned LWD from the Dungeness River. This practice contributed to a loss of sufficiently sized LWD within the river to create structural complexity for fish habitat. Since then, the habitat had started to recover, but continued to lack enough logjams to provide adequate cover for the diverse fish species that use the river, including ESA listed Chinook salmon and bull trout.

The project reach is a very active reach with frequent channel avulsions and a wide floodplain with multiple side channels. The substrate is, on average, too large for spawning salmonids, and the riparian zone includes a range of riparian forest types and ages. The project is expected to benefit approximately 2,092 meters of stream habitat.

Project Description

The project aims to increase in-stream cover, spawning habitat, and resting areas for spawners, as well as rearing habitat for juvenile salmonids. A secondary objective is to re-aggrade the mainstem to encourage flow into disconnected side channels. The log jams are intended to create high flow refugia for both juvenile and adult salmonids and rearing pools within and upstream of each jam. In addition, the network of logjams is designed to stabilize gravel bars for riparian forest establishment and contribute to channel complexity, sinuosity, and pool frequency through time. The target species for the project is Chinook salmon, however additional salmonids are expected to benefit as well.

Project sponsors and design information

The project sponsor is Jamestown S'Klallam Tribe and the primary contact is Byron Rot. The project design was conducted by Herrera Environmental Consultants.

LWD Summary

The project involved installing 7 engineered log jam structures and 2 non-engineered wood structures within the floodplain and active channel of the river. No channel-spanning logjams were constructed and engineered jams were anchored with vertical timber driven into the bank and partially buried with mounded earth. Four of the logjams were within the surveyed reach. All LWD, artificially placed and naturally occurring within the surveyed reach, was documented post-implementation. The size distribution was as follows:

- 63 percent were less than 12 inches in diameter.
- 28 percent had a diameter between 12 and 24 inches.
- 9 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of LWD by transect within the project reach. Year 0 shows the counts pre-installation.

Table 1. Distribution of LWD (Natural and Placed) Throughout Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	21	18
B-C	15	2
C-D	4	47
D-E	7	58
E-F	11	49
F-G	34	100
G-H	29	31
H-I	13	74
I-J	12	27
J-K	23	46

Due to changes in the channel between Year 1 and Year 3, one of the log jams in the impact reach was in the floodplain at the time of the Year 3 survey. Natural channel migration is part of this dynamic system and was anticipated as part of the design in terms of jam placement in both the main channel and in side channels. As of the Year 3 survey, the river had yet to fully integrate with the wood structures, as there had been no 10-year, or greater, flow events. Once an event of that scale occurs, a substantial increase in rack wood on the enhanced logjams is expected, which will provide additional cover habitat for fish and will likely lead to increases in juvenile fish utilization.

In the first year of monitoring following construction, densities of steelhead parr and coho juveniles increased sharply. Figures 1 and 2 show changes in steelhead densities and pool depths for Year 0 and Year 3. In Year 3, steelhead parr continued to increase, while coho and Chinook juveniles slightly decreased (Figure 2). However, densities for coho still remain well above that of the pre-project condition. Localized juvenile fish presence was observed around the three wood structures that were in the water and 9 percent of the fish in the reach were directly using the placed structures at the time of the survey. During the survey in 2010, a live adult pink salmon was observed in the project reach. These fish are not commonly seen in the Dungeness, but indicate that the habitat is usable by a wide variety of salmonids.

Increases in mean vertical pool profile area and residual depth were observed within the first year of implementation. In Year 3, both mean vertical pool profile area decreased and residual depth decreased (Figure 2). Due to the dynamic nature of this site, additional changes to channel configuration and composition are expected during future monitoring events. Year 5 monitoring at this site is scheduled for 2012.

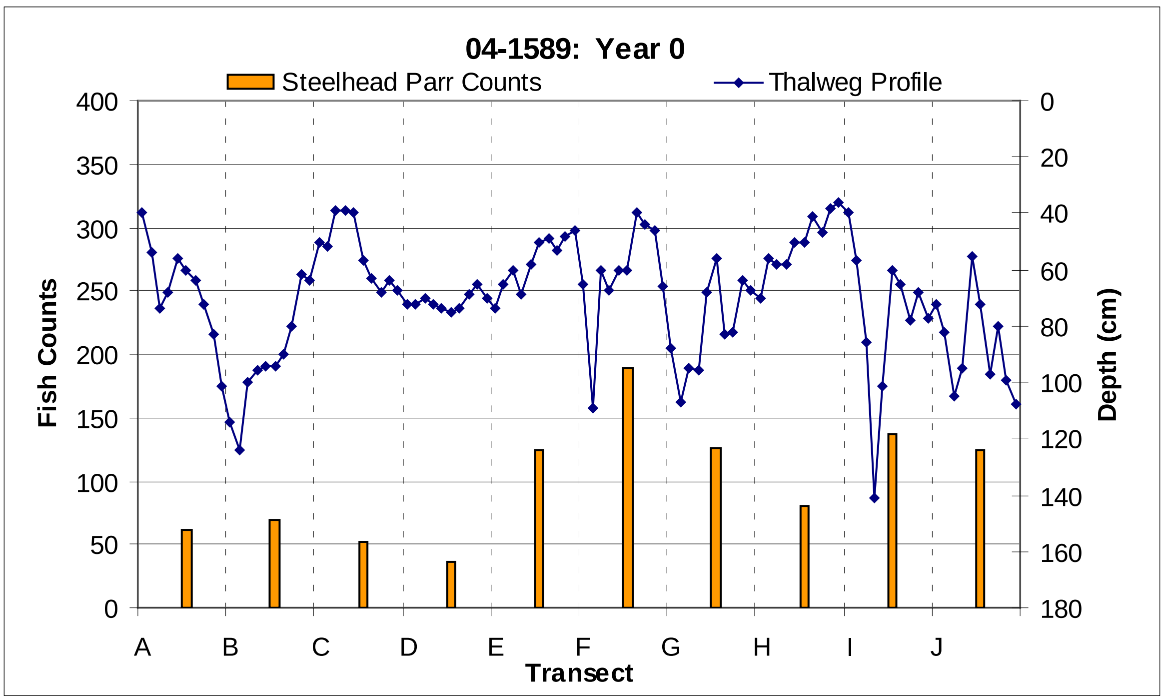

Figure 1. Thalweg Profile and Steelhead Parr Counts Pre-Project (Year 0)

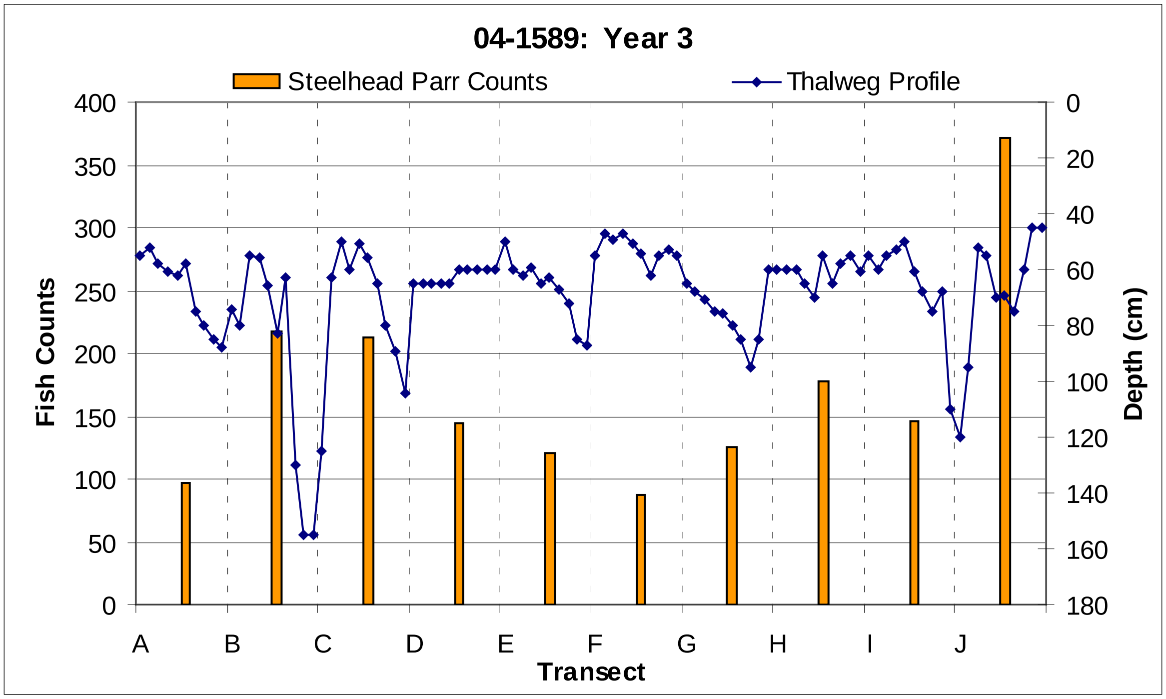

Figure 2. Thalweg Profile and Steelhead Parr Counts Three Years After Implementation (Year 3)

04-1660 Cedar Rapids Floodplain Restoration

04-1660 Cedar Rapids Floodplain Restoration

Project location: Cedar River in King County

Average wetted width: 28 meters
Reach slope 0.4
Reach sinuosity: 1.55
Channel Type: Pool-riffle

Project componentsr: floodplain reconnection, LWD, riparian planting

Project Sponsor: King County Water and Land Resources

Contacts: Nancy Faegenburg

Approximate cost of project: $892,993

Project Setting

The Cedar Rapids Floodplain Project was intended to restore 1,850 feet of riparian and floodplain habitat along a reach of the Cedar River. Historic levees along this reach have constricted, reduced, and degraded in-stream and riparian habitat for Chinook salmon. The project reach contained very few pools, lacked large woody debris, and off-channel habitat was inaccessible or lacking. The riverbed was incised and spawning gravel has been limited by high velocity flows.

The Cedar Rapids Floodplain Restoration Project restored a more natural channel form and improved aquatic, riparian, and off-channel floodplain habitats in this important Chinook spawning and rearing area. The project included the removal of levees and bank armoring, reconnection of high flows to the adjacent floodplain, restoration of in-stream channel, gravel bar, and pool habitats, and the recreation of riparian floodplain and side channel habitats

Project Description

The Cedar Rapids Floodplain Restoration project was intended to increase in-stream cover, spawning, and holding sites for Chinook salmon along the Cedar River. The project included:

1. Removing levees and bank armoring;
2. Reconnecting high flows to the adjacent floodplain;
3. Restoring in-stream channel, gravel bar, and pool habitats;
4. Installing LWD; and
5. Removing invasive plants and planting native vegetation within the riparian area.

Project Sponsor and Design Information

The project sponsor is the King County Department of Natural Resources and Nancy Faegenburg is the primary contact.

LWD Summary

Large woody debris was installed along the banks and active channel. Logs with rootwads attached were used for artificial structures. Logs were chained to ballast for anchoring. High flow events that occurred prior to Year 1 monitoring resulted in loss of some of the structures, which the project sponsors are planning to replace. Spanning logs were proposed for removal to reduce boater conflicts. The distribution of LWD after project implementation was as follows:

- 33 percent were less than 12 inches in diameter.
- 33 percent had a diameter between 12 and 24 inches.
- 34 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of LWD throughout the project reach.

Table 1. Distribution of LWD (Natural and Placed) Throughout Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	10	22
B-C	1	4
C-D	1	30
D-E	0	36
E-F	16	25
F-G	0	64
G-H	0	74
H-I	2	3
I-J	1	24
J-K	5	6

Juvenile Chinook, which is the target species for this project, increased in abundance from Year 0 to Year 1 (Figures 1 and 2). While Year 1 numbers appear to be more strongly associated with pools, the dominance of pool habitat within the reach makes this assumption problematic. Juvenile coho and steelhead parr decreased between Year 1 and Year 0, however these numbers also decreased in the control reach established for effectiveness monitoring at this site. The transect with the largest number of juvenile Chinook in the post-implementation survey had no wood in Year 0 and 36 pieces of LWD in Year 1. However, wood is not always strongly correlated with fish abundance as transect F-G and G-H both went from zero pieces pre-implementation to more than 50 pieces post-implementation, yet showed little increase in fish use. Pool depth in Year 1 decreased slightly with more variation within the profile depths than was seen in year 0 monitoring.

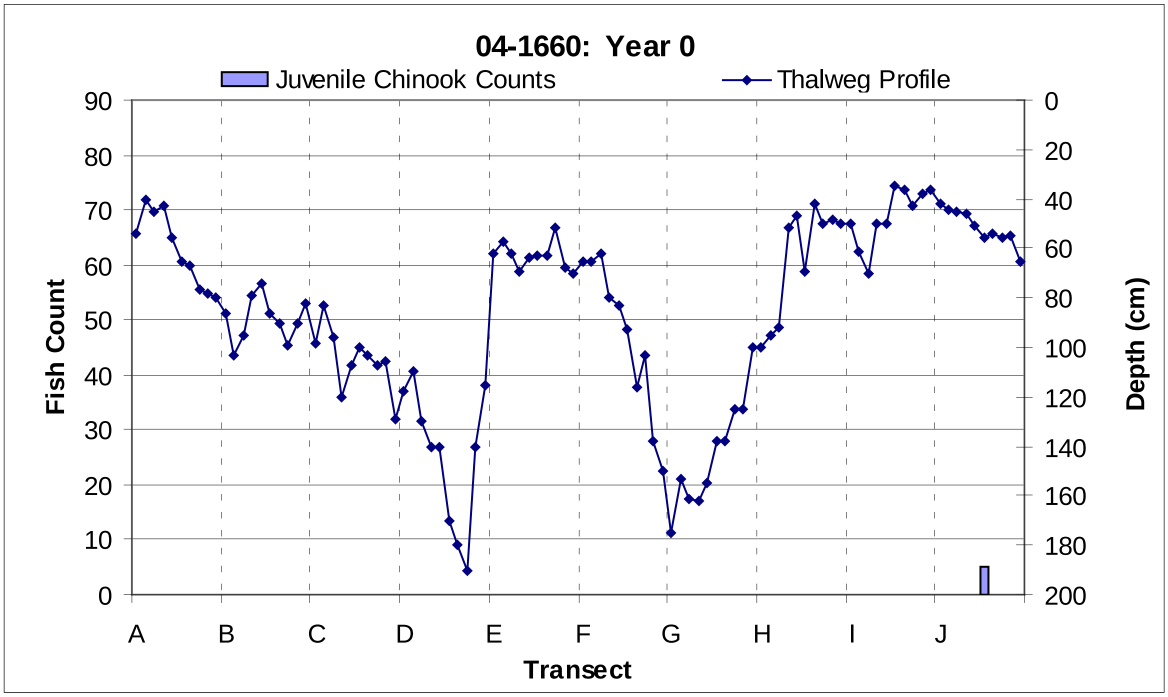

Figure 1. Thalweg Profile and Juvenile Chinook Counts Pre-Project (Year 0*)

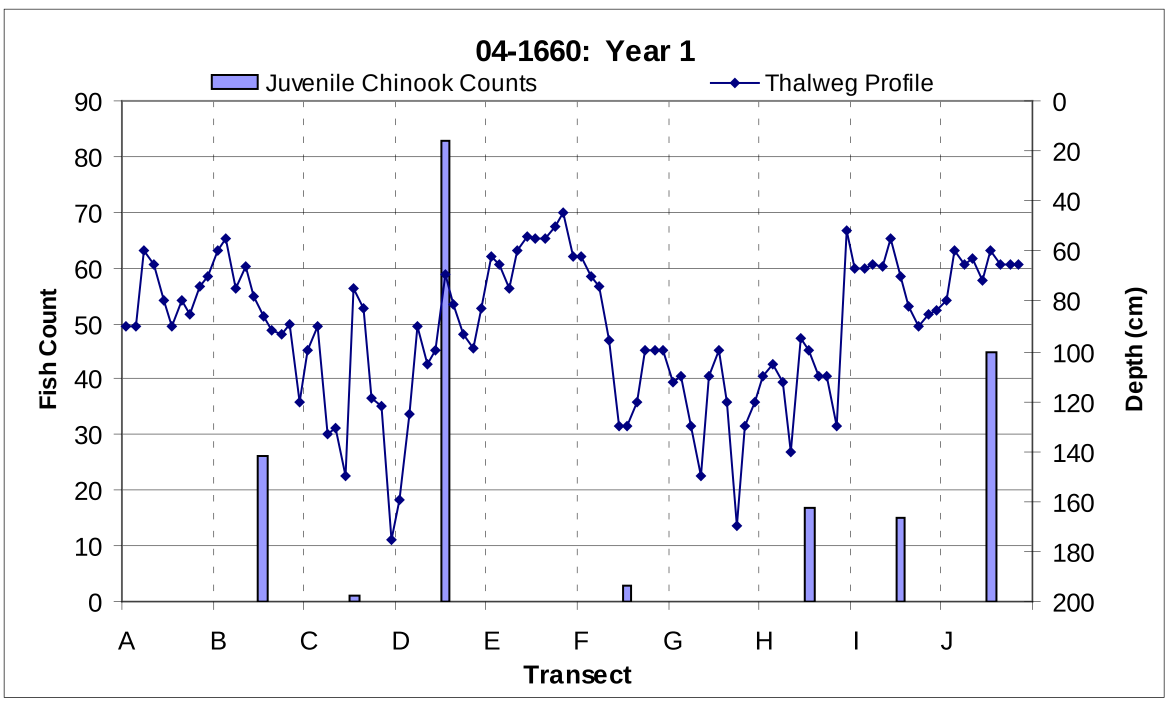

Figure 2. Thalweg Profile and Juvenile Chinook One Year After Implementation (Year 1)

05-1533 Doty Edwards Cedar Creek Restoration Project

05-1533 Doty Edwards Cedar Creek Restoration Project

Project location: Cedar Creek in the Lewis River (WRIA 27) subbasin in Clark County

Average wetted width: 14 meters

Reach slope %: 0.6

Reach sinuosity: 1.03

Channel Type: Pool-Riffle

Project components: LWD, riparian planting, floodplain reconnection

Project Sponsor: Fish First

Contacts: Dick Dyrland

Approximate cost of project: $105,537

Project Setting

The project is located along approximately 1400 feet of Cedar Creek, a tributary to the North Fork Lewis River. Past activities (splash dams, excessive logging, and grazing) essentially caused the creek to become a single long, shallow, unstable "run" with no riffles, pools, or protective cover for all of the life stages of salmonid fish (coho, Chinook, and steelhead) that once made extensive use of this reach of Cedar Creek.

Project Description

The Doty Edwards Cedar Creek Project was designed to create new high-quality spawning areas, resting pools, and cover for adult salmonids and rearing habitat for juveniles. Additionally, the project was intended to reduce summer stream temperatures. This was accomplished by:

1. Installing LWD;
2. Adding gravel holding cross-vanes to restore the pool-to-riffle ratio function and allow eroded banks to re-vegetate;
3. Planting trees and shrubs to provide shading and cover; and
4. Reconnecting a small side-channel to provide off-channel habitat for juveniles.

Project Sponsor

The project sponsor is Fish First and Dick Dyrland is the primary contact.

LWD Summary

The Project involved placement of rootwads and 2 rock weirs within the cedar river. Logs with rootwads attached were placed with the rootwads facing upstream or perpendicular to the bank.

Logs were anchored with large angular boulders. Instream structures were counted and marked in Year 1. All wood was counted and the distribution of sizes was as follows:

- 32 percent were less than 12 inches in diameter.
- 36 percent had a diameter between 12 and 24 inches.
- 32 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of LWD pre- and post-implementation.

Table 1. Distribution of LWD (Natural and Placed) Throughout Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	0	3
B-C	3	4
C-D	3	6
D-E	3	4
E-F	3	15
F-G	1	6
G-H	0	7
H-I	0	5
I-J	0	0
J-K	0	0

Total fish numbers decreased from Year 0 to Year 3, however the overall distribution was more even post construction (Figures 1 and 2). The decrease was due to loss of the majority of the fish found in transect D-E prior to construction. This transect is directly downstream of the transect that received the most wood placement. Correlation with wood presence is difficult to discern for either year.

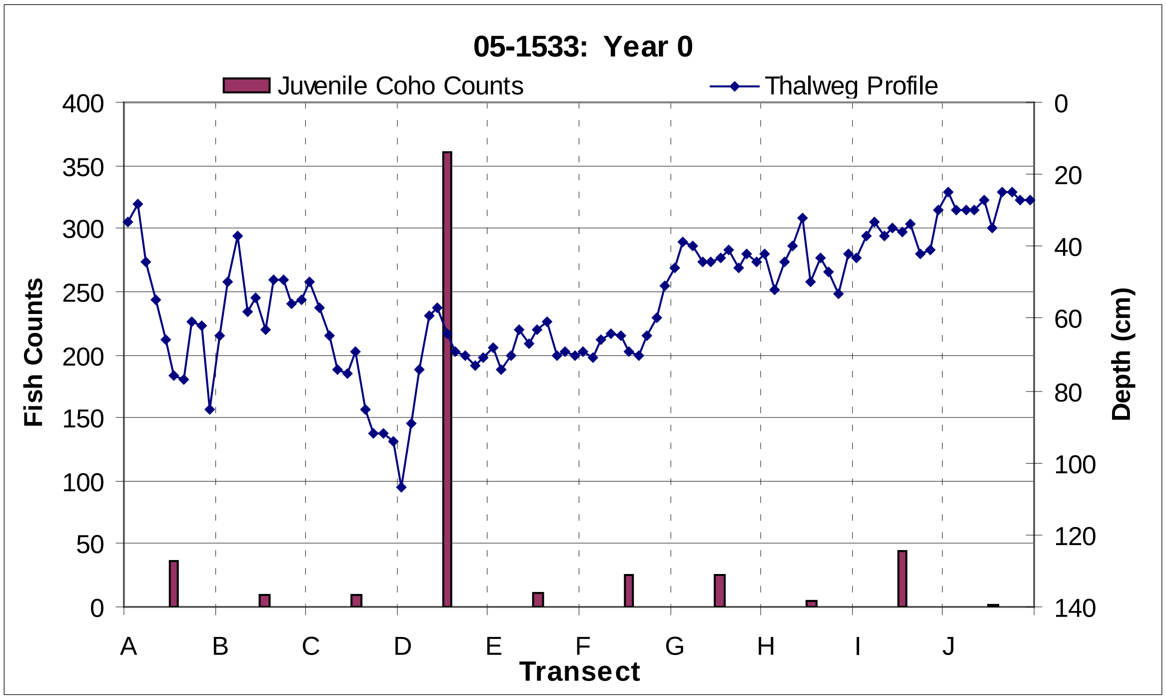

Figure 1. Thalweg Profile and Juvenile Coho Counts Pre-Project (Year 0)

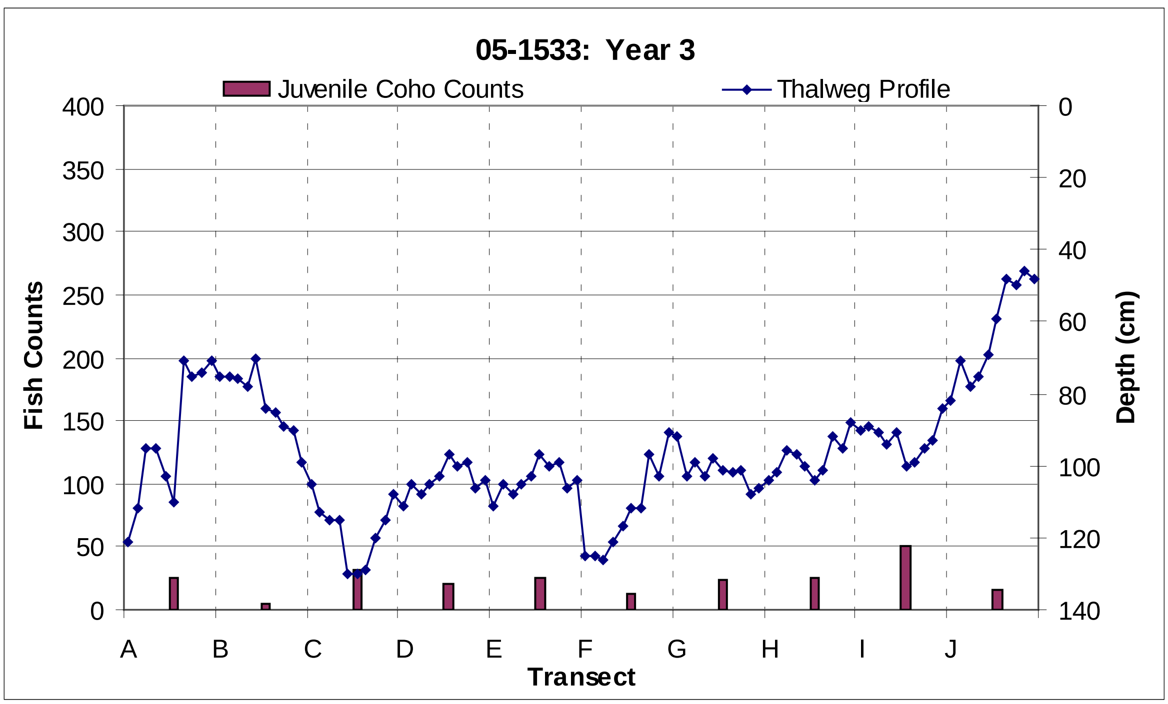

Figure 2. Thalweg Profile and Juvenile Coho Counts Three Years After Implementation (Year 3)

The reach is largely plane-bed and thus has few bedforms for comparison. The stream is relatively deep and consists, for the most part, of a deep run. The Year 0 and Year 1 profiles match each other fairly well until transect E-F, which is where an accumulation of wood was surveyed post-construction (Figure 3). This wood appears to have formed a larger pool, extending for a greater distance at deeper depths. The Year 3 data suggest a maintenance of this new channel structure post-construction.

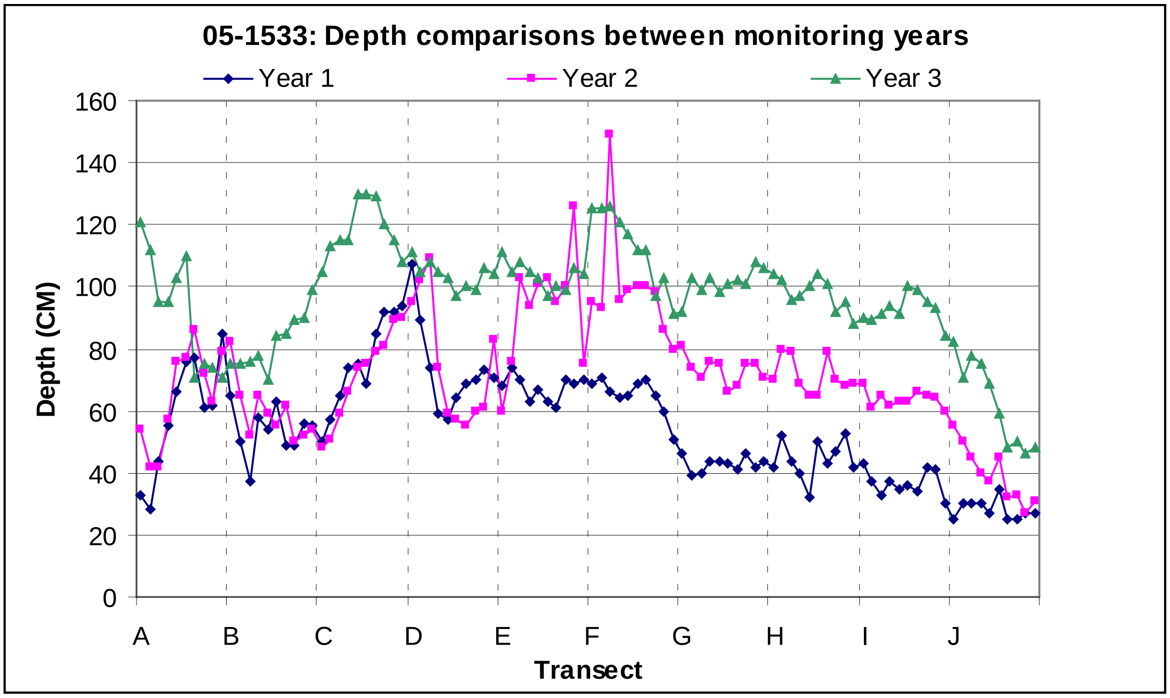

Figure 3. Thalweg Profile Comparisons Across Monitoring Years

07-1803 Skookum Reach Restoration

07-1803 Skookum Reach Restoration

Project location: South Fork Nooksack River, near RM 14, in Whatcom County

Average wetted width: 29 meters
Reach slope %: 1.0
Reach sinuosity: 1.02
Channel Type: Pool-Riffle/Rosgen: C3

Project components: LWD, road decommissioning, channel reconstruction, riparian planting

Project Sponsor: Lummi Indian Business Council

Contact: Alex Levell

Approximate cost of project: $1,180,386

Project Setting

The Skookum Reach Restoration project addresses habitat factors limiting the recovery of South Fork Nooksack River Chinook salmon, bull trout, steelhead trout, and other salmonid species. These factors include elevated water temperatures, lack of key habitat features, and low habitat diversity. The project addresses the WRIA 1 salmon recovery habitat restoration goals for this reach of the South Fork Nooksack River.

Project Description

The objective of the Skookum Reach Restoration Project was to improve in-stream morphology and habitat for salmonid species. The project was intended to increase in-stream cover, spawning, and resting areas within Skookum Reach. The primary species targeted in this project is Chinook salmon; specifically, a population endemic to the South Fork Nooksack. Project actions include the following:

1. Removing and relocating an abandoned county road along 2,500 feet of bank;
2. Restoring channel migration and natural bank conditions;
3. Installing 3 engineered wood structures; and
4. Planting 11.8 acres of riparian buffer.

Project Sponsor

The Lummi Indian Business Council is the project sponsor and Alex Levell is the primary contact.

LWD Summary

This restoration project included the placement of three engineered wood structures. The three engineered logjams were placed in the cool water mixing zone of Skookum Creek, which provides thermal refuge in the temperature-limited South Fork Nooksack. The distribution of diameter sizes for placed and existing wood in Year 1 surveys was as follows:

- 75 percent were less than 12 inches in diameter.
- 24 percent had a diameter between 12 and 24 inches.
- 1 percent had a diameter greater than 24 inches.

Table 1 shows the distribution of wood both before and after project implementation.

Table 1. Distribution of LWD (Natural and Placed) Throughout Impact Reach

Transect (Downstream to Upstream)	Number of LWD Pieces	
	Year 0	Year 1
A-B	1	0
B-C	7	0
C-D	0	28
D-E	8	0
E-F	0	20
F-G	4	0
G-H	5	27
H-I	1	0
I-J	7	1
J-K	3	0

When comparing the impact and control reaches, both pool refuge and residual depth increased between Year 0 and Year 1 at Skookum Reach (Figure 1). Steelhead parr increased substantially and coho juveniles showed a very slight increase (Figure 2). Chinook juveniles decreased slightly in Year 1.

During the snorkel survey, the scour pools around the placed wood structures were inspected for fish. Steelhead parr and juvenile Chinook were documented in one of the pools. Localized use by steelhead parr was observed near one of the other structures, but not within the scour pool. The scour pool of the third, and most upstream, structure was turbid at the time of the survey, so fish utilization could not be determined.

Monitoring of this site was conducted just following the completion of construction. Disturbance of the system likely resulted from installation of the wood structures, which may have displaced fish to some extent. Increases in juvenile fish densities are anticipated during future monitoring events as fish become more accustomed to using the structures.

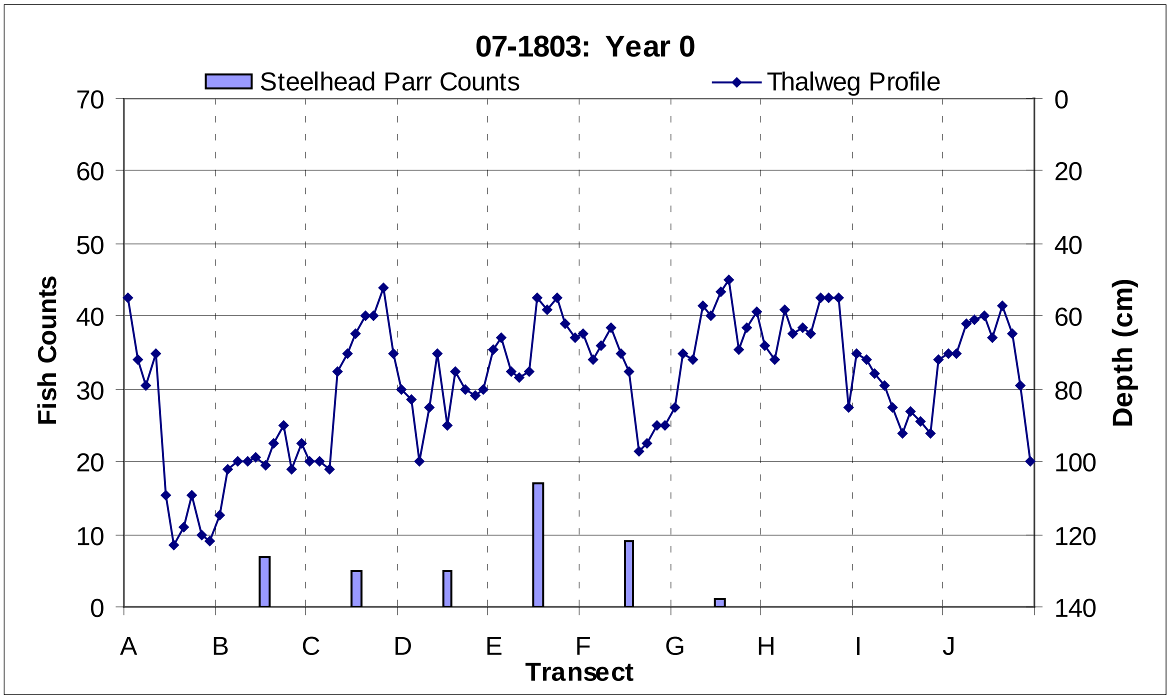

Figure 1. Thalweg Profile and Steelhead Parr Counts Pre-Project (Year 0)

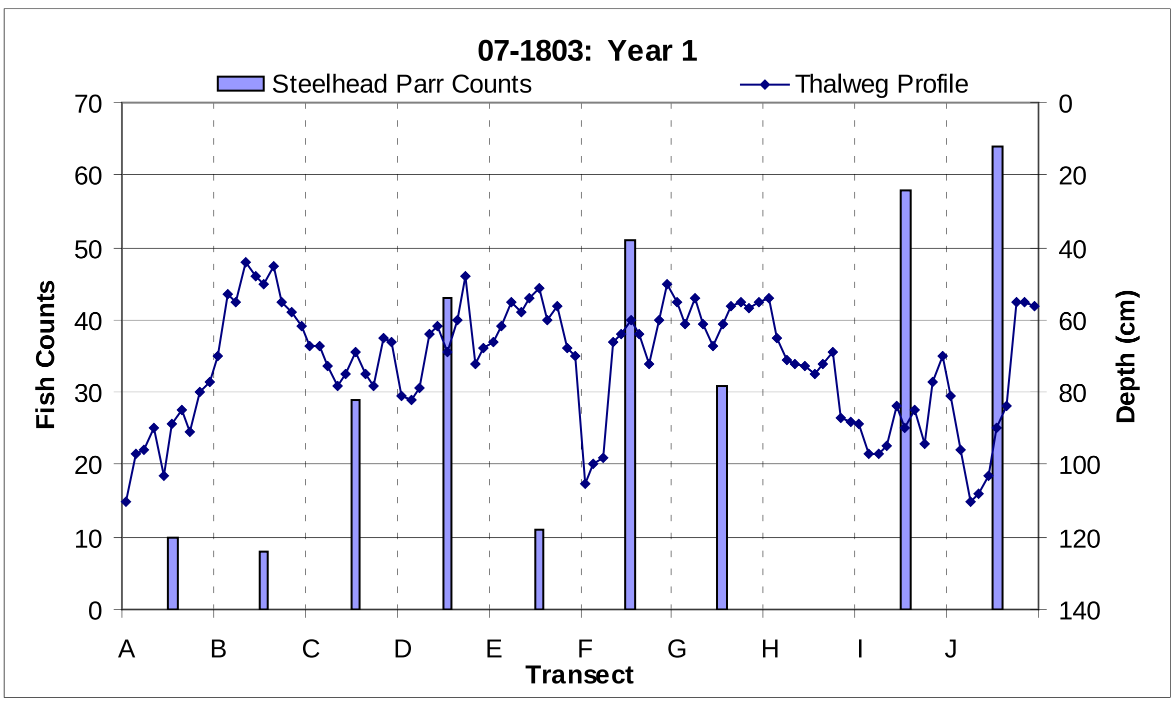

Figure 2. Thalweg Profile and Steelhead Parr Counts One Year After Implementation (Year 1)

Fish presence was greater in Year 1 and was more evenly distributed throughout the reach (Figure 2). Pool numbers and depths appear similar between years; however, depth and size of the pool habitat in the upstream section of the reach appears to have increase post-construction.

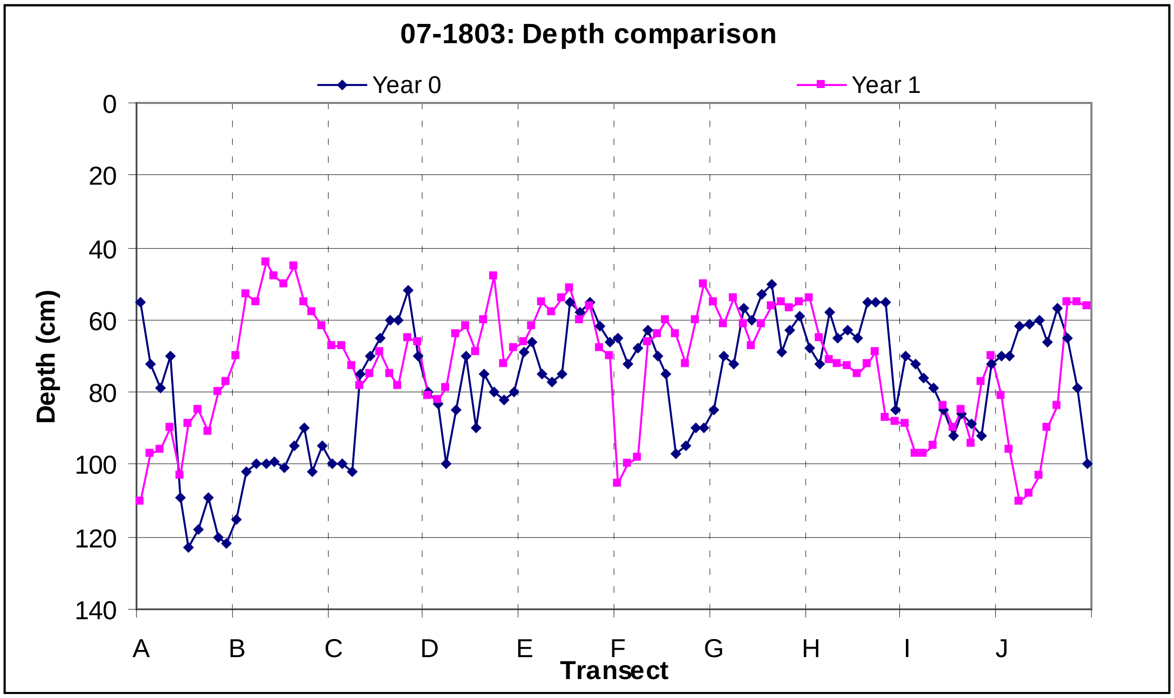

Figure 3. Thalweg Profile Comparison Between Survey Years

In Year 0, there appears to be a correlation between the wood present and the formation of pools within or upstream of the transects containing wood (Figure 3). This pattern is less consistent in the post-construction surveys in Year 1. The number of pools pre- and post- project implementation appears to have remained the same (~4 pools within the reach).

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Salmon Recovery
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Reach-Scale Effectiveness Monitoring Program

Large Woody Debris Catalog