Action Effectiveness Monitoring in the
"Implement Habitat Restoration in the Lower Columbia River and Estuary" Contract

Annual Report

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Action Effectiveness Monitoring in the "Implement Habitat Restoration in the Lower Columbia River and Estuary" Contract

Annual Report for September 15, 2007 – September 14, 2009

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Executive Summary

This report is the annual report documenting Action Effectiveness Monitoring (AEM) efforts implemented by the Lower Columbia River Estuary Partnership (Estuary Partnership) under Bonneville Power Administration (BPA) Project Number 2003-011-00, Contract Number xxx.

The Estuary Partnership contracted Parametrix, NOAA Fisheries, Ash Creek Forest Management (ACFM), Scappoose Bay Watershed Council (SBWC), and Columbia River Estuary Study Taskforce (CREST) to conduct pilot AEM at four sites (Mirror Lake, Sandy River Delta, Scappoose Bottomlands, and Fort Clatsop) in spring 2009. These AEM sites represent different restoration activities (culvert enhancement to improve fish passage, large wood installation, revegetation, cattle exclusion, and culvert removal for tidal reconnection), habitats (bottomland forest, riparian forest, emergent wetland, and brackish wetland), and geographic reaches of the river (Reaches H, G, F, and A, ranging from tidal freshwater in Reach H, or the Columbia River George, to saltwater intrusion in Reach A, near Astoria, Oregon).

<u>Summaries of 2009 AEM Results</u>

- Parametrix monitored the effectiveness of improvements to the culvert that connects the Mirror Lake Restoration Site with the Columbia River with respect to <u>whether the improvements </u>provid~~eing~~ hydraulic refugia for fish. Additionally, Parametrix evaluated the effectiveness of the installation of in-stream habitat structures (Large Woody Debris; LWD) with respect t<u>o whether they</u>~~o~~ increas~~eing~~ fish habitat diversity (**Section 2 Fish Passage Improvement and LWD Monitoring AEM at Mirror Lake**). Site visits occurred after construction, in winter high flows and in summer low flows. No longitudinal movement or rotation of any of the boulders in the culverts and at the outlet of culvert was detected, indicating stability of the installed boulders after high flow events. The velocity of water flow behind these boulders in the culvert and culvert outlet appeared to be providing hydraulic refugia for fish passage, based on qualitative analysis. Lateral scour pools formed under and directly downstream of all LWD structures surveyed, suggesting that habitat diversity is increasing in the stream due to these installed structures. Additionally, some of the structures are providing for recruitment of small woody debris. There were no off-channel pools observed, likely because the stream is incised and streamside vegetation is dense. In the long term, hydraulic forces may begin to create these features, but further monitoring would be required to confirm this. Because the Mirror Lake site is routinely flooded during the winter months (submerging the LWD) and no movement of LWD has been observed to date, it is expected that the LWD will remain in place.

- NOAA Fisheries sampled fishes and macroinvertebrates monthly from April to September 2009 at 3 locations at the Mirror Lake restoration site to describe site usage by fishes, condition and stock of collected juvenile salmonids, and abundance and biomass of macroinvertebrates (**Section 3 <u>3.0 Juvenile Salmonid and Prey AEM at Mirror</u>** <u>Lake</u>~~**Juvenile Salmonid and Prey AEM at Mirror Lake**~~). The Mirror Lake Complex, Sites #1 (Lake)~~-~~, #2 (Young Creek) and #4(Culvert), are being used by juvenile salmonids<u> (site #3 not sampled due to inaccessibility)</u>. The Young Creek site (Site #2) appears to be an important rearing area for juvenile coho, where they are found in large numbers from April through the end of the sampling season.

  Fish species richness ranged from 5 to 17 (**Error! Reference source not found.**~~Table~~ 3-4). The species richness was similar between Site #1 (Lake) and Site #4 (Culvert) including proportions of non-native species. (47% of species present at both sites). At Site #4 (Young Creek), ~~no~~ non-native species were <u>not </u>observed. <u>In </u>April through June, juvenile Chinook and coho were found at sites in Mirror Lake (Lake Site) and downstream of the I-84 culvert (Culvert Site). In April, Chinook salmon

Formatted: Font: (Default) Times New Roman, Bold were all wild, becoming subsatantially marked hatchery fish in May and June while coho were largely unmarked presumably wild fish. Between July and September, no salmonids were captured at Site #1 (Lake) or Site #4 (Culvert). At the upstream Young Creek Site (Site #4), as in 2008, large numbers of unmarked coho (but no Chinook) were captured from May through September. For the first time since monitoring began, chum salmon were captured at the Mirror Lake Complex, at the Young Creek site in April. Overall data from 2008 and 2009 indicate that Sites #1 (Lake) and #4 (Culvert) are being utilized by wild fall Chinook from several stocks, including those from the Upper Columbia and the Snake and Deschutes Rivers. Prey availability and consumption at Mirror Lake sites #1 and #4 in late spring 2008 and 2009 appear similar to patterns seen at other LCRE sites, with a relatively high proportion of Dipterans (primarily Chironomidae larvae and pupae) in the diets of Chinook salmon. Although many of the same taxa were present at Site #2 (Young Creek) samples generally contained lower proportions of Dipterans and higher proportions of other species. Based on samples analyzed to date, exposure to urban and industrial contaminants (i.e., PCBs, PBDEs and PAHs) is relatively low in Chinook salmon caputured at the Mirror Lake sites #1 and #4 (no samples were analyzed for Site #2). Chinook lipid levels and condition factor for the Culvert Site were below average for other LCRE samples and significantly lower than Site #1 (Lake). Lipid analyses on the remaining samples collected 2008 as well as otolith and lipid samples collected in 2009 are now in progress, and those data will be presented in a subsequent report.

- ACFM returned to 5 restoration sites to collect data at 192 vegetation plots across 259 acres at the Sandy River Delta and Mirror Lake restoration sites (19Table 4-1) to assess the success of invasive vegetation removal and native vegetation plantings at these restoration sites (**Section 4** **4.0 Planting Success AEM at Mirror Lake and Sandy River** Delta**Planting Success AEM at Mirror Lake and Sandy River Delta**). At all planted restoration sites, ACFM found a range of 1,100 to 3,300 live, woody plantings per hectare, showing a survival rate of 68 to 98 %; trees comprised 33% to 98% of live, woody plantings measured. Survival rate oif woody plantings was higher in 2009 than in 2008 (68 to 98 % versus 56 to 90%; Table 4-4). In addition, total woody plant stocking estimates increased on all sites (except one site, due to changes in data plot configuration). Duration of weed control before planting, or site preparation, plant growth and natural plant establishment likely contributed to these increases. This AEM suggests that continued maintenance is needed at all sites in order to achieve restoration goals; however, intensity of treatment needs has declined from 2008. Vegetation management treatments for all sites are outlined in **Error! Reference source not found.**Table 4-6.

- Following vegetation plantings and cattle exclusion at the Scappoose Bottomlands restoration area, SBWC deployed two loggers to monitor water temperature and depth, collected photo-points at 7 sites to assess landscape change, assessed planting success in 64 plots, and collected vegetation community data in 3 tidal wetland ponds at Hogan Ranch **(Section 5** **5.0 Vegetation and Habitat AEM at Scappoose** Bottomlands**Vegetation and Habitat AEM at Scappoose Bottomlands**). Photo-point analyses will be included in the 2010 report. The overall survival rate of plantings along Lower Scappoose Creek was 77% with an average planting density (APD) of 0.33 plants/m^2 (Table 5-4). On Hogan Ranch, the overall survival was 89% with an APD of 0.16 plants/m^2. Vigor of the surviving plantings was similar between the two sites and was comparable to the 2008 survival results (Table 5-4**Error! Reference source not found.**). The largest difference between years was at Hogan Ranch in 2009, there was in increase in high vigor plants, due primarily to the additional planting of willow and flood resistant shrubs in the spring of 2009. One-year post cattle exclusion, the Hogan Ranch wetlands are showing signs of recovery. Native wapato dominates a large area of Pond #3, providing a food resource for waterfowl and other wildlife. On Ponds #1 and #2, the wetted area is increasing and the vegetation reflects this change. In 2009, the dissolved oxygen, turbidity, conductivity and pH in Pond #3 in July and August, were higher than in past years, with pH over 9.0. The growth of algae in the pond could be contributing to this issue. This AEM has

Formatted: Font: (Default) Times New Roman, Not Bold, Check spelling and grammar

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- CREST gathered fish and macroinvertebrate data at Scappoose Bottomlands (Hogan Ranch) and habitat (sediment accretion, channel cross-sections, and photo-points), fish, and macroinvertebrate data at the Fort Clatsop restoration and reference sites, for the second year. In 2009, CREST began collecting water quality data. Fish and macroinvertebrates were sampled monthly between February and July at Scappoose Bottomlands and at the Fort Clatsop sites (**Section 6** **6.0 Salmon, Salmon Prey, and Habitat Monitoring at Scappoose Bottomlands and Fort Clatsop****Salmon, Salmon Prey, and Habitat Monitoring at Scappoose Bottomlands and Fort Clatsop**).

  For the site at Scappoose Bottomlands, fish species and abundance varied in 2009, (**Error! Reference source not found.**Table 6-19), consistent with 2008 data, although there was an increase in goldfish and stickleback. Similar to 2008, one wild subyearling coho salmon was collected at the Scappoose Bottomlands in March 2009 (**Error! Reference source not found.**Table 6-19). The March gut sample indicates that Annelida and Corixidae were being consumed,

  At the Fort Clatsop restoration site in 2009, Chinook, coho, chum salmon and cutthroat trout were observed. In 2009, salmon were more abundant and diverse relative to data collected in 2007 prior to restoration actions, and less abundant than in 2008 potentially due to decreased sample frequency in 2009 or other environmental factors. As in previous years, the mean length distribution for salmon in 2009 demonstrated that subyearling sized individuals use the restoration site more-so than yearlings.

  At the reference site in 2009, salmon species diversity was higher than in 2008 or 2007, with collections of Chinook, coho chum and cutthroat trout Insect fall-out trap and benthic core samples demonstrated higher diversity of insect prey taxa available for salmon to consume (e.g. Corophium). Like the restoration slough, there was a potential bias towards adult versus other life history stages, though more non-adult stages were found at the reference site by comparison. At the reference site, terrestrial invertebrates documented in the fall out traps were more numerous later in the spring than earlier whereas aquatic invertebrate results from the benthic sediment cores were more similar over time. Yearlings dominate the reference site, independent of the time of year.

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1.0 Background on Estuary Partnership's Action Effectiveness Monitoring

The 2007 Draft Biological Opinion for the Federal Columbia River Power System (Draft 2007 BiOp) highlights the importance of estuarine habitat restoration for anadromous fishes (Reasonable and Prudent Alternatives [RPA] 36-38). These restoration RPAs are to be implemented in conjunction with action effectiveness monitoring (AEM) identified in RPA 60. AEM is needed to "evaluate the effects of selected individual habitat restoration actions at project sites relative to reference sites and evaluate post-restoration trajectories based on project-specific goals and objectives" (NMFS, 2007).

In response to the Draft 2007 BiOp, the plan for "Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program" (Estuary RME) was prepared for the Bonneville Power Administration (BPA) by the Pacific Northwest National Laboratory (PNNL) in conjunction with National Oceanic and Atmospheric Administration (NOAA) Fisheries and the US Army Corps of Engineers (USACE) with the collaboration of the Lower Columbia River Estuary Partnership (Johnson et al. 2008). This document provides a framework to evaluate progress towards understanding, conserving, and restoring the estuary to benefit ESA listed salmonid species and outlines a plan for AEM.

The Effectiveness Monitoring Program administered by Lower Columbia River Estuary Partnership (Estuary Partnership) will implement AEM to address RPA 60 in the 2007 Draft BiOp based on the Estuary RME plan. This Effectiveness Monitoring Program will focus on projects sponsored by the Estuary Partnership's Habitat Restoration Program. This program has invested more than $4 million in habitat restoration in the lower Columbia River estuary (LCRE) since 1999 and contributed to over 30 projects, ranging from riparian revegetation to tidal reconnection.

1.1 Program Goal and Objectives

On-the-ground AEM efforts will collect the data needed to assess the performance and functional benefits of restoration actions in the LCRE. The goal of this effort is to provide the Estuary Partnership, primary funding agencies (BPA and Environmental Protection Agency [EPA]), restoration partners (e.g., USACE and Columbia River Estuary Study Taskforce [CREST]), and others with information useful for evaluating the success of restoration projects. Such evaluations supported by AEM will facilitate improvements in project design and management, increase the success of restoration projects for ESA listed salmonids, and address RPA 60 of the 2007 Draft BiOp.

The Estuary Partnership's objectives for the Effectiveness Monitoring Program are to:

- Implement AEM as outlined in the Estuary RME plan (Johnson et al. 2008) and following standardized monitoring protocols (e.g., Roegner et al. 2009) where applicable
- Develop long-term datasets for restoration projects and their reference sites
- Increase consistency in monitoring methods and data management and sharing between projects
- Disseminate data and results to facilitate improvements in regional restoration strategies
- Develop of a regional cooperative effort by all agencies and organizations participating in restoration monitoring activities to maximize the usefulness of monitoring data

Additionally, the Estuary Partnership aims for the Effectiveness Monitoring Program to complement our existing Ecosystem Monitoring Project (BPA 2003-007-00). The Ecosystem Monitoring Project implements monitoring activities to characterize undisturbed emergent wetlands and assess juvenile salmonid usage of those habitats. Several sites monitored by the Ecosystem Monitoring Project are included in the Estuary Partnership's Reference Site Study funded by BPA. Since the Ecosystem Monitoring Project monitors many parameters likely to be included in AEM (e.g., vegetation, water quality, and salmon), the collection of comparable datasets by the two programs (where possible) will fill data gaps and add to our understanding of habitat conditions and juvenile salmonids in the lower river.

1.2 Site Selection

In January 2008, the Estuary Partnership and the Estuary and Oceanic Subgroup (EOS) identified sites for pilot AEM. The Estuary Partnership presented a sample of restoration projects supported with BPA funds as potential sites (1~~Table 1-1~~, 1 ~~Figure 1-1~~). Projects included a variety of restoration activities implemented in different habitats and reaches of the river. EOS members recommended selecting sites to represent different restoration activities, habitats, and geographic reaches of the river. Other recommended considerations included:

- Baseline monitoring was conducted at the restoration site.
- Re-vegetation AEM in different habitats would provide useful data and be low in cost relative to AEM for projects such as like tidal reconnection.
- If possible, AEM should occur at sites where restoration actions are apt to continue for multiple years (indicating a financial investment in the project area).
- AEM at sites sponsored by BPA and partners would provide collaboration opportunities.
- Some (but not all) project managers would have the capacity to implement AEM in 2008.

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EOS members recommended 4 projects for AEM (Mirror Lake, Sandy River Delta, Scappoose Bottomlands, and Fort Clatsop; highlighted rows in 1Table 1-1 and green dots in 1 Figure 1-1), that were first sampled in 2008 and 2009. These AEM sites represent different restoration activities (culvert enhancement to improve fish passage, large wood installation, re-vegetation, cattle exclusion, and culvert removal for tidal reconnection), habitats (bottomland forest, riparian forest, emergent wetland, and brackish wetland), and geographic reaches of the river (Reaches H, G, F, and A, ranging from tidal freshwater in Reach H, or the Columbia River Gorge, to saltwater intrusion in Reach A, near Astoria, Oregon).

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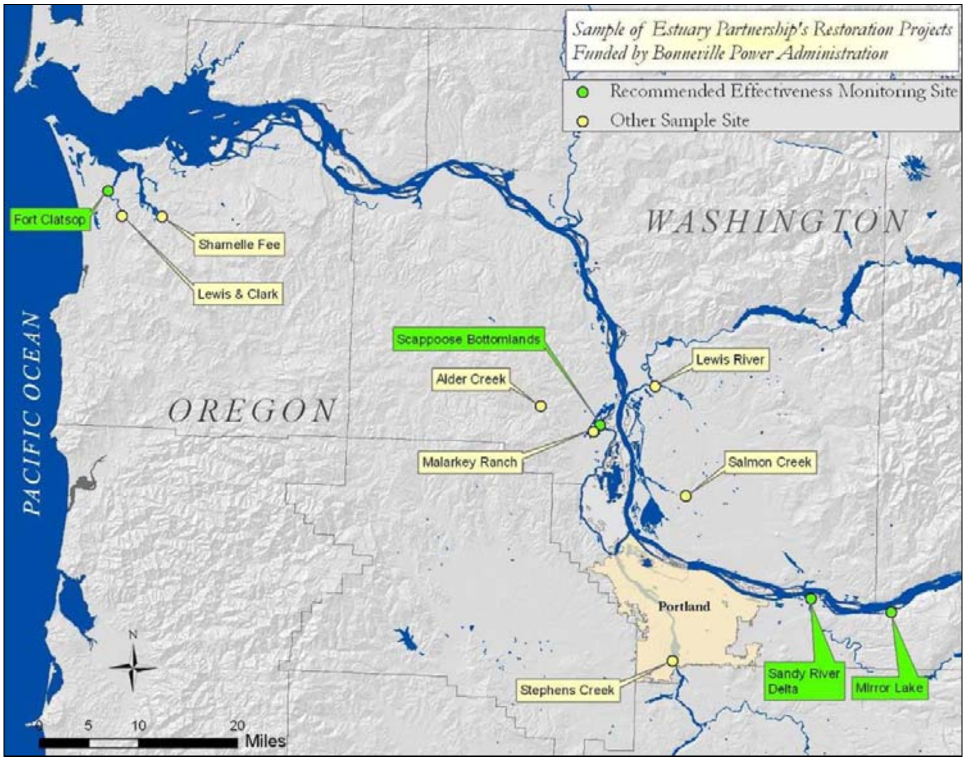
1Table 1-1. Sample of Estuary Partnership restoration projects funded by BPA presented as potential sites to EOS members. Recommended AEM sites are highlighted in gray.

Project Name	Restoration Activity	Year(s) When Restoration Occurred	Habitat Type	Reach	Baseline Monitoring
Mirror Lake	Improve fish passage; Large wood installation; Native plant revegetation	2007 – Present	Bottomland hardwood forest	H	Yes
Sandy River Delta	Native plant revegetation	2004 – 2006	Riparian forest	G	No
Stephens Creek	Floodplain reconnection; Native plant revegetation	2007 – Present	Floodplain	G	Yes
Salmon Creek	Large wood installation	2007 – Present	Riparian	F	TBD
Malarkey Ranch	Culvert removal	2004 – 2005	Instream	F	Yes
Scappoose Bottomlands	Cattle exclusion; Invasive removal; Native plantings	2004 – Present	Emergent wetland	F	Yes
Alder Creek	Culvert removal	2005 – 2006	Instream	F	Yes
Lewis River	Native plant revegetation	2007 – Present	Riparian	E	TBD
Sharnelle Fee	Dike breach	2005 – Present	Tidally influenced wetland	A	Yes
Lewis and Clark	Dike breach	2004 – 2006	Tidal estuarine habitat	A	Yes
Fort Clatsop	Culvert removal and bridge installation	2005 –Present	Brackish wetland	A	Yes



1Figure 1-1. Sample of Estuary Partnership restoration projects funded by BPA presented as potential sites to EOS members. Sites that EOS members recommended for AEM are denoted by the green dots and boxes.

2.0 Fish-passage improvement and LWD monitoring AEM at Mirror Lake

Over the past 4 years, several restoration actions have been implemented at the Mirror Lake site. Actions include replacement of a failing culvert with a wooden bridge; reforestation of 45 acres of riparian habitat; installation of 13 instream habitat structures (composed of 65 pieces of large woody debris, LWD); and improvement of fish passage at the site's outlet culverts. In 2008, AEM efforts by Parametrix (Estuary Partnership Contract #07-2008) focused on assessing temperature conditions and juvenile salmonid use of the site. In 2009, AEM efforts by Parametrix (Estuary Partnership Contract # xxx) focused on evaluating fish-passage culvert improvements connecting the Mirror Lake Restoration Site with the Columbia River, effectiveness of the LWD installation in Young Creek..

Specific objectives of this AEM study are to provide data to:

- Evaluate the effectiveness of the improvements to the culverts connecting the Mirror Lake Restoration Site with the Columbia River with respect to fish passage and evaluate the effectiveness of the LWD installation with respect to increasing fish habitat diversity;
- Guide long-term site management and broad-scale planning of restoration/enhancement activities;
- Evaluate juvenile salmonid use of the site following passage improvements and LWD installation

2.1 Site Description

The Mirror Lake site is a 390-acre parcel located within Rooster Rock State Park, ~10 miles east of Troutdale in the Columbia River Gorge (Gorge). I-84 forms the site's northern boundary; the Union Pacific Railway rail line forms the southern boundary. About 50% of the land is publicly owned by the Oregon Parks and Recreation Department (OPRD) and is undisturbed forest.

The Mirror Lake site is unique in that it provides a large, contiguous tract of historic bottomland hardwood forest within the Columbia River floodplain. The site includes 2 lakes, 2 streams (Latourell Lake and Mirror Lake, Young and Latourell Creeks), expansive wetlands, and remnants of its bottomland hardwood forest. Latourell and Young Creeks enter the site as moderate gradient systems with gravel/cobble substrate, but quickly transition to meandering, low gradient streams flanked by extensive wetlands. Both streams support spawning populations of Lower Columbia River coho salmon (StreamNet 2010; Parametrix 2004) and provide rearing and/or off-channel habitat for steelhead/rainbow trout and Chinook salmon, likely from Lower Columbia and up-river evolutionarily significant units (ESUs) (StreamNet 2010). Juvenile rearing is the only salmonid life history stage that occurs at the site during summer months when temperatures are potentially limiting (**Error! Reference source not found.**~~Table 2-1~~). Spawning, migration, egg incubation, and fry emergence occur during fall, winter, and spring months when temperatures are relatively cool and are not a limiting factor. Numerous other species are found on-site (**Error! Reference source not found.**~~Table 2-2~~).

Young Creek, which runs east to west across the site, enters the site through an open-bottom culvert under the Union Pacific railroad tracks ~100 yards downstream of Shepperds Dell Falls. Within the site, the stream's upper segment (~2,800 ft in length) was flanked by 45 acres of non-native Himalayan blackberry (*Rubus discolor*) and reed canary grass (*Phalaris arundinacea*) that was replanted with native species in 2008 by the EP and the Oregon Department of Transportation (ODOT). At the terminus of this upper reach, Young Creek flows beneath a wooden bridge installed by the EP and OPRD in 2005. From the bridge, Young Creek continues west ~5,800 ft to its confluence with Latourell Creek, flowing between I-84 to the north and an upland forest to the south. The lower reach of Young Creek is a wide, low-gradient creek with silty substrate and relatively homogenous habitat. It has few meanders and is flanked by expansive wetlands dominated by reed canary grass and/or wool grass (*Scirpus cyperinus*). About 500 ft of Young Creek (located immediately downstream of the railroad culvert) contains substrate suitable for salmonid spawning; silty substrate dominates the remainder of the stream.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spawning												
Chinook Salmon												
Coho Salmon												
Steelhead/Rainbow												
Incubation												
Chinook Salmon												
Coho Salmon												
Steelhead/Rainbow												
Rearing												

Chinook Salmon	
Coho Salmon	
Steelhead/Rainbow	

	Species/Life Stage Not Present
	Species/Life Stage May Be Present
	Species/Life Stage Greatest Chance of Presence

2~~Table 2-1~~ Timing of salmonid use of Latourell and Young Creeks. Juvenile chum and sockeye salmon likely use this area as off-channel habitat during out-migration; however, their presence has not been documented

Common Name	Scientific Name	*Above* Confluence	*Below* Confluence
Coho salmon	*Oncorhynchus kisutch*	X	X
Chinook salmon	*O. tshawytscha*	X	X
Steelhead/rainbow trout	*O. mykiss*	X	
Threespine stickleback	*Gasterosteus aculeatus*	X	X
Smallmouth bass	*Micropterus dolomieu*	X	X
Largemouth bass	*M. salmoides*		X
Sculpin	*Cottus spp.*	X	X
Pacific lamprey	*Lampetra tridentata*	X	X
Pumpkinseed	*Lepomis gibbosus*	X	X
Bluegill	*L. macrochirus*		X
Common carp	*Cyprinus carpio*		X
Banded killifish	*Fundulus diaphanus*		X
Yellow bullhead	*Ameiurus natalis*		X
Northern pikeminnow	*Ptychocheilus oregonensis*		X
Chiselmouth	*Acrocheilus alutaceus*		X
Peamouth	*Mylocheilus caurinus*		X
Crayfish	*unknown*	X	X
Red-legged frog	*Rana aurora*	X	
Bullfrog	*R. catesbeiana*	X	X

Sources: Parametrix 2004, 2006; unpublished fish salvage data and field observations by Parametrix staff from 2004 through 2008

3~~Table 2-2~~. Aquatic species observed above and below the confluence of Latourell and Young Creeks.

Due to the existing conditions within the project area as outlined above, this site has been the target of multiple restoration activities. During August and September of 2008, improvements were made on the 200 foot-long parallel concrete box culverts (east and west culverts) installed under Highway I-84 connecting the Mirror Lake project area with the Columbia River.

The culvert improvements included:

- Placement of boulders within the culverts to provide a source of hydraulic refugia for fish migrating through the culvert during high flow events;
- Regrading and placement of boulders on the culvert outlets to channelize flow from the culverts, thereby increasing the depth of flow to improve fish passage; and
- Placement of a low flow diverting check dam on the inlet side of the east culvert to provide adequate flow for fish passage in the west culvert during low flow events.
- During this same time period, improvements were made to Young Creek. These included the installation of 65 individual pieces of large woody debris (LWD) in selected sections of Young Creek, creating a total of 13 separate structures (see Appendix 1).

2.2 Methods

2.2.1 Culvert Monitoring

To assess the stability boulders placed within the culvert, a representative sample of six boulders were selected at the upstream, middle, and downstream sections of the culvert (three in the east culvert and three in the west culvert). These boulders were monitored for movement between the baseline conditions (shortly after construction, on November 19, 2008), and then during winter and summer of 2009.

Baseline documentation of boulder locations consisted of marking boulders with arrows that pointed in the direction of dominant flow when unobstructed by backwater effects from the Columbia River (North). In addition, lines were painted on the culvert dividing walls, corresponding to the downstream edges of the boulders. Measurements were taken for each boulder in the sample documenting the distance between the boulders and the culvert divider wall, the painted arrow and the divider wall, and the downstream edges of the boulders and the culvert outlet. Photo documentation at selected photo points was performed at the culvert inlet, within the culvert and at the culvert outlet. A schematic was drawn of the boulder locations within both culverts to document locations and aid in future location of the sample boulders for measuring movement.

Boulder stability monitoring during the winter and summer seasons consisted of collecting photo documentation from the same selected photo points as set during the baseline monitoring event (where feasible), and measuring any changes in boulder locations within the culverts to determine if movement had occurred and if the boulders appeared effective in providing hydraulic refugia. Criteria for determining the effectiveness of providing hydraulic refugia include verification that velocities felt slower behind the boulders than adjacent to the boulders. Where boulder movement had occurred, the schematic was revised as necessary.

In addition to monitoring the boulders within the culverts, monitoring was also performed at the outlet of the west culvert during baseline, winter and summer monitoring events to measure the effectiveness of boulder placement and regrading. The west culvert outlet monitoring included: measurement of boulder diameters and location relative to the northwest corner of the west culvert outlet; measurement of the graded channel bottom width in 0.5-foot increments across the channel and at 2.5-foot longitudinal increments as measured from the west culvert wingwall; photo documentation of the culvert outlet channel; visual assessment of the graded channel in providing adequate depth of fish passage; and creation of a schematic of the culvert outlet with an overlaid grid to document relative locations of the boulders and the bottom width of the graded channel.

During all three of the boulder stability monitoring events outlined above, the field staff also performed qualitative assessments of the low flow diversion structure to determine if the structure was functioning properly with respect to increasing water depth in the west culvert. This was conducted by a visual comparison of the depths of flow at the culvert inlets and outlets.

2.2.2 Low Flow Diversion Monitoring

During the baseline and season monitoring of the boulder stability monitoring events outlined above, the field staff also performed qualitative assessments of the low flow diversion structure to determine if the structure was functioning properly with respect to increasing water depth in the west culvert. This was conducted by performing a visual comparison of the depths of flow at the culvert inlets and outlets.

2.2.3 Large Woody Debris Monitoring

The methodology used for assessing the effectiveness of the LWD installations was based on Protocol 3 in Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary (NOAA 2009). The locations of end points for all cross sections were recorded using GPS in the Oregon State Plane North coordinate system. For each cross section, the ground surface topography and water surface are shown for each sampling datum. For those cross sections that crossed LWD, the location of the structure was also surveyed. Minor variations in the topography between the two sampling events, especially outside of the active channel, are likely due to minor changes in the vegetation and are not considered to be significant. The following steps were performed to establish the cross sections for baseline and future measurements:

1. Four groups of five cross sections apiece were selected where large woody debris structures were installed
    a. Each set of cross sections included a cross section upstream of the LWD structures, three within the immediate vicinity of the structures, and one downstream of the structures.
2. At the furthest upstream cross section of each group, steel tee posts were driven into the bank on either side as far away from the active channel as possible;
3. Successive downstream cross sections were monumented with rebar stakes;
4. Distances from the tee posts to each of the rebar spikes were recorded for both sides of the bank should some rebar stakes be lost; and
5. GPS coordinates were recorded at each tee post and rebar stake to document locations should the tee posts or stakes be lost.

The project team collected cross sectional survey data using a surveyor's level and stadia rod at 20 cross sections within the study area. The accuracy for the data points is approximately 5 to 10 feet horizontally. To minimize impacts on the streambed, the project team used a ladder or plank to traverse the creek on each cross section. Because no survey data are available for the site, benchmarks were established and assigned "dummy" elevations. This allowed for accurate comparison of the cross sections from different site visits. Data collection consisted of the following steps:

1. Measurement of reference elevation off of benchmark;
    a. When taking a cross section bound by tee posts, record the rod reading for the top of the tee posts on either bank as an additional benchmark.
2. Set-up tape measure pulled tight across the stream from the left bank to right bank facing downstream; and

3. Record rod readings and corresponding station (from measuring tape) moving from the left post/stake to the right post/stake. The distance between consecutive rod readings is sufficient to capture changes in grade (every 1 to 3 feet outside the active channel and at a maximum of 0.5 ft in the active channel).
    a. Ensure the rod is in contact with the ground and not perched on vegetation;
    b. Record rod reading of water surface on either bank;
    c. Make note of undercut banks along with depth of undercut when encountered in cross section; and
    d. Make note of locations of LWD when encountered in cross section.

At each set of cross sections, photo documentation was performed at selected photo points and notes were made as to the effectiveness of the LWD at recruiting small woody debris by noting whether or not it was present in the vicinity of the structures.. Raw data collected in the field were recorded in an Excel spreadsheet. Using the reference benchmark elevations, the stadia rod readings were converted to reference elevations. The resulting elevation data calculated were plotted along with station data to create graphical representations of the cross sections. The water surface elevation and the LWD (as applicable) were also included for each cross section. For all parts of the cross section where undercut banks were noted, an extra data point was created to provide an estimated station and elevation of the undercut bank.

2.3 Results

2.3.1 Boulder Monitoring in Culverts

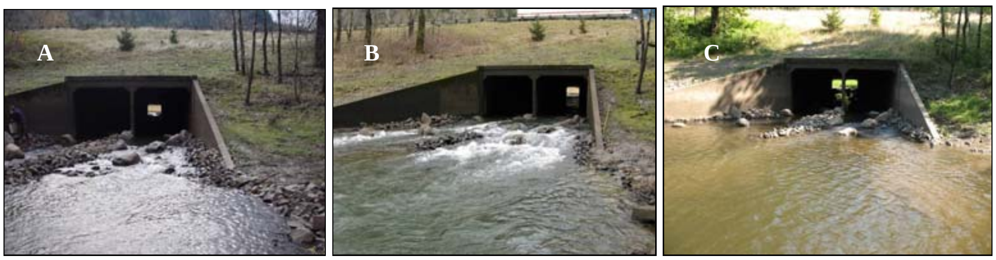
No longitudinal movement or rotation of any of the boulders was detected within the culverts on either the winter or summer follow-up monitoring events in 2009. While the high flows during the winter scoured most of the painted arrows from the boulders, enough remained to positively identify the arrow direction. Figures 2-1 shows comparisons of boulder locations from the three sampling events in the west culvert. The east culvert, while not photo-documented, showed similar results. Every effort was made to coordinate with state park staff to observe the culverts for the winter monitoring event during high flows. However, the site visit did not occur during the highest flows of the season.

During all three events, the field staff noted that the force of the flowing water was lower behind the boulders than in the unobstructed flow area. These observations were qualitative and provide no quantitative scale of the difference in velocities.

2~~Figure 2-1~~. Photos of boulder monitoring locations at the west culvert, Mirror Lake. A) View facing upstream in west culvert, November 2008; B) View facing upstream in west culvert, March 2009; and C) View facing upstream in west culvert, July 2009.

2.3.2 Culvert Outlet Monitoring

Culvert outlet measurements during the monitoring visits (winter and summer) showed no change in the position of the boulders on the west culvert outlet, overall grading, or the measured bottom width of the channel. Figures 2-2 are is photos from the selected photo point showing the culvert outlets during the November 2008, March 2009, and July 2009 monitoring events.



3Figure 2-2.. Photos of culvert outlet monitoring locations at the west culvert, Mirror Lake. A) Culvert outlet November 2008; B) Culvert outlet, March 2009; and C) Culvert outlet, July 2009.

2.3.3 Low Flow Diversion Structure Monitoring

Based on the observations taken during baseline and season monitoring visits, the low flow diversion structure did appear to be diverting a greater portion of the flow to the west culvert. Figure- 2-3 shows the diversion structure during each monitoring event. It is estimated that approximately 60 to 90 percent of flow was being diverted to the west culvert on any given site visit, depending on the overall flow present. Timing of the monitoring events, however, likely did not coincide with the lowest flows of the year; however, observations of flow during the July 2009 site visit estimated that at least 90 percent of flow was diverting to the west culvert. Visual observations of the water level at the outlets of each culvert showed a difference of about 3 to 5 inches, with the west culvert having the higher water level. During all monitoring site visits, at least 6-inches depth of flow was present in the west culvert.

4Figure 2-3. Photos of the low flow diversion structure monitoring, Mirror Lake. A) Diversion structure, November 2008; B) Diversion structure, March 2009; and C) Diversion structure, July 2009.

2.3.4 Large Woody Debris Monitoring

Initial cross section selection and surveying of LWD in Young Creek was performed on November 4 and 5, 2008. The second round of data collection occurred on August 24 and 25, 2009. Benchmarks for each set of cross sections were monumented during the November 2008 sampling event, as well. Figures 2-4 shows the locations of the benchmarks.

5~~Figure 2-4~~. Photos of LWD monitoring, A) Nail set into tree base as benchmark for cross sections 1–5. Tree located on right bank to east of cross section 1. Reference elevation of 30 ft; B) Nail set into tree base as benchmark for cross sections 6–10. Tree located on right bank adjacent to cross section 6. Reference elevation of 25 ft; and C) Benchmark for cross sections 11–20 is in northwest corner of retaining wall on Young Creek Bridge. Reference elevation of 20 ft.

For each cross section, the ground surface topography and water surface are shown for each sampling datum. For those cross sections that crossed LWD, the location of the structure was also surveyed. Minor variations in the topography between the two sampling events, especially outside of the active channel, are likely due to minor changes in the vegetation and are not considered significant. See Appendix 1 for a map of the locations of LWD at Mirror Lake and an example of a channel cross section (Cross Section #3). A description of the results of the cross sections taken on Young Creek is given below:

- Cross section 1, taken about 5 feet upstream of the LWD, showed very little change in shape over the course of the study period.

- The channel at cross section 2, taken 1 foot upstream of LWD, did appear to shift toward the right bank slightly.

- Cross section 3 (see Figure 2-5; Appendix 1) showed significant differences between the two monitoring events. This cross section is located directly downstream of LWD. A beaver dam appears to have been constructed on the LWD, creating pooling upstream (see Figure 2-5 B). Flow bypassed the sides of the beaver dam and scoured both banks, creating slope failures and widening the downstream active channel. The right bank rebar stake was undercut over the course of the winter and spring of 2008- 2009. During the August 2009 site visit, this was replaced with a tee post as close to the position of the original rebar stake as possible. While more bank failures are probable, the LWD does not appear to have moved and is likely anchored sufficiently into the adjacent slope to prevent future movement.

- Cross section 4, located about 7 feet downstream of cross section 3, also showed signs of bank failure, with a large portion of the left bank having recently sloughed into the channel.

- Cross section 5, taken about 12 feet downstream of cross section 3, showed signs of the left and right banks being undercut.

6~~Figure 2-5~~. LWD monitoring at Mirror Lake. A) View of cross sections 1–5 facing downstream, November 2008; B) LWD at cross section 3 showing beaver dam activity, August 2008; and C) View of cross sections 1–5 facing downstream, August 2009.

- Cross section 6 (see Figure 2-6) was taken about 20 feet upstream of the first piece of LWD and showed very little change between monitoring events.

- Cross sections 7–10 (see Figure 2-6) were all taken directly downstream of individual LWD and showed similar patterns of the channel becoming wider and deeper in the vicinity of the LWD structures.

7~~Figure 2-6~~. LWD monitoring at Mirror Lake. A) View of cross sections 6-10 facing downstream from cross section1, November 2008; B) View of cross sections 6-10 facing downstream from cross section 1, August 2009; C) View of cross sections 6-10 from the benchmark, November 2008; and D) View of cross sections 6-10 from the benchmark, August 2009.

- Cross section 11 (see Figure 2-7) was taken directly downstream of the bridge and approximately 10 feet upstream of the first piece of LWD. Comparison of the November 2008 and August 2009 sampling events shows a significant increase in the depth and width of the active channel at this cross section.

- Cross section 12 (see Figure 2-7) shows a slightly different trend; the channel is deepening and banks are actually narrowing. While the LWD surveyed in this cross section does not appear to have moved, there has been a noticeable amount of scour beneath it, creating a deep pool.

- Cross section 13 (see Figure 2-7), taken about 7 feet downstream of cross section 12, shows a noticeable widening of the active channel in the direction of the left bank.

- Conversely, cross section 14 (see Figure 2-7), taken approximately 12 feet down from cross section 13, shows the channel narrowing and deepening significantly, with the location of the thalweg moving toward the left bank.

- Cross section 15 (see Figure 2-7), taken approximately 8 feet downstream of cross section 14 and after the last piece of LWD, shows deepening of the channel with limited widening.

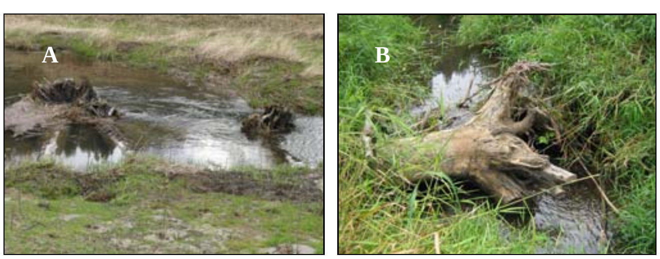
8Figure 2-7. LWD monitoring at Mirror Lake. A) View of cross sections11-15 from south side of bridge, November 2008; B) View of cross sections 11-15 from center of bridge, November 2008; C) View of cross sections 11-15 from north side of bridge, November 2008; D) View of cross sections 11-15 from the south side of the bridge, August 2009; E) View of cross sections 11-15 from center of bridge, August 2009; and F) View of cross sections 11-15 from north side of bridge, August 2009.

- In all cases, for cross sections 16-20, the stream channel deepened without much increase in the width of the active channel. No LWD surveyed showed a noticeable difference in position, indicating that no movement had occurred (see Figure 2-8).

9Figure 2-8. LWD monitoring at Mirror Lake. A) View of cross sections16-20 from top of slope on north side of creek, November 2008; B) View of cross sections 16-20 facing downstream from cross section 16, August 2009; C) View of cross sections 16-20 from top of slope on north side of creek, August 2009; and D) View of cross sections 16-20 facing downstream from cross section 16, November 2008.

2.3.5 Small Woody Debris Recruitment

Field observations during the November 2008 surveying event noted that small woody debris recruitment was occurring at many of the LWD structures. Figure 2-9 A shows an example of this at approximately cross section 12. The second survey event in August noted recruitment at only a few of the structures, most notably the LWD at cross section 3. This is shown in Figure 2-9 B.



10Figure 2-9. LWD monitoring of SWD recruitment at Mirror Lake. A) Small woody debris recruitment on LWD at cross section 12, November 2008; and B) Small woody debris recruitment on LWD at cross section 3, March 2009.

2.4 Discussion

2.4.1 Culvert Monitoring

Based on the monitoring results, all of the boulders in the culverts and at the outlet appear to be stable and providing hydraulic refugia for fish passage. Furthermore, regrading at the outlet of the west culvert appears to be stable and maintaining an adequate depth of flow during the lower flows observed in July 2009.

With respect to the low flow diversion structure results, there does appear to be a significant difference in the volumes of flow passing the west and east culverts; however, quantitative results cannot be determined from available data.

The following are a few suggested strategies for future monitoring to enhance the understanding of the long-term stability and effect that the culvert improvements have had on fish passage:

Calculate the estimated shear velocity that would be required to move the average sized boulder within the culvert and the absolute maximum velocity that the culvert would have flowing full without backwater effects from the Columbia River (theoretical). This would help determine if continuous monitoring of the boulders would be required. If the theoretical maximum velocity in the culverts is below that of the shear velocity required to move the boulders, monitoring of the boulder locations could be discontinued.

Establish a baseline graph of depth versus velocity for the culverts using Manning's Equation, and measure velocities in the culverts at various times of the year. Comparing these would help quantify the effect the boulders have on reducing velocities in the channel, thereby providing quantifiable support for the effectiveness of the boulder placement.

Measure the depth of flow within both culverts and at the outlet of the west culvert on multiple occasions during late summer/early fall; this would capture the relative depth of flow and quantify how well the low flow diversion structure is performing during this time frame.

2.4.2 LWD Monitoring

Results from the cross sectional survey of LWD in Young Creek suggest that the structures are serving their intended purpose. Lateral scour pools appear to be forming under and directly downstream of all structures surveyed, suggesting that habitat diversity is being created by their addition. Furthermore, some of the structures (most notably the LWD adjacent to cross section 3) are providing for recruitment of some small woody debris. There were no off-channel pools observed likely because the incision of the stream and the density of streamside vegetation. In the long term, hydraulic forces may begin to create these features, but further monitoring would be required to confirm this. Because the Mirror Lake site is routinely flooded during the winter months (submerging the LWD) and no movement of LWD has been observed to date, it is expected that the LWD will remain in place.

Differences observed in the cross sections outside the active channel were minimal, with the exception of cross sections 13 and 14. Data collected for these two cross sections was reviewed to determine if data entry errors had occurred. Since no errors were found for the data entry review, deviations in the right bank readings from the two cross sections suggest that errors were made in field measurement and recording during one of the sampling events. Future monitoring at these locations will attempt to address these discrepancies and determine a reason for the differences observed.

Field observations suggested that placement of the LWD within the channel has a significant impact on how well the structures perform. In the case of the LWD adjacent to cross section 3, the root ball was installed far enough into the stream to effectively bisect the channel. With the addition of a beaver dam, this created instability in the banks and what appears to be a new channel has formed around the left and right sides of the root ball. On the other hand, some pieces of LWD placed downstream of the bridge were not placed far enough into the stream and actually accumulated sediment; these pieces therefore no longer provide in-stream habitat during low flows.

All LWD was installed on the right bank of Young Creek due to constraints related to equipment access to the other side of the creek. Some of the cross sections showed signs of scour occurring on the bank opposite the LWD installation. While this will likely create more meandering of the stream, this also suggests that the long-term stream geomorphology may cause the channel to realign around the LWD, making them ineffective. It is suggested that future installations of LWD be done in a staggered pattern on either side of the creek to minimize the chances of stream realignment around the structures.

While the cross sectional study of the LWD performed on Young Creek provides valuable insight into the effectiveness of the structures to provide improved habitat functions, some additional measurements/observations could be made to make analysis more robust. Two of these are:

- Survey the longitudinal cross section of the stream along the thalweg from upstream of each LWD structure to approximately 20 feet downstream to assess where pool habitats are being created in relation to the structures.
- Place a benchmark on top of each piece of LWD within the cross section group to monitor movement overtime.

3.0 Juvenile Salmonid and Prey AEM at Mirror Lake

See Section 2 for a description of the Mirror Lake site and restoration activities. In 2009, NOAA Fisheries investigated prey availability, fish assemblages, and juvenile salmon usage of the Mirror Lake site (Estuary Partnership Contract #02-2008). They focused on the following five work elements:

1) A survey of prey availability and habitat use by salmon and other fishes at site (Mirror Lake)
2) Taxonomic analyses of prey in salmon stomach contents in order to identify prey types at the Mirror Lake project area. NOAA Fisheries will use these data to examine the effects of restoration activities on salmon diets.
3) Analyses of otoliths for determination of growth rates (Mirror Lake and Fort Clatsop)
4) Analyses of biochemical measures of growth and condition (e.g., whole body lipid content for salmon collected at Mirror Lake and Fort Clatsop).
5) Compilation of data and annual report preparation.

3.1 Fish Sampling Locations

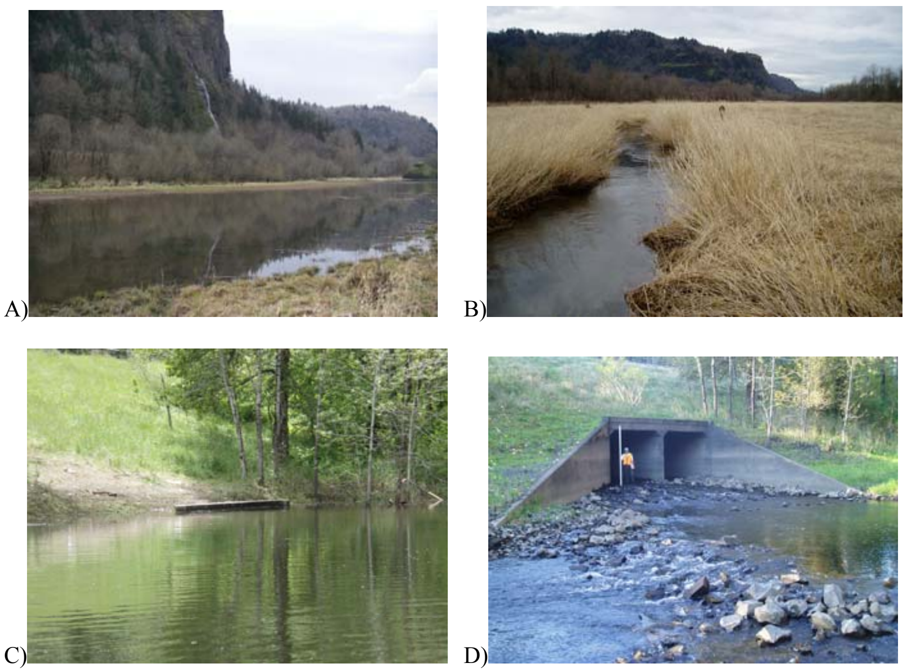
Figure 3-1 shows the three areas of focused fish sampling at the Mirror Lake project area. Site #1 (Lake) is on the open water part of the lake near the I-84 culvert (Figure 3-1, Figure 3-2A). The area is dominated by grasses from the high water mark to the low water edges, and by shrubs and blackberry vines along the bank above and at very high water levels. The lake substrate consists of consolidated to soft-packed mud, with aquatic vegetation later in the season. The lake is fed by waters from Latourell Creek and Young Creek. Its water level varies seasonally depending on the elevation of a beaver dam at its outlet and backwater from the Columbia River that inundates the site during spring runoff.

11Figure 3-1. Photo showing areas of fish collection at Mirror Lake in 2009. Photo provided by Google Earth.

Site #2 (Young Creek) is on Young Creek and is upstream of Site #1 (Lake) (Figure 3-1, Figure 3-2B). The creek varies from about 1.5 meters wide at low water levels to about 5 meters at high water. The riparian area is dominated by reed canary grass to the edge of the creek bed and immediate adjacent areas, with a steep drop (1.5 meters) from the edge of the creek bank. Bottom sediment is composed of very soft mud. From mid June to late summer, the creek banks are overgrown with tall grasses, which overhang the banks, provide shade, and cover for stream inhabitants. Between 2004 and 2007, before monitoring was initiated, a failing culvert (dam) at this site was replaced with a 70 ft bridge to give salmon species access to upstream spawning areas. Prior to restoration activities, very little large woody debris existed at this site and grasses provided the only available cover. To improve this situation, invasive plants along the creek were removed and native willows and cottonwoods were planted. In summer of 2008, large woody debris was added to Young Creek to improve salmon habitat.

Site #3(Latourell Creek; not shown) is on Latourell Creek and is accessed from the hamlet of Latourell on the Crown Point Highway by wading down Latourell Creek, crossing beneath the railroad to where the elevation flattens and water opens up to a small lake area. This site was not sampled in 2009 because it was judged too difficult to access safely for fishing and other sampling operations.

Site #4 (Culvert) is located immediately below the I-84 culvert and adjacent areas opposite the boat launch and associated docks (Figure 3-1, Figure 3-2C,D). The area immediately below the culvert had very little to no vegetation associated with the banks or bottom. The banks were steep, and rocky, areas consisting of pebbles to small boulders. Bottom sediment was the same. The adjacent areas were dominated by grasses, with a steep bank (1.5 meter) that dropped off quickly. The bottom sediments were composed of very soft mud. In the summer of 2008, boulders were added to the culvert at I-84 to improve water flow for salmon passage.



12~~Figure 3-2~~. Photos of fish sampling sites at the Mirror Lake project area. A) Site #1 (Lake); B) Site #2 (Young Creek); C) Site #4 (Culvert) at high water; and D) Site #4 (Culvert) at low water.

Between 2004 and 2007, before monitoring was initiated, at Young Creek a failing culvert (dam) was replaced with a 70ft bridge to give salmon species access to upstream spawning areas. Also, invasive plants along the creek were removed and native willows and cottonwoods were planted. In summer of 2008, large woody debris was added to Young Creek to improve salmon habitat, and boulders were added to the culvert at I-84 to improve water flow for salmon passage.

3.2 Methods

3.2.1 Fish Sampling

Fish use of restoration sites was assessed by analysis of catch data. Fish were collected from April 2009 through September 2009. Due to variation in topography, accessibility, and water levels among the restoration sites, several types of gear were used to sample the Mirror Lake sites. Table 3-1 shows the coordinate of each site, and Figure 3-1 is a map detailing sampling site locations.

4~~Table 3-1~~. Coordinates of the sites sampled at Mirror Lake in 2009.

Site Name	Latitude	Longitude
Site #1 (Lake)	45° 32.562'N	122° 14.703'W
Site #2 (Young Creek)	45° 32.735'N	122° 12.275'W

Site #4 (Culvert)	45° 32.606'N	122° 14.878'W

Fish were collected using a Puget Sound beach seine (PSBS) (37x2.4m, 10mm mesh size), a modified PSBS (shortened to 7.5 x 2.4 m, 10 mm mesh size), or a modified block net (MBN) where the middle portion of the PSBS was used as a block net and a second net (2 x1.5m, 10mm mesh size) was used as a fish chase net.

PSBS sets were deployed using a 17ft Boston Whaler or 9ft inflatable raft. The modified PSBS(MPSBS) was deployed on foot in shallow water where efficient boat deployment was not possible. The MBN was used to sample fish in small stream channels where fishing with the PSBS or modified PSBS was not efficient or feasible. Up to three sets were performed per sampling time as conditions allowed.

Sampled fish were identified to the species level and counted. Salmonid species (up to 30 specimens) were measured (fork length in mm) and weighted (in g) and checked for adipose fin clips to distinguish between marked hatchery fish and unmarked, presumably wild fish.

At each sampling event, NOAA Fisheries recorded the coordinates of the sampling locations, the time of sampling, water temperature, weather, habitat conditions, and vegetation.

When Chinook salmon were present, up to 30 individual juvenile Chinook were collected for necropsy at each field site at each sampling time. Salmon were measured (to the nearest mm) and weighed (to the nearest 0.1 g), then sacrificed anthethesia with a lethal dose of MS-222. The following samples were collected from the field-sampled fish: stomach contents for taxonomic analysis of prey; whole bodies (minus stomach contents) for measurement of lipids and persistent organic pollutants (POPs); fin clips for genetic stock identification; otoliths for aging and growth rate determination, and, when sufficient fish were available, bile for measurement of metabolites of polycyclic aromatic hydrocarbons (PAHs); stomach contents for measurement of PAHs and POPs, including dichlorodiphenyltrichloroethanes (DDTs), polychlorinated biphenyls (PCBs), polybrominateddiphenyl ethers (PBDEs), and various organochlorine pesticides. These samples were not collected for coho salmon or other salmonid species because our permits did not authorize this type of sampling for these species.

Samples for chemical analyses were frozen and stored at –80°C until analyses were performed. Samples for taxonomic analyses were preserved in 10% neutral buffered formalin. Fin clips for genetic analyses were collected and preserved in alcohol, following protocols described in (Myers et al. 2006). Otoliths for age and growth determination were also stored in alcohol. The number and type of samples collected at each site and sampling time are listed in Table 3-2.

5~~Table 3-2~~. Samples collected from juvenile Chinook salmon at Mirror Lake in 2009 as part of the Effectiveness Monitoring Program.

Site	Date	# of fish	% hatchery (marked)	otolith	Bile*	stom tax	Stomach chemistry*	body chemistry	genetics
Site #1	5/5/09	34	100	34	1	11	1	34	34
	6/30/09	3	33	2	0	1	0	2	4
Site #4	4/6/09	1	0	0	0	0	0	0	1
	5/5/09	7	100	7	0	7	0	7	7
	6/30/09	2	0	2	0	1	0	2	1
Total		47	89%	45	1	20	1	45	47

- samples composited at the time of collection. Each composite contains samples from ~10 individual fish.

3.2.2 Prey Sampling

For the invertebrate prey sampling, the objective was to collect aquatic and terrestrial invertebrate samples and identify the taxonomic composition and abundance of salmonid prey available at sites when juvenile salmonids were collected. These data could then be compared with the taxonomic composition of prey found in stomach contents of fish collected concurrently.

In 2009, NOAA Fisheries conducted the following types of invertebrate collections at the Mirror Lake project area:

1) Open water column Neuston tows (2 tows at each site at each sampling time). These tows collect prey available to fish in the water column and on the surface of open water habitats. For each tow, the net was towed for a measured distance of at least 10 m. Invertebrates, detritus, and other material collected in the net were sieved, and invertebrates were removed and transferred to a labeled glass jar or Ziploc bag. The jar or bag was then filled with 95% ethanol so that the entire sample was covered.
2) Emergent vegetation Neuston tows (2 tows at each site at each sampling time). These vegetation tows collect prey associated with emergent vegetation and available to fish in shallow areas. For each tow, the net was dragged through water and vegetation at the river margin where emergent vegetation was present and where the water depth was < 0.5 m deep for a recorded distance of at least 5 m. The samples were then processed and preserved in the same manner as the open water tows.

In 2008, terrestrial sweep netting and benthic core sampling were also performed, but we did not collect these samples in 2009 because preliminary data suggest that the Neuston two samples are more representative of the stomach contents of juvenile Chinook (see Results), and because of the very large number of samples already being analyzed.

In 2008 and 2009, 58 samples over 6 sampling periods (Table 3-3) and corresponding diets were collected from several fish at Mirror Lake #1 and #4 in early May (see table).

6~~Table 3-3~~. Summary table showing number of prey samples collected at each site for each month of sampling

sites	early April	early May	early June	late June	late July	late August	Total
Site #1 (Mirror Lake)	6	4*	4	4	4	4	26
Site #2 (Young Creek)	2	6		2	2	2	14
Site #4 (Park/Culvert)	1	4*	4	4	3	2	18
Total	9	14	8	10	9	8	58

3.2.3 Sample Analyses

Genetic analysis. Genetic stock identification (GSI) techniques (see Manel et al. 2005) were used to investigate the origins of juvenile Chinook salmon using the Mirror Lake Complex sites, as described in Teel et al. 2009 and Roegner et al. 2010. The stock composition of juveniles was estimated with a regional microsatellite DNA data set (Seeb et al. 2007) that includes baseline data for spawning populations from throughout the Columbia River basin (described in Teel et al. 2009). The overall proportional stock composition of Mirror Lake samples was estimated with the GSI computer program ONCOR (Kalinowski et al. 2007), which implemented the likelihood model of Rannala and Mountain (1997). Probability of origin was estimated for the following regional genetic stock groups (Seeb et al. 2007; Teel et al. 2009): Deschutes River fall Chinook; West Cascades fall Chinook; West Cascades Spring Chinook; Middle and Upper Columbia Spring Chinook; Spring Creek Group fall Chinook; Snake River Fall Chinook; Snake River Spring Chinook; Upper Columbia River Summer/Fall Chinook; and Upper Willamette River Spring Chinook. West Cascades and Spring Creek Group Chinook are Lower Columbia River stocks.

Lipid Determination. As part of our study we determined lipid content in salmon whole bodies. Lipid content can be a useful indicator of salmon health (Biro et al. 2004), and also affects contaminant uptake and toxicity (Elskus et al. 2005). Studies show that the tissue concentration of a lipophilic chemical that causes a toxic response is directly related to the amount of lipid in an organism (Lassiter and Hallam, 1990; van Wezel et al., 1995); in animals with a high lipid content, a higher proportion of the hydrophobic compound is associated with the lipid and unavailable to cause toxicity.

Prior to analyses, salmon whole body samples from the field were composited by genetic reporting group and date and site of collection into a set of composite samples, each containing 3-5 fish each. In salmon whole bodies composite samples from the total amount of extractable lipid (percent lipid) was determined by Iatroscan and lipid classes were determined by thin layer chromatography with flame ionization detection (TLC/FID), as described in Ylitalo et al. (2005).

Otolith Analyses. Otoliths of juvenile Chinook collected from Mirror Lake sites #1 (Lake) and #4 (Culvert) were extracted and are now being processed for microstructural analysis of recent growth. Specifically, sagittalotoliths are being embedded in Crystal Bond© and polished in a transverse plane using 30-3µm lapping film. Using Image Pro Plus© (version 5.1), with a mediacybernetics (evolutionMP color) digital camera operating at a magnification of 20 x, NOAA-Fisheries will determine the average fish daily growth rate (i.e., mm of fish length/day) for three time periods: a) the last 7 days of their life, b) the last 14 days of their life, and c) the last 21 days of their life (total otoliths analyzed = 131; left sagittalotoliths were used). Average daily growth (DG, mm/day) was determined using the Fraser-Lee equation:

$$La = d + [(Lc - d)/Oc] \times Oa$$

$$DG = [(Lc - La)/a]$$

where La and Oa represents fish length and otolith radius at time a (i.e., last 7, 14, or 21 days), respectively, d is the intercept (13.563) of the regression between fish length and otolith radius, Lc and Oc are the fish length and otolith radius at capture, respectively. Results of these analyses will be available later and will be included in a subsequent version of this report.

Chemical Contaminants in Whole Bodies and Stomach Contents. Composite whole body, stomach contents, and feed samples were extracted with dichloromethane using an accelerated solvent extractor. The sample extracts were cleaned up using size exclusion liquid chromatography and analyzed by gas chromatography/mass spectrometry (GC/MS) for PCB congeners, PBDE congeners, andorganochlorine

(OC) pesticides including DDTs, hexachlorocyclohexanes (HCHs), chlordanes, aldrin, dieldrin, mirex, and endosulfans, as described by Sloan et al. (2004, 2006). Summed PCBs were determined by adding the concentrations of 45 congeners (PCBs 17, 18, 28, 31, 33, 44, 49, 52, 66, 70, 74, 82, 87, 95, 99, 101/90, 105, 110, 118, 128, 138/163/164, 149, 151, 153/132, 156, 158, 170/190, 171, 177, 180, 183, 187, 191, 194, 195, 199, 205, 206, 208, 209). Summed DDT levels (∑DDTs) were calculated by summing the concentrations of *p,p'*-DDT, *p,p'*-DDE, *p,p'*-DDD, *o,p'*-DDD, *o,p'*-DDE and *o,p'*-DDT. Summed chlordanes (∑CHLDs) were determined by adding the concentrations of heptachlor, heptachlor epoxide, g-chlordane, a-chlordane, oxychlordane, *cis*-nonachlor, *trans*-nonachlor and nonachlor III. Summed hexachlorocyclohexanes (∑HCHs) were calculated by adding the concentrations of a-HCH, b-HCH, g-HCH, and lindane.

In addition to POPs, stomach content samples, feed samples, and hatchery body samples were analyzed for low (2-3 ring) and high (4-6 ring) molecular weight aromatic hydrocarbons using capillary column GC/MS (Sloan et al. 2004, 2006). Summed low molecular weight aromatic hydrocarbons (∑LAHs) were determined by adding the concentrations of biphenyl, naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, 2,6-dimethylnapthalene, acenaphthene, fluorene, phenanthrene; 1-methylphenanthrene, and anthracene. Summed high molecular weight aromatic hydrocarbons (∑HAHs) were calculated by adding the concentrations of fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[a]pyrene, benzo[e]pyrene, perylene, dibenz[a,h]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, indenopyrene, and benzo[ghi]perylene. Summed total aromatic hydrocarbons (∑TAHs) were calculated by adding ∑HAHs and ∑LAHs.

To adjust for the influence of lipid on toxicity, we normalized whole body contaminant concentrations for lipid, and relied primarily on lipid-normalized data to evaluate potential health effects of toxicants on juvenile salmon. Wet weight data are also presented to facilitate comparison with other studies, and to evaluate risks to predators who consume salmon that have accumulated toxicants.

PAH metabolites in salmon bile. Bile samples were analyzed for metabolites of PAHs using a high-performance liquid chromatography/fluorescence detection (HPLC/fluorescence) method described by Krahn*et al.* (1984). Briefly, bile was injected directly onto a C-18 reverse-phase column (PhenomenexSynergi Hydro) and eluted with a linear gradient from 100% water (containing a trace amount of acetic acid) to 100% methanol at a flow of 1.0 mL/min. Chromatograms were recorded at the following wavelength pairs: 1) 260/380 nm where several 3-4 ring compounds (e.g., phenanthrene) fluoresce, and 2) 380/430 nm where 4-5 ring compounds (e.g., benzo[a]pyrene) fluoresce. Peaks eluting after 5 minutes were integrated and the areas of these peaks were summed. The concentrations of fluorescent PAHs in the bile samples of juvenile fall Chinook salmon were determined using phenanthrene (PHN) and benzo[a]pyrene (BaP) as external standards and converting the fluorescence response of bile to phenanthrene (ng PHN equivalents/g bile) and benzo(a)pyrene (ng BaP equivalents/g bile) equivalents.

To ensure that the HPLC/fluorescence system was operating properly, a PHN/BaP calibration standard was analyzed at least 5 times, and a relative standard deviation of less than 10% was obtained for each PAC. As part of our laboratory quality assurance (QA) plan, two QA samples [a method blank and a fish bile control sample (bile of Atlantic salmon, *Salmosalar*, exposed to 25 µg/mL of Monterey crude oil for 48 hours)] were analyzed with the fish bile samples (Sloan et al. 2006).

Biliary protein was measured according to the method described by Lowry et al. (1951). Biliary fluorescence values were normalized to protein content, which is an indication of feeding state and water content of the bile. Fish that have not eaten for several days exhibit higher biliary FAC values and higher protein content than fish that are feeding constantly and excreting bile more frequently (Collier and Varanasi 1991).

3.2.4 Fish Community Characteristics, Catch per Unit Effort, and Fish Condition Calculations

Fish species diversity was calculated using the Shannon-Weiner diversity index (Margaley 1958):

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i)$$

Where

ni = the number of individuals in species i; the abundance of species i.

S = the number of species. Also called species richness.

N = the total number of all individuals

Pi = the relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community.

Catch per unit effort (CPUE) was calculated as described in Roegner et al. 2009, with fish density reported in number per 1000 m^2.

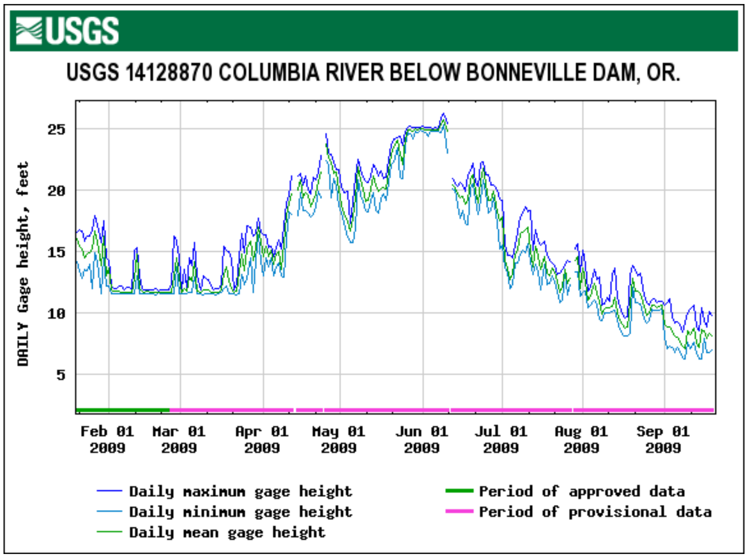
For all salmonid species, Fulton's condition factor (K) (Fulton 1902; Ricker 1975) was calculated as an indicator of fish health and fitness, using the formula:

K =[weight (g)/fork length (cm)3] x 100

3.3 Results

3.3.1 Water Level and Its Effect on Fishing

At all sites, water level increased from April through June and declined thereafter. **Error! Reference source not found.**~~Figure 3-3~~ shows the water depth measured below Bonneville Dam on the Columbia River during this period. During spring runoff (April through July), water levels at the Mirror Lake sites coincided with Columbia River water levels. After early July, water levels at the site were more constant and influenced by the elevation of the beaver dam at the I-84 culvert and flows in Latourell and Young Creeks.



13~~Figure 3-3~~. Water depth (ft) below Bonneville Dam (Lat 45° 38'00", long 121° 57'33"). Data provided by USGS.

The rise and fall of water levels prohibited effective sampling of the Mirror Lake sites as described below.

- Site #1 (Lake): This site was successfully fished in April and May using PSBS; however, higher water levels in early June limited fishability at this site, because the site was submerged and nearby trees and shrubs interfered with successful sampling. From late June through August, water levels receded while the growth of aquatic vegetation increased. Low water levels and increased vegetation cover made site access difficult and prohibited the use of the PSBS (Figure 3-4), thus the modified PSBS was used then to sample the site from late July through August.

14~~Figure 3-4~~. Fishing at high water with PSBS (note the absence of vegetation in water) vs site at low water (full of vegetation)

- Site #2 (Young Creek). This site is approximately two miles upstream of Site #1 (Lake), and followed a similar trend in water levels. The water level was so high in June that NOAA Fisheries could not use the MBN to fish this site (Figure 3-5).

15Figure 3-5. Fishing with modified block net at lower water vs. sampling at relatively higher water levels (photograph from 2008).

- Site #4 (Culvert). This site is connected to Site #1 (Lake) by the I-84 culvert, and had similar water level trends. At mid to higher water, NOAA Fisheries sampled the area immediately below the culvert and two adjacent areas with PSBS. At low water, NOAA Fisheries noted that the bottom substrate was comprised of very soft mud, which prevents successful beach seining. In the month of August, the modified PSBS was used to fish below the culvert and two adjacent areas (Figure 3-6).

16Figure 3-6. Low water level below the culvert, and fishing below the culvert using modified PSBS.

3.3.2 Water Temperature

Inter-site differences in water temperature were observed (17. Figure 3-7). These differences were likely associated with habitat conditions and time of sampling at a particular site. Typically, NOAA Fisheries sampled Site #1 (Lake) in the morning, Site #2 (Young Creek) in the mid-morning through mid afternoon, and Site #4 (Culvert) later in the afternoon.

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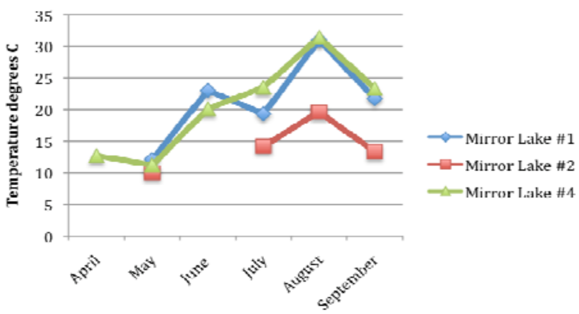
At all of the sampling sites, water temperature increased from April through August, and then declined in September. In April and May, water temperatures were similar at all sites (10-11°C). At Sites #1 (Lake) and #4 (Culvert), water temperature increased substantially from May to August, reaching a maximum of 30°C. However, at Site #2 (Young Creek) surface water temperature remained relatively low, reaching a maximum of 20°C in August. In September, surface water temperature at sites #1 and #4 was still above 20°C, while at Site #2 it had declined to below 15°C. Site #2 had the lowest surface water temperature due primarily to its upstream-most location in the basin, overhanging vegetation, and channel morphology.



17Figure 3-7. Water temperature (°C) at Mirror Lake Sites #1 (Lake), #2 (Young Creek), and #4 (Culvert) at the time of fish collection. Temperature data are not available in June for Site #2.

3.3.3 Fish Species Composition

All three Mirror Lake sampling sites were utilized by fish (Table 3-4). However, the number and type of fish present varied with time and site (Table 3-4). Of the sites, the total number of species captured was lowest at Site #2 (Young Creek), where five different species were collected. At Sites #1 (Lake) and #4 (Culvert), 15 and 17 species, respectively, were collected. These two sites had similar species composition, in terms of the types of species present. The proportions of non-native species were similar at the two sites as well, comprising 47% of the species present at both sites. At Young Creek, no non-native species were observed. However, fish species diversity (Figure 3-8) as calculated by the Shannon-Wiener diversity index (Margalev 1958) was lowest at sites #2 and #1, while highest at site #4. This was due to the high number of individuals from a few dominant species captured at sites #1 and #2 (Figure 3-9). Stickleback and carp comprised 89% of the total number of fish captured at site #1 (73% and 16%, respectively), while coho and stickleback comprised 96% of the total caught at site #2 (68% and 28%, respectively). At site #4, although the total number of species was similar to site #1, the number of individuals of each species captured was much more equally distributed (Figure 3-9).

Table 3-5 shows the percentage of each species caught at each site by month of capture. The percentages of species collected varied somewhat for Sites #1 (Lake) and #4 (Culvert) as counts of killifish, stickleback, bass and other species fluctuated between sampling events. At Site #2 (Young Creek), juvenile coho salmon, stickleback, and sculpin were consistently collected (though at varying levels) while lamprey were detected only in April and May.

3.3.4 Salmon Occurrence at Mirror Lake Sites

Juvenile salmonids were collected at all sites (Table 3-4). Juvenile Chinook salmon were found at Site #1 (Lake) and Site #4 (Culvert) from April through June. Chinook salmon were most abundant at Site #1 in May and at Site #4 in April (Table 3-6). After June, no Chinook were observed at any of the sites. All of the juvenile Chinook salmon caught at Site #4 in April were unmarked, presumably wild fish. However, in May and June, marked hatchery fish made up a substantial part of the catch. They made up 88% of the catch at Site #1 in May, and 50% of the catch at Site #1 in June and Site #4 in May.

Coho salmon were collected at all three sites, but in relatively low numbers at Sites #1 and Sites #4 (Table 3-7). At Site #2, coho salmon were present in low numbers in April and May, then in relatively large numbers from June through August, although they were less abundant than in the 2008 sampling (Sol et al. 2009). Coho were also present, but less numerous, at Sites #1 and #4, and were found in April and May only at these two sites. The great majority of coho collected from the Mirror Lake sites (97% of 231 coho collected) were unmarked, presumably wild fish, and. all of the coho captured at site #2 were unmarked. In addition to Chinook and coho salmon, chum salmon were collected at Site #4 in April. Although the number collected was relatively small (10 fish, Table 3-8), chum were not observed at all at any of the Mirror Lake sites in 2008 (Sol et al. 2009). In terms of catch per unit effort (CPUE), Chinook were most abundant at site #4 (Figure 3-10), while coho at Site #2 had the highest CPUE of any salmonid captured at any site.

7~~Table 3-4~~. Summary table showing number of number of successful fishing attempts made at each site by month, and total number of species. PSBS (Puget Sound Beach Seine), modified PSBS (MPSBS), MBN (modified block net). NS = not sampled. Site #2 was not sampled on this date because high water levels interfered with fishing operations.

Site	Date	gear	# of attempts	Number of Species	Species caught (total number)
Site #1	04/08/09	PSBS	3	1	Chinook, coho, three spine stickleback, banded killifish, bluegill, sculpin, pumpkinseed, yellow bullhead, brown bullhead, smallmouth bass, peamouth, chiselmouth, pike minnow, carp, sucker (15)
	05/06/09	PSBS	2	5	
	06/03/09	PSBS	1	2	
	06/30/09	MPSBS	3	9	
	07/28/09	MPSBS	3	9	
	08/27/09	MPSBS	3	3	
Site #2	04/08/09	MBN	2	3	Coho, three spine stickleback, sculpin, chiselmouth, lamprey (5)
	05/06/09	MBN	3	3	
	06/03/09	NS[1]	0	-	
	06/30/09	MBN	2	3	
	07/28/09	MBN	2	2	
	08/27/09	MBN	2	3	
Site #4	04/07/09	PSBS	1	7	Chinook, coho, chum, three spine stickleback, banded killifish, bluegill, sculpin, pumpkinseed, smallmouth bass, peamouth, chiselmouth, carp, pikeminnow, shad, crappie, shad, walleye, chub (17)
	05/06/09	PSBS	1	5	
	06/02/09	PSBS	1	2	
	06/30/09	PSBS	3	13	
	07/27/09	PSBS	3	11	
	08/27/09	MPSBS	3	5	

8Table 3-5. Total number of each species captured as a percentage of the total number of all individual fish captured.

site	date	stickleback	shad	sculpin tot	coho	chum	Chinook	pumpkinseed	peamouth	pikeminnow	lamprey	killifish	chiselmouth	carp	Smalmouth bass	blue gill	others
Site #1	04/08/09	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	05/06/09	65.5	0.0	0.3	1.3	0.0	30.1	0.2	0.0	0.0	0.0	2.2	0.2	0.0	0.0	0.0	Bullhead, yellow (0.2)
	06/03/09	78.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.2	0.0	0.0	0.0	0.0	
	06/30/09	82.1	0.0	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.2	2.8	14.5	0.1	0.0	
	07/28/09	23.7	0.0	0.5	0.0	0.0	0.0	5.8	1.0	0.5	0.0	5.3	0.0	53.1	8.2	1.0	sucker (0.6), bullhead, brown (0.6)
	08/27/09	19.4	0.0	0.3	0.0	0.0	0.0	16.0	0.6	0.9	0.0	42.9	0.0	17.3	0.0	2.5	
Site #2	04/08/09	0.0	0.0	8.3	66.7	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	
	05/06/09	6.7	0.0	0.0	46.7	0.0	0.0	0.0	0.0	0.0	46.7	0.0	0.0	0.0	0.0	0.0	
	06/30/09	11.6	0.0	2.3	86.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	07/28/09	34.0	0.0	0.7	65.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	08/27/09	34.1	0.0	2.3	63.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Site #4	04/07/09	8.5	0.0	0.6	12.7	6.1	68.5	0.0	0.0	0.0	0.0	3.0	0.6	0.0	0.0	0.0	
	05/06/09	10.3	0.0	0.0	4.5	0.0	70.1	0.3	0.0	0.0	0.0	2.7	11.5	0.6	0.0	0.0	
	06/02/09	64.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.7	0.0	0.0	0.0	
	06/30/09	1.5	9.8	0.2	0.0	0.0	0.2	0.1	9.0	10.2	0.0	1.9	62.6	2.3	0.4	0.0	walleye (1.6), chub (0.1)
	07/27/09	0.2	0.2	1.0	0.0	0.0	0.0	10.5	0.2	2.5	0.0	53.3	0.0	26.2	3.9	0.0	crappie (2.0)
	08/27/09	9.8	0.0	0.0	0.0	0.0	0.0	41.7	0.0	0.0	0.0	39.3	0.0	0.0	8.0	1.2	

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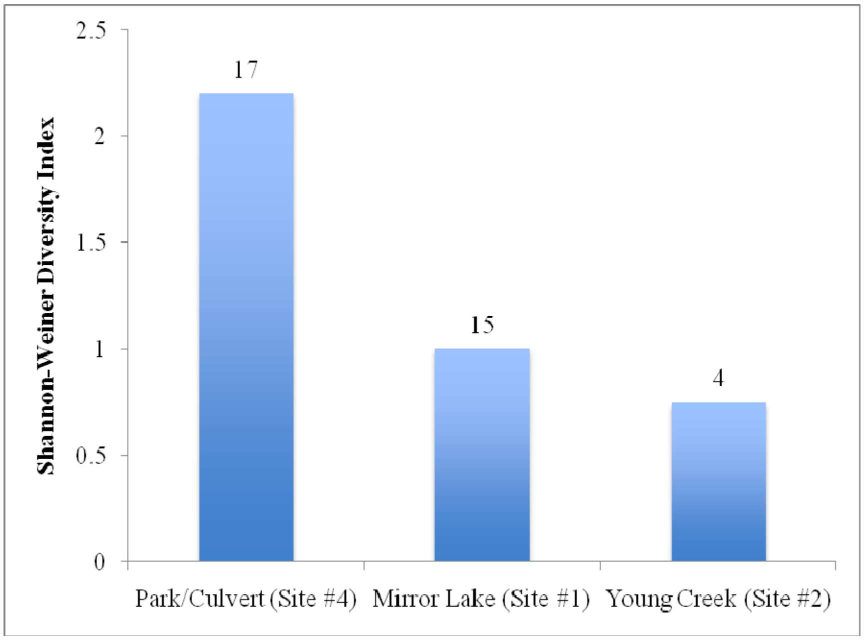
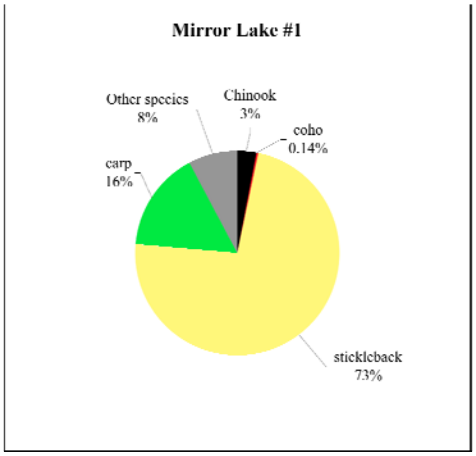
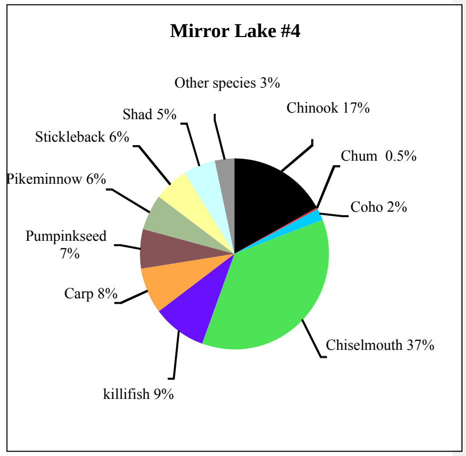
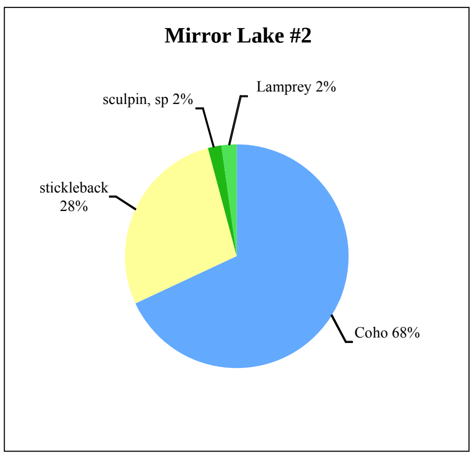


18~~Figure 3-8~~. Fish species diversity (Shannon-Wiener Diversity Index) at Mirror Lake sites in 2009. Number above bars represents the total number of species captured at each site.







19~~Figure 3-9~~. The major groups of species captured in 2009 at the three Mirror Lake sites

9Table 3-6. Summary table showing number of Chinook salmon caught at each site for each month of sampling using either Puget Sound beach seine (PSBS), modified Puget Sound Beach seine (MPSBS), or modified block net (MBN).

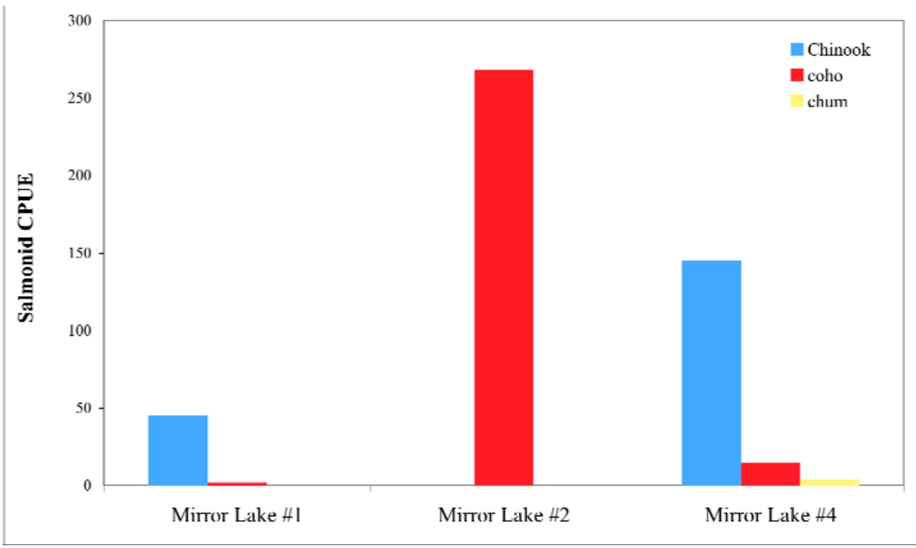
		Chinook (unmarked)				Chinook (marked)			
site	date	number caught	number measured	fork length (mm)	mean wt (g)	number caught	number measured	fork length (mm)	mean wt (g)
Site #1	5/06/09	40	39	52.4±14.6	1.9±1.5	139	15	78.4±19.7	5.7±1.3
	6/30/09	1	1	84.0±0.0	6.9±0.0	1	1	77.0±0.0	5.7±0.0
Site #4	4/07/09	113	31	51.06±7.94	1.55±0.80	0	0		
	5/06/09	2	2	60.0±7.07	2.50±1.27	4	4	81.8±2.6	5.3±0.4

10Table 3-7. Summary table showing number of coho salmon caught at each site for each month of sampling using either Puget Sound beach seine (PSBS), modified Puget Sound Beach seine (MPSBS), or modified block net (MBN).

		Coho (unmarked)				Coho (marked)			
site	date	number caught	number measured	fork length (mm)	mean wt (g)	number caught	number measured	fork length (mm)	mean wt (g)
Site #1	5/06/09	8	8	96.1±43.7	14.4±14.0	0	0		
Site #2	4/08/09	8	8	82.0±22.6	6.6±3.6	0	0		
	5/6/09	7	7	105.7±23.9	14.1±6.4	0	0		
	6/30/09	74	62	70.2±14.2	4.6±2.9	0	0		
	7/28/09	96	58	80.6±14.6	7.4±4.3	0	0		
	8/27/09	110	63	81.1±15.3	7.1±4.2	0	0		
Site #4	4/07/09	10	10	41.2±3.3	0.6±0.2	0	0		
	5/06/09	9	9	100.0±41.5	12.5±9.0	6	6	139.0±8.1	26.8±6.0

11~~Table 3-8~~. Summary table showing number of chum salmon caught at each site for each month of sampling using either Puget Sound beach seine (PSBS), modified Puget Sound Beach seine (MPSBS), or modified block net (MBN).

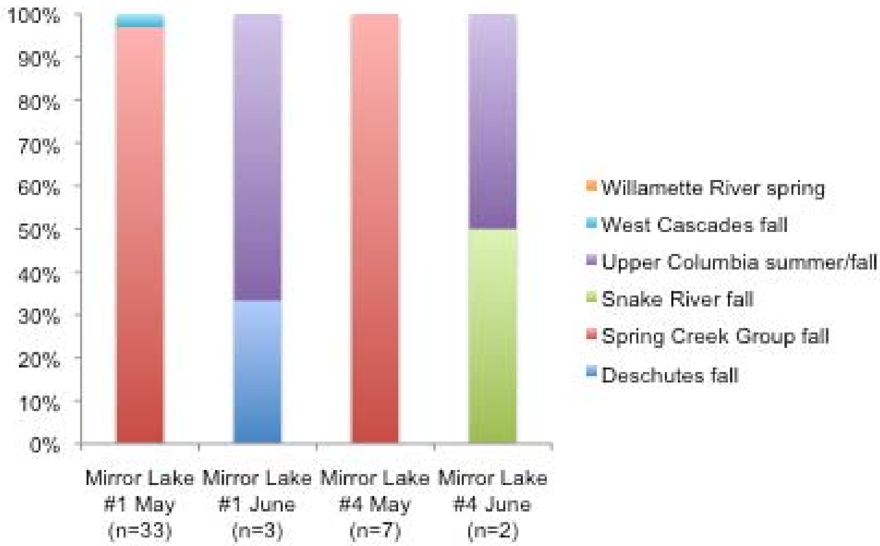
site	date	n	fork length (mm)	Weight (g)
Site #4	4/7/09	10	44.8±5.2	0.7±0.2



20~~Figure 3-10~~. The number of juvenile salmonids captured in 2009 when adjusted for fishing effort (per 1000 sq meters)

3.3.5 Genetic stock identification

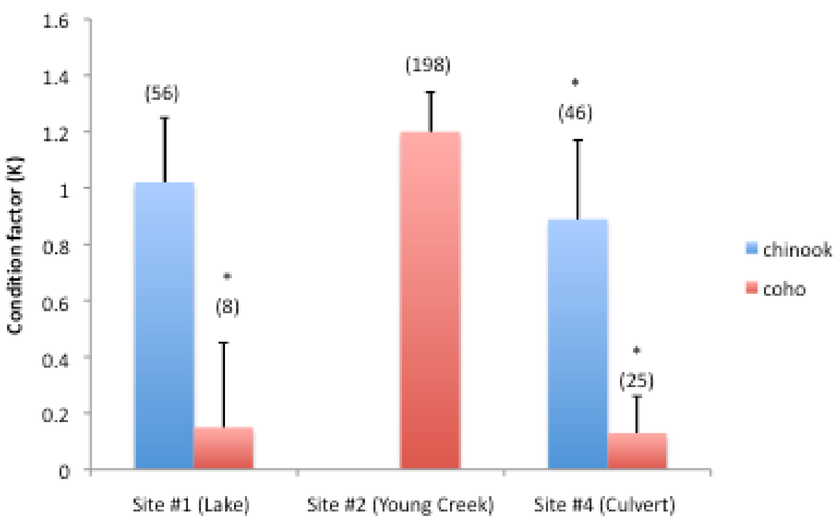
Genetic samples of Chinook salmon were collected from the Mirror Lake complex sites primarily in May and June, and because of concerns about minimizing lethal take of the very small, wild fish present at the site in April. Consequently, most of the fish analyzed were of hatchery origin, 94% of the fish collected at Site #1 and 89% of the fish collected from Site #4. At both sites, the majority of fish collected in May (97% at Site #1 and 100% at Site #4) belonged to the Spring Creek Group, a Lower Columbia River stock. In June, however, stocks from other ESUs tended to dominate the catch. At Site #1, 67% of the fish collected were Upper Columbia River summer/fall Chinook, and the remaining 33% were Deschutes and Snake River fall Chinook. At Site #4, 50% of the fish examined were Snake River fall Chinook, and 50% were Upper Columbia summer/fall Chinook. Of the fish belonging to the Lower Columbia River stocks (West Cascades fall and Spring Creek Group fall Chinook) only 5% were unmarked, presumably wild fish, whereas 100% of the fish belonging to other stocks were unmarked fish.



21~~Figure 3-11~~. Genetic stock assignments for juvenile Chinook salmon from Mirror Lake sites.

3.3.6 Salmon Size and Condition

Significant differences were found in fish condition factor (K) between juvenile Chinook salmon from Site #1 and Site#4 (Figure 3-12). The K value for salmon from Site #1 was 1.01 ± 0.15 (n=56) while the K value for salmon from Site #4 was 0.89 + 0.13 (n=46). The value for Site #1 was significantly higher (One-way ANOVA, $p < 0.0001$). Similarly, K was significantly lower in juvenile coho from Site #4 than in coho from the other two sampling sites. K values for sites #1, #2, and #4 were 1.17 + 0.30 (n=8), 1.20 ± 0.14 (n=198) and 0.90 ± 0.13 (n=25), respectively.



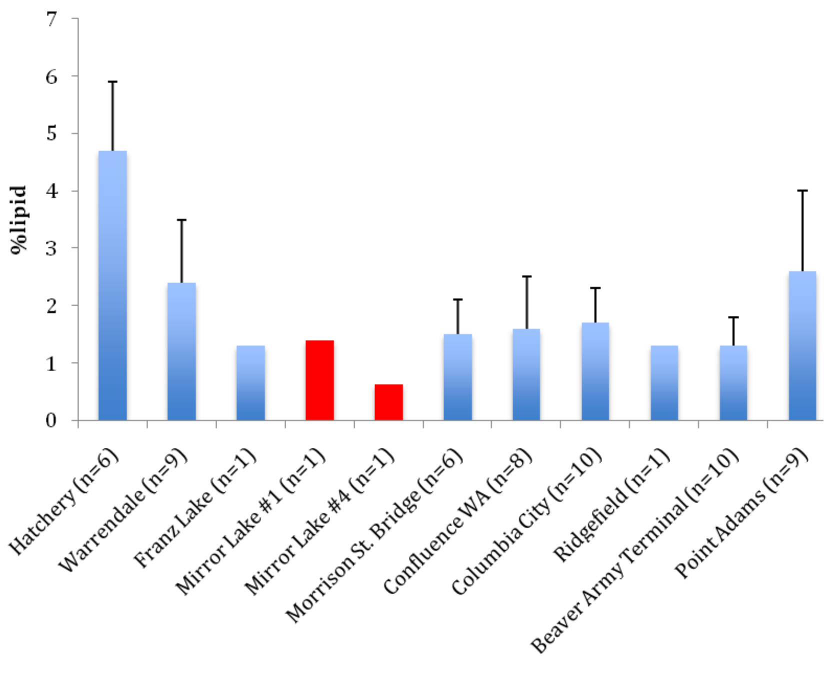
22~~Figure 3-12~~. Mean condition factor of juvenile coho and chinook salmon from Mirror Lake Sites #1 (Lake), #2 (Young Creek) and #4 (Culvert). Error bars represent standard deviation from the mean. * = value is significantly lower than the value or values for the same species at the other sampling sites (ANOVA and Tukey's HSD, $p < 0.05$).

3.3.7 Lipid content of Mirror Lake juvenile Chinook salmon

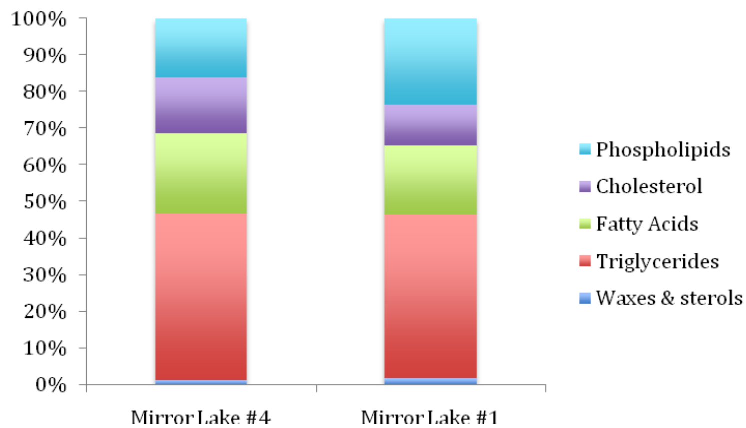
The lipid levels of juvenile Chinook salmon collected from Sites #1 and Sites #4 in 2008 were quite different from each other (Figure 3-13). Salmon from Mirror Lake #1 (lake site) had a lipid content of 1.4%. This level is comparable to values observed for juvenile Chinook from field sampling sites in the Salmon and Water Quality study (LCREP 2007; Figure 3-13). However, salmon from Mirror Lake #4 (culvert) had a lipid content of only 0.63%, lower than the average lipid level observed for juvenile Chinook from any site sampled in the Salmon and Water Quality Study (Figure 3-13). The proportions of various lipid classes in whole bodies of Chinook salmon from these two sites were similar, with triglycerides making up the highest proportion of lipid in fish from both sites (Figure 3-14). Lipid analyses on the remaining samples collected 2008 and the samples collected in 2009 are now in progress, and those data will be presented in a subsequent report.

3.3.8 Otolith Analyses

In 2009, 36 chinook salmon otolith samples were collected from Site #4 and 9 otolith samples from Site #4. Analyses of these samples are in progress.



23~~Figure 3-13~~. Lipid content of juvenile Chinook salmon from the Mirror Lake sampling sites as compared to lipid content in juvenile Chinook salmon sampled from other sites as part of the Salmon and Water Quality Study (LCREP 2007).



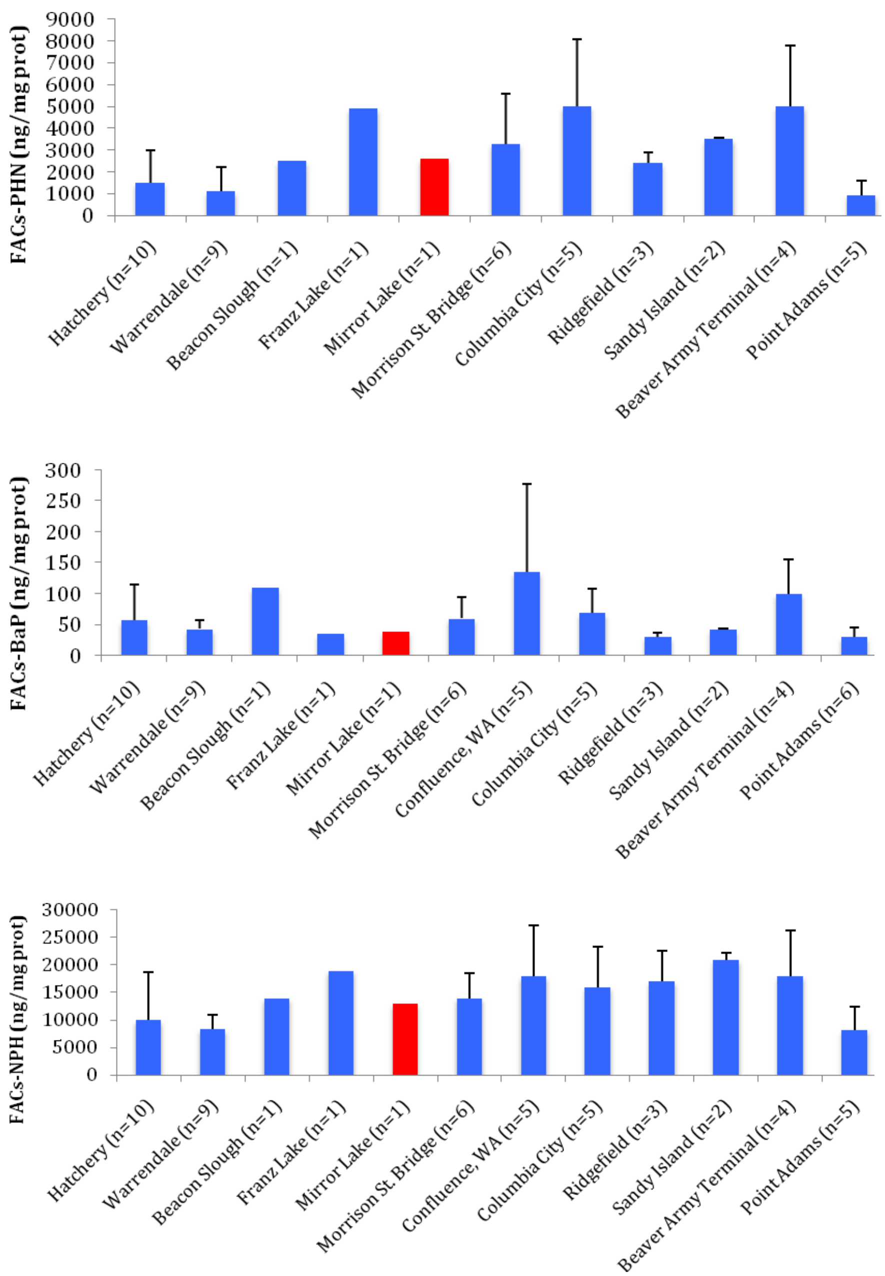
24~~Figure 3-14~~. Lipid classes in whole bodies of Whole body lipid content of juvenile Chinook salmon from Mirror Lake sampling sites. Samples were collected in 2008.

3.3.9 Contaminant concentrations in Mirror Lake juvenile Chinook salmon

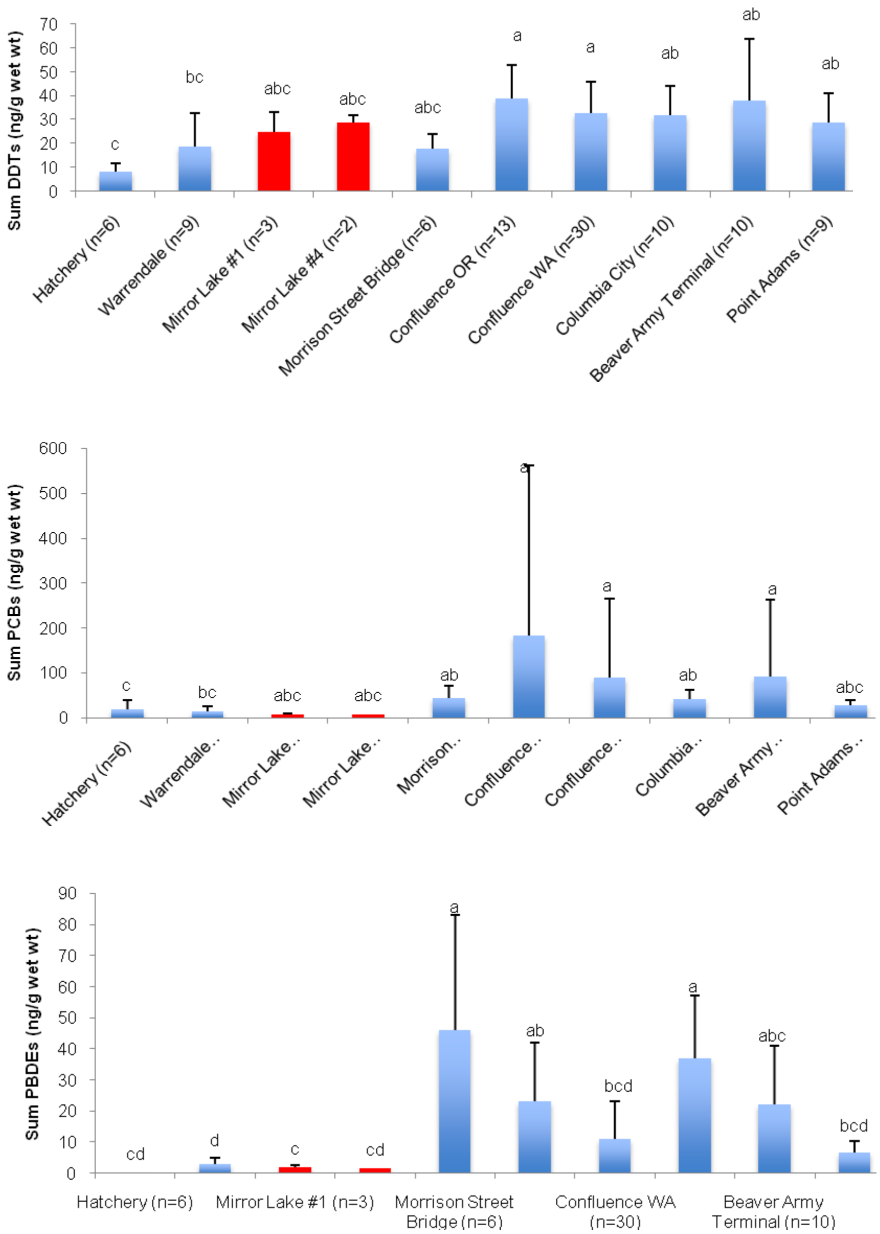
PAH metabolites in bile. Due to the small volume of bile produced by juvenile Chinook salmon, only one bile sample was collected in 2009 (Site #1). Concentrations of PAH metabolites fluorescing at phenanthrene (PHN), benzo[a]pyrene (BaP) and naphthalene (NPH) wavelengths in this bile sample were in the lower range of values observed in juvenile Chinook salmon from sites sampled as part of the Salmon and Water Quality Study (LCREP 2007; Figure 3-15).

Persistent organic pollutants in whole bodies of Chinook salmon from Mirror Lake. In juvenile Chinook from Mirror Lake sites #1 and #4, DDTs were the predominant contaminants measured (Figure 3-16), with the highest concentrations of DDTs in the samples from Mirror Lake #4 (Culvert). Concentrations of PCBs and PBDEs in fish from the two sites were much lower, and fairly similar (Figure 3-16). When compared with POP concentrations in juvenile Chinook salmon from other sites, concentrations of PCBs and PBDEs in Mirror Lake fish were quite low, but concentrations of DDTs in fish from Mirror Lake Sites #1 and #4 were comparable or slightly higher than levels found at most other sites (LCREP 2007; Figure 3-16).

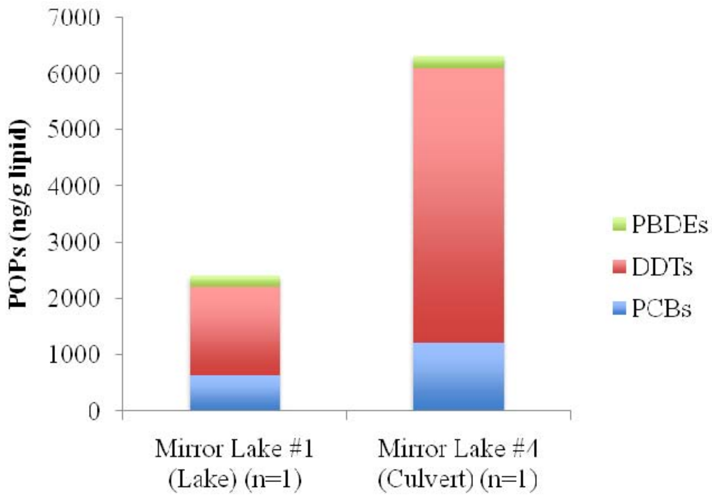
Lipid content values are currently available for only one sample from Site #1 and one sample from Site #4, but based on these limited data, lipid adjusted concentrations of DDTs were substantially higher in Chinook salmon from Site #4 than in Chinook salmon from Site #1 (4900 ng/g lipid vs. 1600 ng/g lipid), due in part to the very low lipid content (0.63%) of the composite samples from Site #4 (Figure 3-17). Concentrations of PCBs and PBDEs were also somewhat higher at Site #4 (Figure 3-17).



25~~Figure 3-15~~. Concentrations of PAH metabolites in bile of juvenile salmon from Mirror Lake, as compared to other sites sampled as part of the Salmon and Water Quality Study (LCREP 2007).



26Figure 3-16. Concentrations of three classes of persistent organic pollutants (POPs), PCBs, DDTs, and PBDEs, in bodies of juvenile Chinook salmon from Mirror Lake, as compared to other sites sampled as part of the Salmon and Water Quality Study (LCREP 2007).



27~~Figure 3-17~~. Lipid adjusted concentrations of three classes of persistent organic pollutants (POPs), PCBs, DDTs, and PBDEs, in bodies of juvenile Chinook salmon from Mirror Lake sampling sites.

3.3.10 Salmonid Prey Availability Surveys and Diet Analyses for Juvenile Chinook Salmon

Prey availability surveys were conducted at the Mirror Lake sites by sampling with benthic cores, terrestrial sweep nets, and Neuston tows to investigate the availability of salmonid prey species in benthic, terrestrial, and water column environments. Results of the benthic core sampling (conducted in 2008) are shown in Table 3-9. Dominant macroinvertebrate species at all three sites included oligochate worms and Dipteran larvae and pupae. Dipterans (primarily adults) were also prominent in the terrestrial sweep samples (Table 3-10), especially at Site #1, where they made up 73-78% of macroinertebrates collected. At Site #2, Hemipterans dominated the terrestrial sweep samples, accounting for 68% of individuals collected.

Data from the open water and emergent vegetation Neuston tow samples (are shown in Tables 3-11 through 3-15). Samples from May and June when fish diet samples were collected are shown in Tables 3-11 and 3-12, and additional data from other time periods in 2009 are shown in Tables 3-13 through 3-15). The tow samples are quite variable, reflecting the diversity in composition and abundance of invertebrate taxa found at the Mirror Lake comlex over time and between sites. Dipteran species made up a significant proportion of most of the open water and emergent vegetation samples at Sites #1 and #4. This was less true at Site #2; while Dipterans were consistently present, and accounting for at least 10% of the samples, they were usually not the dominant organisms. Other groups that made up a high proportion of samples at Young Creek included Ephemeroptera, Acari (mites), amphipods, and oligochate worms.

12Table 3-9. Mean counts of macroinvertebrates from sediment cores collected in 2008. Note these are mean counts based on 4-5 samples per event. % indicates the proportion of each mean that is composed of that taxon; values are bolded if that taxon made up 10% or more of the mean for that event.

	Mirror Lake [illegible]			Mirror Lake [illegible]			Mirror Lake [illegible]					
	[illegible]											
	July			July			May			July		
	[illegible]			[illegible]			[illegible]			[illegible]		
Taxa	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-
[illegible]	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-
[illegible]	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-

13~~Table 3-10~~. Mean counts of macroinvertebrates from terrestrial sweet net samples collected in 2008. Note these are mean counts based on 2-3 samples per event, with transects of 10 m each. % indicates the proportion of each mean that is composed of that taxon; values are bolded if that taxon made up 10% or more of the mean for that event.

Taxa	Mirror Lake #1						Mirror Lake #4			Mirror Lake #2		
	2008											
	May			July			May			July		
	[illegible]			[illegible]			[illegible]			[illegible]		
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]

Densities and diversity of invertebrates in the tows were much lower in 2009 compared to 2008 (Tables 3-11and 3-12), though we should note that the number of tows collected was small in both years (n=2 per sampling type per event). Macroinvertebrate prey availability may be patchy over time and between these sites; for example, Cyclopoids were very abundant at Site #4 by the culvert in May 2008 and nearby at Site #1 in June 2008, but were rare at Site #1 in May 2008 (Table 3-11, Table 3-12).

At two Mirror Lake sites (#1 and & #4) prey collections coincided with collections of juvenile Chinook salmon, so that when sufficient numbers of fish were collected the taxonomic composition and abundance of consumed prey could be compared with available prey. The results of this comparison are shown in Tables 11 and 12. The prey samples shown in this analysis were collected using Neuston nets, towed by boat for open water collections or by hand through aquatic habitat associated with emergent vegetation, to collect invertebrates in the water column that would be available to foraging fish. The analysis also focuses on the months of May and June, when fish were most prevalent at the sites. Fish were generally most abundant in May in both years, though we also have samples from June from site #1 in 2008.

In contrast to the diversity of the tow samples, the Chinook salmon diet sample generally contained a high proportion of Dipterans (primarily Chironomidae larvae and pupae), and in certain cases Cladocera or cyclopoid copepods. Of these paired sets of samples (tows compared to diets by site, year and month), the relative proportions of Dipterans in the diets compared to the tows were always greater. Chinook diets were found to be significantly different from the prey available to them at the time of sampling (2-way paired test using Permanova, sample type (diet *vs.* tow) p=0.03, sampling event p=0.18), and this is largely explained by their selection of Dipterans and occasionally other taxa. For example, the five fish sampled in June 2008 at site #1 did consume a relatively high proportion of Cladocera (68% of their diets on average, Table 3-11), but they did not consume the abundant Cyclopoids.

14~~Table 3-11~~. Mean counts of macroinvertebrates from Chinook diets (unshaded) and from Neuston net tows (shaded). Nets were towed through aquatic habitats that were either adjacent to emergent vegetation (along the margin of the habitat) or away from the margin in the open water at Mirror Lake site #1 in 2008 and 2009. Tows and fish were collected from the same sites on the same dates within each sampling event. Note these are mean counts based on 2 samples per event, with emergent vegetation tows sampling 10 m each and open water tows sampling 50 m each. % indicates the proportion of each mean that is composed of that taxon; values are bolded if that taxon made up 10% or more of the mean for that event.

	Mirror Lake #1																				
	[illegible]												[illegible]								
	May						June						May								
	emergent vegetation			[illegible]			emergent vegetation			[illegible]			emergent vegetation			open water			[illegible]		
Taxa	mean	SE	%	[illegible]	[illegible]	[illegible]	mean	SE	%	[illegible]	[illegible]	[illegible]	mean	SE	%	mean	SE	%	[illegible]	[illegible]	[illegible]
[illegible]	0.67	0.41	0.02	[illegible]	[illegible]	[illegible]	27.00	8.57	0.01	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	0.67	0.00	0.02	-	-	-	-	-	-	-	-	-	4.00	4.00	**0.14**	0.50	0.50	**0.11**	-	-	-
[illegible]	-	-	-	-	-	-	23.33	20.41	0.01	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	0.33	0.41	0.01	[illegible]	[illegible]	[illegible]	639.83	80.42	**0.20**	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	4.33	1.22	**0.13**	-	-	-	2.00	2.45	0.00	-	-	-	1.00	1.00	0.03	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]
[illegible]	0.33	0.41	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	0.67	0.41	0.02	-	-	-	1418.33	70.22	**0.45**	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	20.67	3.27	**0.60**	[illegible]	[illegible]	[illegible]	426.33	66.95	**0.14**	[illegible]	[illegible]	[illegible]	17.50	14.50	**0.59**	2.50	2.50	**0.56**	[illegible]	[illegible]	[illegible]
[illegible]	0.33	0.00	0.01	[illegible]	[illegible]	[illegible]	37.00	1.00	0.01	[illegible]	[illegible]	[illegible]	1.50	1.50	0.05	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]
[illegible]	4.33	0.41	**0.13**	[illegible]	[illegible]	[illegible]	36.67	16.33	0.01	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	2.50	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	8.17	2.86	0.00	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	1.00	0.41	0.03	[illegible]	[illegible]	[illegible]	434.33	2.86	**0.14**	-	-	-	3.00	3.00	**0.10**	1.00	1.00	**0.22**	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	20.17	5.31	0.01	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	6.00	7.35	0.00	-	-	-	1.00	1.00	0.03	0.50	0.50	**0.11**	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	-	-	-	58.00	1.22	0.02	-	-	-	0.50	0.50	0.02	-	-	-	-	-	-
[illegible]	1.00	1.22	0.03	-	-	-	-	-	-	-	-	-	1.00	1.00	0.03	-	-	-	-	-	-

15~~Table 3-12~~. Mean counts of macroinvertebrates from Chinook diets (unshaded) and from Neuston net tows (shaded). Nets were towed through aquatic habitats that were either adjacent to emergent vegetation (along the margin of the habitat) or away from the margin in the open water at Mirror Lake site #4 in 2008 and 2009. Tows and fish were collected from the same sites on the same dates within each sampling event. Note these are mean counts based on 2 samples per event, with emergent vegetation tows sampling 10 m each and open water tows sampling 50 m each. % indicates the proportion of each mean that is composed of that taxon; values are bolded if that taxon made up 10% or more of the mean for that event.

Taxa	Mirror Lake #4														
	2008						2009								
	May						May								
	emergent vegetation			[illegible]			emergent vegetation			open water			[illegible]		
	mean	SE	%	[illegible]	[illegible]	[illegible]	mean	SE	%	mean	SE	%	[illegible]	[illegible]	[illegible]
[illegible]	5.00	5.00	0.00	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	12.14	7.86	0.01	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	53.57	23.57	0.03	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	4.64	0.36	0.00	[illegible]	[illegible]	[illegible]	-	-	-	1.00	1.00	**1.00**	-	-	-
[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	1026.79	241.79	**0.48**	[illegible]	[illegible]	[illegible]	0.50	0.50	0.08	-	-	-	-	-	-
[illegible]	127.50	7.50	0.06	[illegible]	[illegible]	[illegible]	3.00	2.00	**0.50**	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	20.71	0.71	0.01	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	732.50	72.50	**0.35**	[illegible]	[illegible]	[illegible]	0.50	0.50	0.08	-	-	-	-	-	-
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	11.43	1.43	0.01	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	10.00	10.00	0.00	-	-	-	1.00	1.00	**0.17**	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	7.50	7.50	0.00	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	-	-	-
[illegible]	4.64	0.36	0.00	[illegible]	[illegible]	[illegible]	1.00	1.00	**0.17**	-	-	-	[illegible]	[illegible]	[illegible]
[illegible]	102.50	42.50	0.05	-	-	-	-	-	-	-	-	-	-	-	-
[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

16~~Table 3-13~~. Mean counts of macroinvertebrates from Neuston net tows at Mirror Lake Site #1 (Lake) in 2009. Nets were towed through aquatic habitats that were either adjacent to emergent vegetation (along the margin of the habitat) or away from the margin in the open water. Note these are mean counts based on 2-3 samples per event, with emergent vegetation tows sampling 10 m each and open water tows sampling 50 m each. % indicates the proportion of each mean that is composed of that taxon; values are bolded if that taxon made up 10% or more of the mean for that event.

	Mirror Lake #1																										
	2009																										
	April						Early June			Late June						July						August					
	Open water			Emergent vegetation			Open water			Open water			Emergent vegetation			Open water			Emergent vegetation			Open water			Emergent vegetation		
Taxa	Mean	SE	%	Mean	SE	%	Mean	SE	%	Mean	SE	%	Mean	SE	%	Mean	SE	%	Mean	SE	%	Mean	SE	%	Mean	SE	%
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]	-	-	-	[illegible]	[illegible]	[illegible]
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17~~Table 3-14~~. Mean counts of macroinvertebrates from Neuston net tows at Mirror Lake Site #2 (Young Creek) in 2009. Nets were towed through aquatic habitats that were either adjacent to emergent vegetation (along the margin of the habitat) or away from the margin in the open water. Note these are mean counts based on 2-3 samples per event, with emergent vegetation tows sampling 10 m each and open water tows sampling 50 m each. % indicates the proportion of each mean that is composed of that taxon; values are bolded if that taxon made up 10% or more of the mean for that event.

	Mirror Lake [illegible]																							
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	April			Early June						Late June						July						August		
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18~~Table 3-15~~. Mean counts of macroinvertebrates from Neuston net tows at Mirror Lake Site #2 (Young Creek) in 2009. Nets were towed through aquatic habitats that were either adjacent to emergent vegetation (along the margin of the habitat) or away from the margin in the open water. Note these are mean counts based on 2-3 samples per event, with emergent vegetation tows sampling 10 m each and open water tows sampling 50 m each. % indicates the proportion of each mean that is composed of that taxon; values are bolded if that taxon made up 10% or more of the mean for that event.

Taxa	Mirror Lake #2														
	2009														
	April			May						July			August		
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3.4 Conclusions

The goal of the Mirror Lake salmon and prey sampling is to evaluate the effectiveness of site enhancements on salmonid prey availability, salmonid occurrence, and salmonid health and condition at the Mirror Lake Complex restoration sites. This is being accomplished by 1) comparing data on fish assemblages, prey types and abundance, salmon habitat occurrence, and salmon health indicators before and after the enhancements, and 2) comparing data from Mirror Lake with other relatively undisturbed monitoring sites in the Lower Columbia, such as the Ecosystem Monitoring sites in Reach H to see whether the restoration activities are helping the sites to approach reference conditions.

As mentioned earlier, between 2004 and 2007, before monitoring was initiated, at Young Creek a failing culvert (dam) was replaced with a 70 ft bridge to give salmon species access to upstream spawning areas. Also, invasive plants along the creek were removed and native willows and cottonwoods were planted. In summer of 2008, large woody debris was added to Young Creek to improve salmon habitat, and boulders were added to the culvert at I-84 to improve water flow for salmon passage. As yet we have only two years of data on the Mirror Lake sites, so it is too early to make any kind of comprehensive evaluation of the effectiveness of these restoration activities. However, we can make some preliminary observations about how the sites compare with reference areas and pattern of salmon and prey occurrence at the sites.

Summary of 2008 Findings

Culvert (Site #4) and Lake (Site #1) Sites. Two of our sampling sites Site #1 (Lake) and Site #4 (Culvert) were of a habitat type comparable to the emergent marsh habitats sampled as part of the Ecosystem Monitoring Project (e.g. Jones et al. 2008, Johnson et al. 2009), although with higher levels of disturbance or alteration. In our 2008 sampling we found that the fish communities at these two sites were quite similar to those observed at the tidal freshwater sites sampled in Reaches F-H as part of the Ecosystem Monitoring project (Jones et al. 2008). The number of species found at these two sites ranged 13-16 (Sol et al. 2009), and commonly observed non-salmonid species included carp, stickleback, chiselmouth, and pumpkinseed, with chiselmouth (28% of total catch) and pumpkinseed (17% of total catch) predominating at the Culver site, and carp (23% of total catch) and stickleback (26% of total catch) predominating at the Lake site. Species diversity was also similar at the two sites (Shannon-Weiner diversity index values of ~2) and comparable to values observed for Reach H Ecosystem Monitoring sites (Jones et al. 2008, Johnson et al. 2009).

Patterns of salmon occurrence at Sites #1 and #4 in 2008 were also fairly similar, and comparable to those observed at the Reach H Ecosystem Monitoring sites (Jones et al. 2008, Johnson et al. 2009). Salmonids made up 4% of the total catch at Site #1, and 29% of the total catch at Site #4, with coho salmon being the dominant species at Site #4 (~80% of salmonid catch) and Chinook salmon at Site #1 (~75% of salmonid catch). Catch per unit effort (CPUE) for Chinook salmon at both sites and coho salmon at Site #1 were quite low (<5-10 fish per 1000 m^2), with somewhat higher values for coho salmon at Site #4 (~100 fish per 1000 m^2). Salmon were present at these two sites from the beginning of the sampling season in April though June, with peak number present in May, but were only rarely observed later in the summer, perhaps in part because of high water temperatures that in the 15-25^{o}C range, warmer than the preferred temperature for Chinook and coho salmon. The proportions of unmarked, presumably wild fish in the catches were fairly high (typically over 80% in most months when fish were present) with the exception of coho salmon caught at Site #4 in May, which were primarily marked hatchery fish.

Genetic analysis of a subset of Chinook salmon from the two sites showed that stocks present included Spring Creek Group fall Chinook, a Lower Columbia stock, but also salmon from Snake River fall, Deschutes River fall, and Upper Columbia Summer fall Chinook stocks. The Spring Creek Group fall Chinook tended to be more abundant in May, while the salmon from the other stocks were observed more frequently in June. The Chinook salmon utilizing the Lake and Culvert sites appeared to be entering the area from the mainstem Columbia, as this species was not present at the upstream Young Creek site (see below). Condition factor (K) of both Chinook and coho salmon was higher in fish from Site #1 then in fish from Site #4 (1.24 vs. 1.03 for Chinook and 1.24 vs. 0.98 for coho), and also higher than the average value for K from coho and Chinook at the Ecosystem Monitoring site in Reach H (1.09 ± 0.25, n = 195 for Chinook; 1.03 ± 0.14, n =144 for coho). Values of K below 1.00 are generally considered indicative of poor nutritional health for juvenile salmonids.

Young Creek. Site #2 (Young Creek) was very different from the Lake and Culvert sites, a more riparian habitat, with a narrow channel and more rapidly flowing water that was not clearly comparable to any of the Ecosystem Monitoring sites samples in Reach H. Our 2008 sampling showed that this site supported a wild coho population, but was not utilized by Chinook or chum salmon. Water temperatures at this site remained relatively cool throughout the sampling season, ranging from 10-15^{o}C. Species richness and diversity were lower at this site than at the Lake or Culvert sites, with fewer non-salmonid fish species. Coho salmon constituted 84% of the catch and stickleback made up most of the rest of the catch (13%). In both 2008 and 2009 (see Sol et al. 2009as well as this report) catches were dominated by coho salmon, constituting 84% of the catch in 2008 and 68% of the catch in 2009, and smaller number of predominantly native non-salmonid species were present, so the total number of species was only 5-6. Species diversity was also quite low, due to the dominance of the coho salmon. Based on catch per unit effort data (~1700 fish per 1000 m2), coho salmon were quite abundant at the Young Creek, with much higher number than at the Lake or Culvert sites. Also, they were present at the sampling site from April through the end of the sampling period in September, and had not yet left the area when sampling was concluded. Condition of the coho salmon from the Young Creek site seemed good, with an average K value of 1.09. This value was lower than the value observed for the small number of coho sampled from Site #1 (1.17) but higher than the values observed for coho from Site #4 (0.90) or the average value for coho from the Reach H Ecosystem Monitoring sites (1.03 ± 0.14, n = 144).

Fish Monitoring Findings for 2009

Culvert (Site #4) and Lake (Site #1) Sites. In general, fish community characteristics, and patterns of occurrence of salmon species at Sites #1 and #4 in 2009 were consistent with our observations in the previous sampling in 2008. The numbers and type of species present were almost the same (15 total species at the lake and 17 at the Culvert), although, a few non-salmonid species were reported in 2009 that were not observed in 2008, including walleye, crappie, and chub. The proportions of salmonids in the total catch (3% at the Lake site and 21% of the total catch at the Culvert site in 2009) were also consistent, along with the time periods when salmon were present (April through June). There was some variation. First, in 2009, stickleback made up a much higher proportion of the total catch at Site #1 than in 2008 (73% vs. 26%), so species diversity was much lower at Site #1 in 2009 than in 2008. The proportions of various salmon species observed at the sites also changed; in 2009, very few coho salmon were collected at Site #4, and Chinook salmon were the dominant salmonid species at both sites. Additionally, chum salmon were captured at Site #4 for the first time in 2009.

In 2009, as in 2008, the genetic stock composition was fairly similar in Chinook salmon from Sites #1 and #4, and the stocks present were similar to those observed in 2008. However, marked hatchery Chinook from the Spring Creek fall Chinook group were more predominant in 2009 than in 2008. In May 2009, when the majority of genetics samples were collected, hatchery-reared Chinook from this stock dominated both sites. The Spring Creek National Fish Hatchery, located near Hood River, OR, is a potential source of these fish, as it does release substantial number of subyearling Chinook at this time, although other hatcheries in the Columbia Gorge area may also have contributed fish of a similar genetic origin. In June, Spring Creek Group fall Chinook were observed, but Upper Columbia summer/fall, Snake River fall, and Deschutes River fall Chinook were present, consistent with our observations in 2008. At yet, we have no information on the genetic origin of the small, wild Chinook that were observed at Site #4 in April, a data gap that should be addressed in future sampling. However, overall, the data from both years indicate that Sites #1 and #4 are being utilized by wild fall Chinook from several stocks, including those from the Upper Columbia and the Snake and Deschutes Rivers.

The relatively low condition factor observed in Chinook and coho salmon from Site #4 was also observed in 2009. This finding is consistent with the lower lipid content measured in Chinook from Site #4 in 2008. Similarly, K was significantly lower in juvenile coho from Site #4 than in coho from Site #1. Lipid content values in juvenile Chinook salmon from Site #1 were comparable to values observed for juvenile Chinook from field sampling sites in the Salmon and Water Quality study (LCREP 2007), and would be considered within the normal range (Biro et al. 2004). However, salmon from Mirror Lake #4 (culvert) had a lipid content of only 0.63%, lower than the average lipid level observed for juvenile Chinook from any site sampled in the Salmon and Water Quality Study (LCREP 2007). Lipid content below 1% is considered to be associated with an increased risk of mortality during the first year of life (Biro et al. 2004). These findings could be an indication of relatively poor quality of the habitat at Site #4 in the culvert, but other factors such as the migration history of the sampled fish could also influence their lipid content. Data from additional samples are needed to establish that this preliminary observation is really representative of lipid levels in fish from the Culvert site. Another interesting finding was significantly lower condition (K) values in Chinook salmon from both the Lake and the Culvert sites (for Site #4 0.89 + 0.13 vs. 1.03 + 0.28; $p = 0.0032$; for site #1, 1.24 + 0.23 vs. 1.01 + 0.15; $p < 0.0001$). Coho salmon from Site #4 also had significantly lower K values in 2009 than in 2008 (0.90 + 0.02 vs. 0.98 + 0.01; $p = 0.003$). The same trend was seen at Site #1 (1.16 + 0.13 vs. 1.23 + 0.30), but the K values were not significantly different, in part probably because of the small samples size (8-9 coho at each site). The reasons for this are unclear, but lower condition was concurrent with higher CPUE at the sites in 2009, and also lower densities of prey items in tow samples in 2009. Unusually high water temperatures in 2009 may also have made condition less favorable for salmon growth.

Based on the samples we have analyzed to date, exposure to urban and industrial contaminants (i.e., PCBs, PBDEs and PAHs) is relatively low in Chinook salmon captured at the Mirror Lake sites #1 and #4. This is consistent with what we have observed in Chinook salmon from other sites in the Columbia Gorge sampled as part of the Ecosystem Monitoring project (Jones et al. 2008). Concentrations of PAH metabolites fluorescing at phenanthrene (PHN), benzo[a]pyrene (BaP) and naphthalene (NPH) wavelengths in this bile sample were in the lower range of values observed in juvenile Chinook salmon from sites sampled as part of the Salmon and Water Quality Study (LCREP 2007; Figure 3-15). Meador et al. (2008) have estimated an effect threshold of around 2.3 ug/mg bile protein for FACs-PHN. The bile from Mirror Lake Chinook salmon was below that threshold. Thus the limited data available at this point suggest that exposure to PAHs is not a serious problems for juvenile salmon utilizing the Mirror Lake site. When compared with concentrations in juvenile Chinook salmon from other Lower Columbia River sites (LCREP 2007), concentrations of PCBs and PBDEs in Mirror Lake fish were also quite low, with PCB levels well below threshold for toxic effects (Meador et al. 2002). Levels of DDTs in juvenile Chinook from these sites, on the other hand, were somewhat higher, comparable to those found in juvenile salmon from sites throughout the Lower Columbia sampled as part of the Salmon and Water Quality study (LCREP 2007). In fact, because of the very low lipid content of the fish sampled from Site #4, the lipid-adjusted DDT concentration of fish from this site approached the adverse effect concentrations for DDTs as estimated by Johnson et al. (2007), based on data from Beckvar et al. (2005). It is difficult to know where the juvenile salmon from the Mirror Lake sites were exposed to this pesticide, as it is found throughout the Columbia River. However, the fish from the Site #4 composite with the very low lipid content were unmarked Spring Creek Group fall Chinook, so presumably came from a wild population from somewhere in the Columbia Gorge area. Information on contaminant concentrations in stomach contents or prey in the area would be useful in determining whether or not DDT contamination could be a problem at the restoration site itself.

Based on the consistently high summer water temperatures observed at Sites #1 and #4, temperature may have been a limiting factor for salmon at the Lake and Culvert sites, although it is uncertain how long outmigrant subyearling Chinook would reside at these sites that are relatively far from the saltwater estuary even if conditions were more favorable. At both sites, water temperatures increased substantially from May to August, reaching a maximum of 30°C and remaining above 20°C in September. Temperatures in this range are associated with increased mortality in juvenile Chinook salmon (McCollough 1999). Moreover, sub-lethal effects may occur at lower temperatures. Reductions in growth rates were found when juvenile fish were held in water temperatures exceeding about 16°C (Bisson and Davis 1976; Marine and Cech 1998), and there is evidence that temperatures in excess of about 12–13°C may inhibit the development of migratory response and saltwater adaptation in juvenile fish (DWR 1988). Juvenile Chinook salmon may have been exposed to water temperature in this range in June or possibly even in May, the months when fish densities were highest.

Like salmonid occurrence data, diet and prey availability sampling for Chinook salmon at Sites #1 and #4 revealed similarities between these two sites. Moreover, prey availability and consumption at Mirror Lake sites #1 and #4 in late spring of 2008 and 2009 appear to be quite similar to patterns seen at other Lower Columbia Rivers sites sampled as part of the Ecosystem Monitoring Project (Jones et al. 2008). The diversity and density of macroinvertebrates in the samples from Sites #1 and #4 were quite variable, and there were no clear differences between Sites #1 and #4 in relative abundance of salmonid prey items. Prey densities in tow samples were substantially lower in 2009 than in 2008. Because of the limited number of samples analyzed and the spatial and temporal variability in prey, it is hard to be certain that these results represent the true conditions at these sites. However, interestingly, the lower apparent prey abundance coincides with significantly lower condition factor (K) values in 2009 than in 2008 in Chinook salmon from both Sites #1 and #4, and in coho salmon from site #4. Further analyses will include comparisons between the Mirror Lake sites and other sites throughout the region, which will provide a more robust assessment of the quality of prey resources at the Mirror Lake restoration sites.

One finding that is striking at these sites, and is consistent with other sites sampled in the region during these two years, is the relatively high proportion of Dipterans (primarily Chironomidae larvae and pupae) in the diets. We suspect the preference for these prey items is largely explained by their relative abundance coupled with their size. Although Chironomids are quite small, and Chinook could consume much larger prey items, few larger prey items are plentiful if even available. This evidence of selectivity in prey items may be useful in evaluating the quality of prey resources at the Mirror Lake restoration sites.

Young Creek. As at the Culvert and Lake sites, fish community and salmon occurrence patterns in 2009 generally confirmed our findings in 2008. Water temperatures at this site were slightly higher in 2009 than in 2008, but still remained relatively cool throughout the sampling season in comparison so Sites #1 and #4, ranging from 11°C to a maximum of 20°C in August. Again catches were dominated by juvenile coho salmon (68% of the total catch in 2009), the fish community was characterized by low species richness and low species diversity. As in 2008, stickleback was the primary non-salmonid species, accounting for 28% of the total catch.

As in 2008, juvenile coho were present at Young Creek from April until sampling was concluded in September, suggesting that this site provides favorable habitat, with low temperatures even during the summer months. We have no data on lipid content of juvenile coho from Young Creek or reference sites, but condition factor (K) in juvenile coho from this site was significantly higher than in coho from Site #4 (Culvert) or the Franz Lake Ecosystem Monitoring in Reach H, suggesting that this site provides good conditions for coho growth. K was also significantly higher in 2009 than in 2008 for coho salmon from Young Creek (1.20 ± 0.14 vs. 1.09 ± 0.17, $p < 0.0001$).

Based on catch per unit effort data, coho salmon were somewhat less abundant at Young Creek in 2009 than in the 2008 (Sol et al. 2009 and this report). Many factors could contribute to variations in coho abundance, but it is possible that placement of large woody debris at the Young Creek site might have reduced efficiency of fishing with the MBN at the site.

The efficiency of our sampling methods at Site #2 (modified block net utilizing a smaller "chase" net) may have affected the number of non-salmonid species caught. While the MBN appeared efficient for capturing juvenile salmonids, other species, including lampreys and bottom-dwelling fish, are probably more capable of eluding the chase net as it herds fish downstream into the block net. For instance, one lamprey was collected in August using the MBN technique. During salvage efforts for site restoration activities, higher numbers of lamprey were collected using a backpack electro-shocker (C. Collins-personal communication). Based on these observations, the data presented here provide a relative estimate of non-salmonid species and their numbers at this site. Additional sampling methods may be needed to describe the non-salmonid species composition more accurately.

Prey availability data from Young Creek suggested that the macroinvertebrate community at this site is somewhat different from that at the Lake and Culvert sites. While many of the same taxa were present, the Young Creek samples generally contained lower proportions of Dipterans and higher proportions of other species, including Ephemeroptera, Acari (mites), amphipods, and oligochate worms than samples from the Culvert and Lake sites. As yet we have no information on coho salmon diets at the Young Creek site, so it is uncertain which of the macroinvertebrate species present might constitute preferred prey, or how densities of these prey items compare with other undisturbed sites. Other studies indicate that, like juvenile Chinook salmon, coho salmon consume Dipterans, especially Chironomid larvae, pupae, and adults, as well as other insects such as along Ephmeroptera, Trichoptera, Plecoptera; amphipods and oligochaetes may also be significant components of the diet when available (Gonzales 2006; Roegner et al. 2010; Allan et al. 2003; Hetrick et al. 1998). These taxa were often present in significant proportion in sediment core, terrestrial sweep, and Neuston tow samples from Young Creek, suggesting that appropriate prey items are available for the coho salmon utilizing the site. However, diet information for juvenile coho salmon from the Young Creek site, as well as comparative data on diets and prey availability from comparable reference sites, would be helpful in interpreting the quality of prey resources in this area and how they may be affecting by restoration activities.

In summary, our results show that the Mirror Lake complex is being used by juvenile salmonids. The Young Creek site appears to be an important rearing area for juvenile coho, where they are found in large numbers from April through the end of our sampling season. However, with the exception of a small number of steelhead, cutthroat, and rainbow trout, the site did not support any other salmon species. Coho salmon were also found in at the lake and culvert sites, but generally in low numbers except in the case of hatchery releases. Chinook salmon, including some wild fall Chinook from Upper Columbia, Snake River, and Deschutes River stocks, were found only at the Lake and Culvert sites, where they were present in relatively small numbers from April until June. The Chinook salmon appeared to be entering the site from the main stem Columbia River and did not migrate up to Young Creek. Species diversity and richness tended to increase closer to the mainstem Columbia River but invasive species were also more predominant at these sites.

Between 2008 and 2009, there was some variability in fish community composition, and salmon catch, although the general patterns of occurrence were the same. Catches of Chinook salmon at the Lake and Culvert sites tended to be higher in 2009 than in 2008, but prey densities and Chinook salmon condition factor values tended to be lower. The Young Creek site showed the opposites trends, with lower catches of coho salmon, but higher condition factor values for the fish that were collected. These mixed findings suggest that the benefits of the habitat improvements made during the past years are not yet evident or cannot be clearly differentiated from variations in fish catch and condition associated with other factors. However, site characteristics at the Lake and Culvert sites were generally similar to those at comparable references areas sampled as part of the Ecosystem Monitoring project, and preliminary data suggest that the health and condition of the salmon using the sites is favorable, especially at the Lake. Based on the data available, conditions also appeared favorable for coho salmon at the Young Creek. However, our evaluation of restoration effectiveness at the Young Creek site would be improved by collection of data on diet, lipid content, and growth for the coho salmon that utilize this site. Identification of a suitable reference site with which we could compare the coho population and prey resources at Young Creek would also assist with this evaluation.

4.0 Planting Success AEM at Mirror Lake and Sandy River Delta

In August and September 2008, Ash Creek Forest Management (ACFM) staff established and sampled 192 vegetation plots across 259 acres at the Sandy River Delta and Mirror Lake restoration sites (19Ta19Table 4-1ble 10) in east Multnomah County, Oregon (Estuary Partnership Contract #06-2009). Treatments on project sites include re-establishing native plants and controlling competing noxious and non-native vegetation. Resulting native plant cover is expected to contribute to improved riparian function through large wood recruitment in aquatic habitats, increased shading of aquatic habitats, increased quantity, quality, and diversity of allocthonous input, and erosion control. Anticipated effects on terrestrial resources include reduced edge, greater extent of hardwood forest cover and greater habitat diversity. The goal of continued monitoring of these sites is to systematically assess the effectiveness of treatments on weed control, native plant establishment and habitat conditions.

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Vegetation monitoring and analyses rendered in this report are intended to gauge current stocking levels, estimate responses of critical weeds to treatments, identify impediments to successful plant establishment, and recommend future courses of treatments that will ensure the overall success of the project. A conceptual model for planting AEM at Sandy River Delta and Mirror Lake is presented in Appendix Appendix 2.

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4.1 Introduction

4.1.1 Restoration Sites and Monitoring Locations

For a description of the Mirror Lake site, refer to Section 2 in this report. The Sandy River Delta is an island at the confluence of the Sandy and Columbia Rivers. At both sites, restoration actions were implemented to control competing noxious and non-native vegetation (e.g., Himalayan blackberry and reed canary grass) and to recover native Columbia River floodplain forest and scrub plant communities with associated ecosystem function. Resulting native plant cover is expected to contribute to improved riparian function through large wood recruitment in aquatic habitats, increased shading of aquatic habitats, increased quantity, quality, and diversity of allochthonous input, and erosion control. Anticipated effects on terrestrial resources include reduced edge, greater extent of hardwood forest cover and greater habitat diversity.

At the Sandy River Delta site, Ash Creek Forest Management staff monitored 5 restoration locations, covering a total area of 259 acres. These 5 locations included: Estuary Partnership's (EP) 15-acre "North bank Sandy Channel;" Estuary Partnership's 20-acre "South Bank/North Slough;" Estuary Partnership's and BPA's 40-acre "Southwest Quad;" and USACE's 155 acres "Sundial Island North" (19Table 4-1, Figure 8). Staff also monitored one 29-acre restoration site at Rooster Rock State Park, "Mirror Lake."

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In 2008, ACFM also established and sampled a reference site representing target conditions for restoration activities. The reference site, located riverward from the Sandy Drainage Dike at the confluence of the western Sandy River outlet, is approximately 40 acres of relatively undisturbed ash-cottonwood forest located within a 70-acre forested area. The site typifies ash-cottonwood floodplain forest of the lower Columbia River, remnants of which exist on islands and elsewhere on the Columbia floodplain from Bonneville Dam downstream to near the town of Rainier, Oregon, at which point marine influences increase dramatically. Mixed-age cottonwood and ash comprise the great majority of canopy trees within the sampled area, with the oldest stems estimated in excess of 100 years.

19~~Table 4-1~~. Restoration locations and number of acres restored at the Sandy River Delta (SRD) and Mirror Lake (ML) sites.

Restoration Location	Restoration Location	Restoration Funder(s)	Number of Acres Restored and Monitored	Year(s) of Initial Planting
Sundial Island North	SRD	USACE	155	2007
Southwest Quad	SRD	EP and BPA	40	2005, 2008
South Bank/North Slough	SRD	EP	20	2005
North Bank Sandy Channel	SRD	EP	15	2006
Mirror Lake	ML	EP	29	2008
Total	-	-	259	-

4.1.2. Physical Characteristics at the Monitoring Locations

Many similarities and differences in site conditions and restoration approaches exist between sites at Sandy River Delta and Mirror Lake. All restoration locations and the reference site are within ten miles of one-another on the Oregon side of the Columbia River and are within the active Columbia River floodplain on alluvial soils (predominantly Rafton, Sauvie, and Faloma silt loams). These soils, although described as poorly drained, are relatively coarse with a large fraction of sand and moderate to very high rates of water transmission. Despite saturation in winter and spring under flood conditions, these soils can become severely dry late in the growing season, posing significant challenges to establishment of young planted trees and shrubs. Portions of all restoration sites contain soils that are nearly pure sand. These areas support very poor vegetation growth and resist establishment of woody vegetation.

All sites are exposed to weather extremes at the mouth of the Columbia River Gorge, including cold, dry east winds in winter and hot, dry east winds in summer and early fall. Winter winds are often accompanied by freezing rain, sleet, and snow; ice and snow sometimes accumulate to a thickness able to cause severe tree crown damage. Flooding may occur in winter as well as in late spring following snowmelt. This bi-modal flood regime, with flooding occurring well into the growing season, creates growing conditions that are unlike anywhere else in western Oregon. Harsh conditions have yielded communities of plants that are relatively simple, but also unique to the Columbia River floodplain, including a small number of endemics, such as *Coreopsis atkinsoniana* and *Salix fluviatilis*. Species with wider distributions occurring in the Columbia floodplain nevertheless exhibit characteristics that distinguish them from populations elsewhere, such as markedly later budbreak in *Fraxinus latifolia*, and later seed dispersal in *Populus balsamifera spp. trichocarpa.* These distinctions, perhaps developed in response to late spring floods, point out the strong selective forces at work within this floodplain, and the need to preserve and promote plants of local genetic origin.

Wildlife at the restoration sites present challenges to restoration success. In particular, blacktail deer and voles are present to varying degrees at all sites, and have damaged or killed plantings by browsing, antler rubbing, and girdling. Elk, however, are present in large numbers only at Mirror Lake, where they are browsing, antler-rubbing and trampling planted trees and shrubs in high-traffic areas.

The proportion of pre-existing tree cover varies significantly among sites. Overall, the Southwest Quad and the 20-Acre South Bank North Slough sites have the lowest proportion of pre-existing canopy, and the 15-acre Sandy River Riparian site has the highest. In areas with heavy tree cover, restoration focus shifts to eliminating understory weeds – primarily Himalayan blackberry – and establishing native shrubs. Forested areas present a variety of challenges to restoration operations. Trees, down logs and other habitat components prevent or curtail the use of many mowing and farming implements; these obstacles also make laying out consistent plant rows difficult or impossible.

4.1.3. Comparison of Pre-planting Preparation and Plant Installation by Site

Pre-planting treatment varied greatly among the five restoration sites, both in duration of site preparation and the number and types of treatments applied (20~~Table 4-2~~). These differences reflected differing conditions on sites, funding constraints, expanding knowledge of area restoration techniques, weather, access, and desires of funding partners. For instance, site constraints limited the use of soil cultivation techniques and row layout at the 15-acre North Bank Sandy Channel site, and funders wished to minimize the use of herbicides. Funding was available for a short window; hence, a limited number of site preparation treatments was compressed into a three-month period prior to planting.

Restoration sites also differed in installed plant density and species (21~~Table 4-3~~). Crews planted exclusively shrubs in areas beneath power lines, and predominantly trees elsewhere. Outside of power line corridors, the same set of floodplain-adapted species were generally planted on each of the sites, with a few exceptions (21~~Table 4-3~~). Planters generally placed trees and shrubs based on hydrologic, light, or other site conditions. For instance, spiraea was planted mostly in low, wet areas, red elderberry was planted predominantly in uplands with partial shade, and Pacific ninebark was placed near streams with beaver activity.

20~~Table 4-2~~. Preparation treatments applied to restoration and AEM locations at the SRD and ML.

Larger Restoration Site	Monitoring Location	Treatment Types and Number Applied to Site						
		Year(s) of Site Prep.	Goat Grazing	Site-Prep Mowing	Pre-cultivation Herbicide Application	Plowing	Discing	Post-cultivation Herbicide Application
SRD	Sundial Island North	1.5	1	1	1	1	3	1
SRD	SW Quad	2		1	1		2	2
SRD	South Bank/North Slough	1.5		1	1		2	1
SRD	North Bank Sandy Channel	0.25		1	1			
ML	ML	2.25		1	1		3	3

21~~Table 4-3~~. Woody species installed at SRD and ML Site.

TREES	SHRUBS

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Scientific name	Common name
*Abies grandis**	Grand fir
Acer macrophyllum	Bigleaf maple
Alnus rubra	Red alder
Crataegus douglasii	Black hawthorn
Fraxinus latifolia	Oregon ash
Populus balsamifera	Black cottonwood
*Pseudotsuga menziesii**	Douglas-fir
Quercus garryana	Oregon oak
Rhamnus purshiana	Cascara
Thuja plicata	Western redcedar
*Planted at Mirror Lake only	

Scientific name	Common name
Cornus stolonifera	Red-osier dogwood
Holodiscus discolor	Ocean spray
Mahonia aquifolium	Oregon grape
Lonicera involucrata	Black twinberry
Oemleria cerasiformis	Indian plum
Philadelphis lewisii	Mock orange
Physocarpus capitatus	Pacific ninebark
Ribes sanguineum	Redflowering currant
Rosa pisocarpa	Swamp rose
Rubus parviflorus	Thimbleberry
Rubus spectabilis	Salmonberry
Salix lasiandra	Pacific willow
Salix piperi	Piper willow
Salix scouleriana	Scouler willow
Sambucus cerulea	Blue elderberry
Sambucus racemosa	Red elderberry
Spiraea douglasii	Spiraea
Symphoricarpos albus	Snowberry

4.2 Methods

Sampling protocol in 2008 and 2009 generally followed Roegner et al. (2008, 2009), in "Protocols for Monitoring Habitat Projects in the Lower Columbia River and Estuary"Rapid Monitoring. In 2008, per the Roegner comprehensive monitoring protocol, baseline transects and plots were established at all sites and spaced according to site size to ensure sampling of entire restoration area. At the 15-acre North Bank Sandy River, plots were established along a changing azimuth to capture interior and edge restored habitat. Baseline and transect points on the baseline were re-marked with fresh flagging, and PVC stakes reset and pink marking whiskers uncovered. One-third of total plots per site were randomly chosen and marked as permanent with PVC, pink flagging and a pink marking whisker, and photos were taken in each cardinal direction. In 2009, according to the Roegner rapid monitoring protocol, permanent plots were re-located, marked and sampled. Additionally, four photos were taken in each cardinal direction at every permanent plot for future reference. All other plots along each transect were evenly spaced following a north-south direction. The surveyor paced pre-determined distances to establish plot spacinglocatedinstalled systematically at intervals pre-determined for each survey unit based on unit size. At the Southwest Quad, the surveyor added several plots and located a larger proportion of rapid monitoring plots within lower-stocked forest restoration portions of the site, with proportionately fewer plots in densely stocked scrub restoration areas.

At each plot, the surveyor recorded woody vegetation as live or dead, natural or planted; plant vigor and suppression by weedy vegetation were noted. Notes include plot and vegetation conditions, such as herbivory, animal activity, and herbicide damage. Herbaceous species were recorded. Where a plot center landed on or near a boundary, the plot was transformed into a 16m 5.66 radius semicircle (noted in data).

Surveyors noted specific habitat features for plots falling within existing forested areas or exhibiting other atypical conditions. Where the middle of the woody plant (shrub or tree trunk) was not within a 4m-radius plot, it was not included in the survey. Surveyors noted specific habitat features for plots falling within existing forested areas or exhibiting other atypical conditions.

Photos were taken at most permanent plot locations where change can be shown over time. Care was taken to capture landscapes or trees that would be easily located for future reference. Cardinal direction wais noted for each photo.

For all sites, the number of plants installed per hectare was were calculated by dividing simply the total number of plants initially installed at the site divided by the number of hectares planted. Stocking and percent survival werewere calculated as follows using the following methodology: total number of live, installed plants (T) is divided by number of plots sampled (n) to yield average of live, installed plants per plot (Tp). Total per plot wasis then multiplied by 200 (because a 4-m radius plot is 1/200th ha) to estimate total number of live, installed plants per hectare (Th). This total wasis then divided by number of plants originally installed per hectare (i) to get survival rate of installed woody plants.

$$T / n = Tp$$

$$Tp * 200 = Th$$

$$Th / i = \% \text{ survival.}$$

4.3 Results

At all planted restoration sites, ACFM found a range of 1,500 to 3,300 live, woody plantings per hectare, showing a survival rate of 68% to 98%; trees comprised 33% to 88% of live, woody plantings measured. When naturally occurring (non-planted) trees and reference shrubs are included, the total of live, woody native plants on all restoration sites ranged from 2,200 to 3,800 per hectare. Duration of weed control before planting, or site preparation, appears to be positively correlated with planting success on all sites. Table 4-4Table 4-4 provides a comparison of plant survival and stocking between the two years of monitoring, 2008 and 2009.

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22Table 4-4. Plant survival and stocking by location.

Site		ACE	SW Quad	20 acre	15-acre North Bank	Mirror Lake
Plants installed per hectare		2,010	3,840	2,150	4,610	3,444
Plots per site						
	2008	50	30	20	50	38
	2009	50	37	22	50	33
Live, installed plants per hectare						
	2008	1,228	3,240	1,540	2,588	3,100
	2009	1,509	2,627	2,086	N/A*	3,362
Percent survival						
	2008	61%	84%	72%	56%	90%
	2009	75%	68%	97%	N/A*	98%
Total live woody plants per hectare						
	2008	1,784	3,367	1,660	2,860	3,100
	2009	2,396	2,795	2,196	3,793	3,396

Proportion trees of total woody plants					
2008	75%	37%	75%	64%	51%
2009	60%	33%	88%	33%	40%

23~~Table 4-5~~ shows vigor of native plants averaged across all of the sites and the effect competing vegetation on vigor of installed woody plants sampled. 'Low vigor' describes a plant which is severely suppressed or damaged. 'Medium vigor' indicates the plant shows normal stress expected in early outplantings (discoloration of leaves, herbivory, etc). 'High vigor' is applied to plants that are in excellent condition and growing vigorously relative to species growth potential. Plants that are designated 'suppressed' are significantly shaded, crowded, and overtopped by competing weedy vegetation. While these plants may eventually grow through competing weeds, and weed covering may provide some protection from browsing deer, weeds are significantly affecting their growth and survival.

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23~~Table 4-5~~. Plant vigor and suppression averaged across AEM locations at SRD and ML.

VIGOR	**LOW**	**MEDIUM**	**HIGH**
total live, installed trees and shrubs on restoration sites	26	1,690	220
2009 ratio per rating	2%	87%	11%
2008 ratio per rating	6%	87%	7%
SUPPRESSED	**Yes**	**No**	
total live, installed trees and shrubs on restoration sites	175	769	
2009 ratio per rating	19%	81%	
2008 ratio per rating	25%	75%	

The primary weed species throughout the surveyed sites were common teasel (*Dipsacus sylvestris*), Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), reed canary grass (*Phalaris arundinacea*), and Himalayan blackberry (*Rubus discolor*). Reed canary grass was prevalent in sloughs, back channels and areas with partial tree canopies. Himalayan blackberry was observed throughout the surveyed sites, mostly in low-lying small patches or individual sprigs. There was no evidence of voles, mice or other small mammals adversely affecting native plants.

4.4 Discussion

Significant differences are apparent in the data between 2008 and 2009. In particular, total woody plant stocking estimates increased on all sites except for the Southwest Quad. Several factors may have contributed to increases at Sundial Island North, South Bank/North Slough, North Bank Sandy Channel and Mirror Lake, including site conditions and natural plant establishment. Adjustments in sampling likely decreased estimates at the Southwest Quad. Suppression by noxious, non-native weeds also decreased from 2008, and sites appeared to move toward reference site conditions.

Site Conditions

Data collected in 2008 included intensive herbaceous vegetation monitoring. To accommodate this data collection, sites were left unmowed until after monitoring completion. As a result, herbaceous vegetation was over 2 meters tall on many plots, impeding the location and identification of small planted and natural seedlings. In 2009, all sites were mowed prior to monitoring, facilitating more accurate plant counts. In addition, many plants were significantly larger after an additional year of growth, making the plants more visible.

Natural Plant Establishment

Actual stocking is increasing due natural seeding, development of mutli-stemmed clones and rhizomatous spread of native trees and shrubs. Especially on the North Bank Sandy Channel, earlier plantings from 2003 and 2004 are beginning to yield large quantities of native seed, which are dispersed across the restoration sites by birds. As vegetation management treatments and shading suppress weeds, opportunities for shade-tolerant native plant establishment from naturally distributed seed is increasing. Naturally recruiting species prevalent on Sundial Island sites include red elderberry, red-osier dogwood, cascara, black currant, and black hawthorn. Sword fern is also appearing in many locations. Species such as swamp rose, spirea and black cottonwood are spreading via rhizomes and root suckers. These processes are propelling restoration sites toward target conditions measured at the reference site. As naturally recruited plants begin to appear in restoration sites, however, distinguishing planted from naturally recruited individuals is expected to become increasingly difficult. On the North Bank site, surveyors can no longer reliably distinguish between planted and naturally recruited plants.

Data analysis also yielded comparable results between 2008 and 2009 for Mirror Lake for both overall plant survival and woody plant stocking. Overall survival of installed plants was approximately 90% in 2008 and 98% in 2009. The increased stocking was due to recording rhizomatous sprouts of swamp rose (*Rosa pisocarpa*) and spiraea (*Spiraea douglasii*) as installed plants. Additionally, numerous cottonwood cuttings that may have appeared dead in 2008 had new basal sprouts in 2009.

Sampling Bias

On the Southwest Quad, total stocking estimates were lower in 2009 than those recorded in 2008, in spite of significant natural recruitment of shrubs in some areas. This apparent decrease in stocking was due primarily to redistribution of plots to create a more representative sampling of the site. As noted in methods, the surveyor located a larger proportion of plots within lower-stocked forest restoration portions of the site, with relatively fewer plots in densely stocked scrub restoration areas.

Noxious/Non-Native weeds

Overall suppression of planted plants by weed species decreased from 2008 to 2009 (Table 4-5). Reed canary grass and Himalayan blackberry appeared to have the most significant impacts on native plant survival. Other weed species appeared to be nuisances for native plants, but did not seem to impede survival and moderate growth. Some broadleaf herbaceous weeds appeared to provide some protection from deer browse.

Planted willows, spirea, twinberry and Pacific ninebark were generally growing well even in areas dominated by reed canary grass. In treed areas spiraea was not over-topped by reed canary grass, and abundant rhizomatous sprouts were observed.

The surveyor also located indigo bush (*Amorpha fruticosa*), a relatively new weed to the Sandy River Delta. Numerous plants were treated in fall 2008 in the streambed along the North Bank Sandy Channel by cutting each stem and immediately treating the stump with undiluted Roundup. Although the treatment was successful, other plants have frequently been observed outside of the treatment area. Recent inspections indicate the plant thrives in the Columbia River floodplain, where it has been observed spreading rapidly along channels in numerous areas previously devoid of the plant.

Recommendations

Continued maintenance is needed at all of the sites sampled in order to achieve the goal of restoring Columbia River floodplain forest and scrub. Interplanting to increase stocking on Sundial Island North and South Bank North Slough will help ensure long-term occupancy of these sites with native trees and shrubs. Additional vegetation management treatments are indicated for all of the sites, as shown below in Table 4-6.

2009 monitoring indicates that site preparation, planting, and maintenance treatments are resulting in establishment of significant areas of Columbia River floodplain forest. Additional treatments to enhance native cover and control the most aggressive weeds continue to be necessary for establishment of all sites, but intensity of treatment needs is declining. The advent of native plant establishment through natural processes observed in 2009 is highly encouraging for the long-term, sustainable restoration of these sites.

24Table 4-6. Recommended 2010 maintenance treatments

Site	Treatment Date	ACE Sundial I North	SW Quad	20- acre S Bank N Slough	15- acre N Bank Sandy	Mirror Lake
Interplanting	2/1/2010	X	X	X		X
Spring moisture cons. Spot spray	3/1/2010	X	X	X		X
RCG and blackberry spot spray	5/1/2010					X
Mow	8/1/2010					X
Spot-spray blackberry	9/1/2010	X	X	X	X	X

5.0 Vegetation and Habitat AEM at Scappoose Bottomlands

5.1 Introduction

The purpose of these action effectiveness assessments is to build upon previously conducted baseline studies (ORAF 2004) in order to understand how cattle exclusion and riparian revegetation affect the function of Lower Scappoose Creek and the Hogan Ranch wetlands. Assessing changes following riparian restoration can be difficult to measure until the vegetation becomes established. At this time, SBWC staff monitor baseline conditions and document changes in the site with photo points. In the future, this information will be helpful in combination with other datasets (e.g., on-the-ground planting monitoring) to determine the effects of restoration activities over time. Conceptual models for planting and cattle exclusion at Scappoose Bottomlands are presented in Appendix Appendix 2.

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The long-term goal of restoration activities in Scappoose Bay Watershed is to enhance the critical habitat connections between Scappoose Bay and the salmon refugia habitat in the upper watershed. To date, restoration work has focused on a three-mile section of Lower Scappoose Creek (between the confluence of North and South Scappoose Creeks) and 100 acres of wetland complex on the Hogan Ranch property. Restoration activities were implemented to enhance both the riparian corridor along Scappoose Creek and the wetlands on Hogan Ranch through control of invasive plant species, planting with native trees and shrubs, and fencing along waterways to exclude livestock. Water quailty is one of the monitoring elements because warm water (water temperatures greater than 20 degrees Celsius), low dissolved oxygen (less than 8 milligrams per liter [mg/L]), and high pH (higher than 9) can create stressful conditions for salmon.

In 2008 and 2009, SBWC implemented the following work elements for their AEM:

1. Photo-Point Collection. SBWC collected photo-points twice during late spring and summer and compiled previously collected photo point data.
2. Water Quality Sampling. SBWC monitored water quality monthly for temperature, dissolved oxygen, turbidity, conductivity, and pH and installed temperature and depth loggers at the 2 sites. SBWC also collected monthly *E. coli* bacteria samples at Hogan Ranch.
3. Vegetation Planting and Community Sampling. SBWC assessed the success of vegetation plantings along Lower Scappoose Creek and the Hogan Ranch wetlands and vegetation communities at Hogan Ranch.

5.1.1 Site and Restoration Description

The Scappoose Bay Watershed has a variety of habitats, including the bay area, tidal wetlands and sloughs in the Scappoose Bottomlands, and instream habitats in Scappoose Creek and its tributaries, North and South Scappoose Creek. Scappoose Creek connects the Scappoose Bottomlands with salmon refugia habitat in the Scappoose tributaries. Four salmonid species (including Endangered Species Act listed steelhead and coho salmon) spawn and rear within the Scappoose Bay Watershed. The Bottomlands, in particular, provide habitat for resident fish species, wildlife, and plants (including threatened and endangered species) and for salmon and bird species migrating through the Columbia and Willamette River Basins and Pacific flyway. The ash gallery forests, oak woodlands, and tidal wetland plant communities throughout the watershed host numerous migratory birds such as waterfowl and neo-tropical migrants such as heron, eagle, osprey, and other birds of prey.

Over 90% of the lands surrounding the Scappoose Bay Bottomlands are used as pasturelands for livestock. As such, riparian areas were cleared and little to no canopy cover exists along Lower Scappoose Creek and with few native species in the Hogan Ranch wetlands. Temperature and sediment are considered limiting factors for salmonids in this area. In the summertime, livestock graze right up to the stream edges in some areas. In particular, heavy cattle grazing around the wetlands on the Hogan Ranch property has resulted in an under story dominated by non-native invasive species like reed canary grass and blackberry. Little regeneration of native ash and willow has occurred, and beaver take down mature trees. Cattle heavily graze on unprotected wetland plants in late summer, reducing the diversity of native wetland vegetation.

Restoration activities at Lower Scappoose Creek and Hogan Ranch were made possible by partnerships between the landowners, Scappoose Bay Watershed Council (SBWC), Oregon Watershed Enhancement Board (OWEB), Natural Resources Conservation Service (NRCS), Ducks Unlimited (DU), and the Lower Columbia River Estuary Partnership (Estuary Partnership). Riparian fencing was installed along Scappoose Creek in 2007 and 2008 and at Hogan Ranch in 2005 with supplemental fencing in 2007. Significant weed management and riparian planting was conducted in 2007 and 2008 at both sites. Overall, habitat was conserved on 173 acres at Hogan's Ranch, when volunteers installed 10,000 ft of fencing to exclude cattle from waterways, removed 5 ac of invasive species like Himalayan blackberry and Canadian thistle, and repopulated areas with native fauna like ash and dogwood. While this work has not caused significant modifications of hydrology on either site, Ducks Unlimited has replaced water control structures on two of the wetlands on the Hogan Ranch site, allowing water to be held longer through the summer encouraging native aquatic vegetation & discouraging invasive reed canary grass, while providing water fowl habitat. Without the water control structures the water levels would drop in spring allowing reed canary grass to out-compete native vegetation. Water levels are adjusted by pulling boards in the water control structures.

The Lower Scappoose Creek project site is located on two private properties (Wilson and LaCombe properties) along Scappoose Creek. This area consists of low alluvial rolling plains that form the floodplains along Scappoose Creek (DEA 2000). This section of Scappoose Creek is low gradient, dominated by fine sediments, and tidally influenced year round. The surrounding area is subject to sheet flows during high water events in winter. Areas adjacent to the stream are used for pasture and hay crops, and have little to no tree canopy.

The Hogan Ranch site is north of the city of Scappoose, and bordered by Scappoose Creek on the east and Multnomah Channel on the west. The property's legal description is T4N, R1W, S20, 29, 31 (Lev 2004). This area has low alluvial rolling plains with numerous ponds, creeks and sloughs (DEA 2000). For this action effectiveness monitoring effort, all 3 major ponds (referred to as Ponds #1, #2, and # 3) are being evaluated. Pond #3 lies on the eastern edge of the property and is tidally influence year round whereas Ponds #1 and #2 experience sheet flows and tidal influence at higher water levels. This area consists of seasonal and perennial wetlands and ash forests.

5.1.2 Habitat Classification

Using the Cowardin hierarchy of habitat types for palustrine systems, the Lower Scappoose Creek properties are classified as "seasonally flooded" with tidal influence in the stream channel. The immediately surrounding fields, or meadows, are "irregularly flooded" during rain events and/or when inundated by high water levels in Lower Scappoose Creek (EPA 2002). Fennessy (EPA 2002) uses a scale of 1 (relatively low impact) to 24 (relatively high impact) to assess the degree of hydrologic alterations at wetland sites based on the amount and type of human disturbance; type of usage; and type of vegetation. Following cattle exclusion and native vegetation plantings, the score for this section of Lower Scappoose Creek has improved from 11 to 9. Here, Lower Scappoose Creek has functional hydrology, but remains affected by past grazing activities and current grazing on adjacent properties. The replanted riparian buffer will take several years to become established. Grazing has impacted the native plant communities by increasing the occurrence of invasive weeds, decreasing regeneration of native species, compacting the soil, and eroding stream banks.

In the Hogan Ranch wetlands, Pond #1 is classified as "seasonally flooded" following the Cowardin hierarchy. The forested and emergent wetlands and surrounding fields, or meadows, are "irregularly flooded" during rain events and/or when inundated by high water levels in nearby stream channels. In the dry season, water levels are largely controlled by a water control structure at the Northwest corner, but the site is still affected by tidal influences, river levels in the Multnomah Channel, and subsurface hydrology. Prior to the installation of this control structure, Pond #1 tended to dry up by late summer. In both the first and second years (2008 and 2009) since the control structures have been replaced and the there is still a wetted area within the pond.

Pond # 2 lies to the south of Pond # 1. This pond is affected by the same influences as Pond # 1 and a second water control structure located between the two ponds. Pond # 2 is overall deeper and larger than Pond #1 and holds a fair quantity of water year round. Thus, this pond is classified as half-seasonal wetland and half permanently flooded, making it Type 2 in the Cowardin hierarchy.

Pond # 3 is a subtidal, emergent wetland pond that is classified as "semi-permanently flooded." The immediately surrounding fields (meadows) are "irregularly flooded" during rain events and/or when river levels inundate them (EPA 2002).

5.2 Methods

5.2.1 Protocols

The SBWC combined applicable methods from Methods for Evaluating Wetland Condition (EPA, 2002), Field & Laboratory Methods for General Ecology (Brower et al. 1997), and Oregon Riparian Assessment Framework (ORAF 2004) to formulate the original monitoring protocols for Lower Scappoose Creek. Since this area is tidally influenced and considered a freshwater estuary, the site and monitoring activities fall outside the scope of the above methodologies. By integrating methods from each text, SBWC developed appropriate and workable methods for this area in 2007. In 2008, the "Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary" (Roegner et al. 2008) were released. The SBWC established methods are comparable with these newly released protocols.

5.2.2 Habitat Classification

SBWC classified wetlands in the Lower Scappoose Creek area with the Cowardin wetland classification system (EPA, 2002). These habitats were then ranked by the degree of hydrologic alteration following Fennessy (EPA 2002).

5.2.3 Photo Points

SBWC established 5 photo points on April 11, 2007 at the Lower Scappoose Creek site (28Figure 5-1) and at the Hogan Ranch site, 15 photo points on July 28, 2004, with 2 more added in 2008 (29Figure 5-2). GPS coordinates were collected and archived for these photo point locations. Photos were taken at 90° intervals (4 pictures) at each location and once each season for a total of 4 times per year. SBWC established the photo point locations to track long-term environmental changes at this restoration site.

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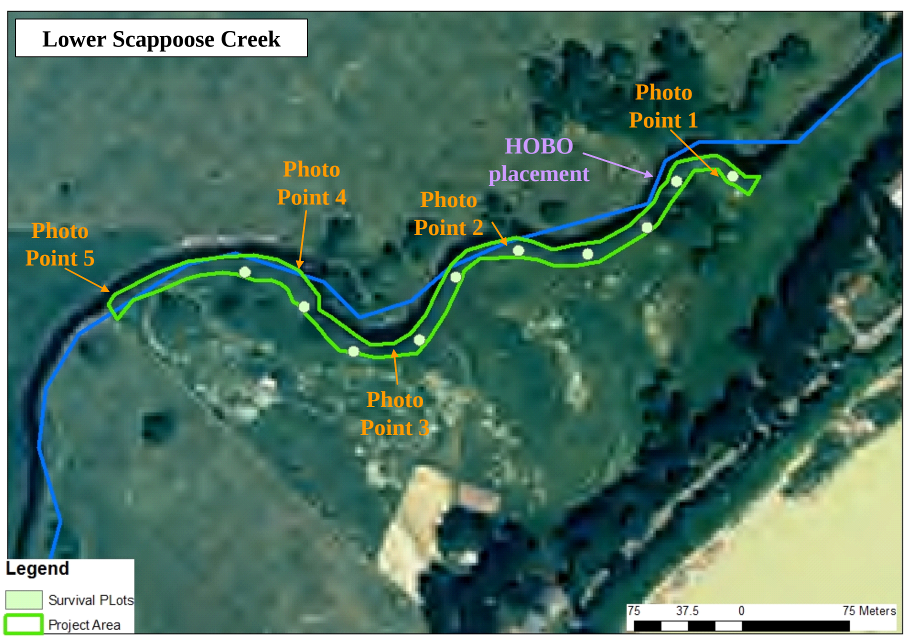
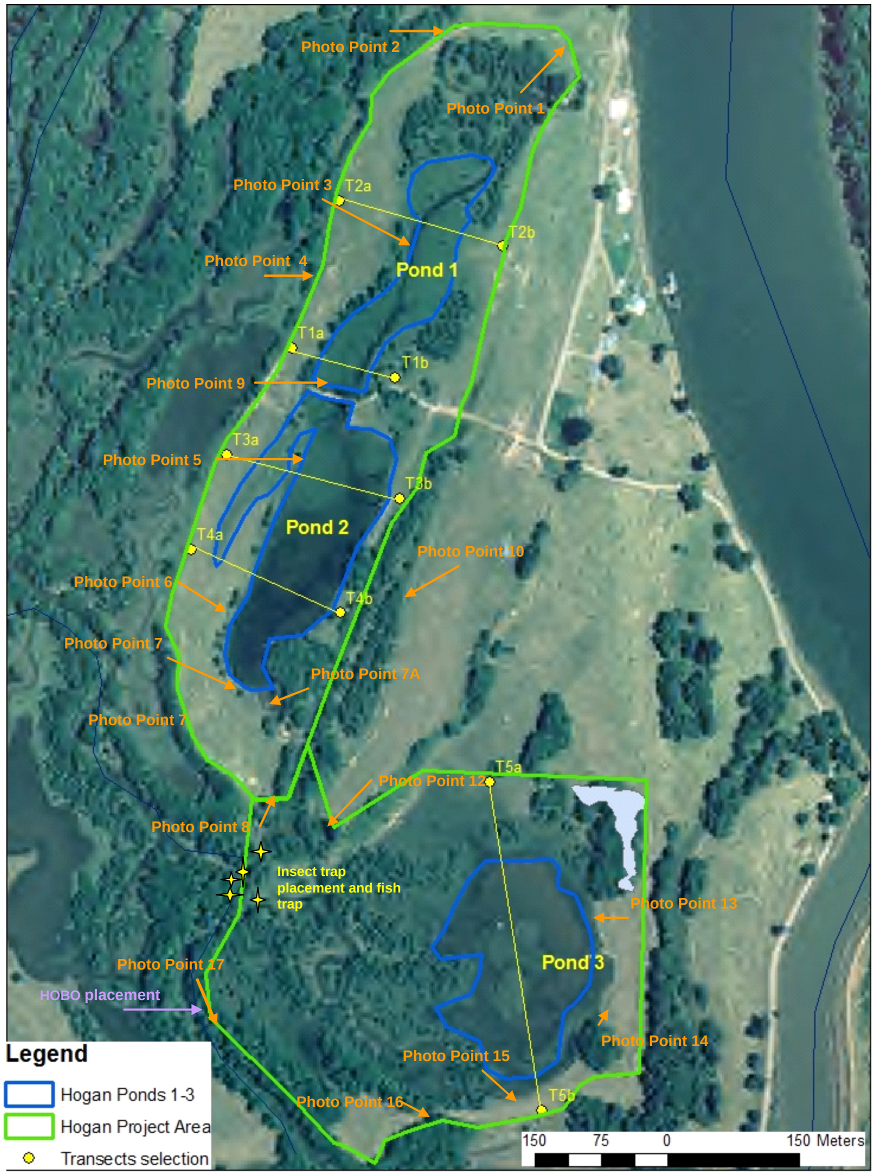


28Figure 5-1. Photo-point, HOBO logger location, and planting survival monitoring plots along Lower Scappoose Creek.



29Figure 5-2. Locations of photo-point, vegetation transects, insect traps, fish sampling, and HOBO logger at Hogan Ranch.

5.2.4 Water Quality and Depth Monitoring

Water samples were collected from Scappoose Creek at the downstream corner of the Wilson property (GIS # SSCA01) and the upstream corner of the LaCombe property (GIS # SSCA05). These samples were tested for dissolved oxygen (using a Hach Dissolved Oxygen Titration Kit), turbidity (Hach Turbidity Meter), pH (Orion pH meter), and conductivity (YSI 30 Conductivity Meter). In 2007, SBWC tested water samples collected from Lower Scappoose Creek and Hogan Ranch for nitrogen and phosphorus. Since this testing detected little (if any) of these nutrients, SBWC were advised by the Oregon Department of Environmental Quality (ODEQ) to discontinue this sampling. During sampling, air temperature was measured with a NIST Thermometer. SBWC installed a HOBO temperature and pressure sensor was installed to provide temperature and water level data at 60-minute intervals at the two sites. SBWC installed a HOBO between Photo-points #1 and # 3 on Scappoose Creek (28Figure 5-1) and another HOBO near Photo-point # 17 at Hogan Ranch (29Figure 5-2). Due to mechanical difficulties, SBWC was not able to retrieve the HOBO loggers from Scappoose Creek in 2009. Data from the HOBO loggers will be included in the 2010 report and a new HOBO will be placed for continued data collection in the winter 2010.

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5.2.5 Success of Vegetation Plantings

SBWC staff assessed the survival and vigor of plantings in riparian areas along Lower Scappoose Creek and marshy wetlands at Hogan Ranch. Both sites were fenced to exclude livestock and then planted with native woody plants in winter 2008. At each site, SBWC staff followed the planting protocol outlined in Roegner et al. (2008) as closely as possible.

The riparian site at Lower Scappoose Creek has a narrow planting strip (4-5 m; 28Figure 5-1), making it infeasible to implement the baseline and perpendicular transects called for in the monitoring protocol. Instead, they placed plots systematically from a random start in a path parallel to the creek. Plots were located every 50 m along the length of the planted area (28Figure 5-1), starting at the property line. The start point was chosen with a random number table. SBWC staff assessed planting survival and vigor at 12 8-m diameter plots at this site, following the guidelines in Roegner et al. (2008) for this 0.4 hectare project.

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At the second site, Hogan Ranch Pond #3, the planted area was wide, but irregularly shaped. SBWC staff implemented the baseline and transect sampling design for this area, but needed to modify transect widths and locations along the baseline to conform to the planted area. Plantings at Hogan Ranch include ash forest, willow, and shrub communities. SBWC staff placed a baseline through each of the communities and constructed transects and plots systematically from a random start as much as was feasible. In total, they assessed planting survival and vigor at 62 plots on this site (up from 54 in 2008; 30Figure 5-3), following the Roegner et al. (2008) recommendations.

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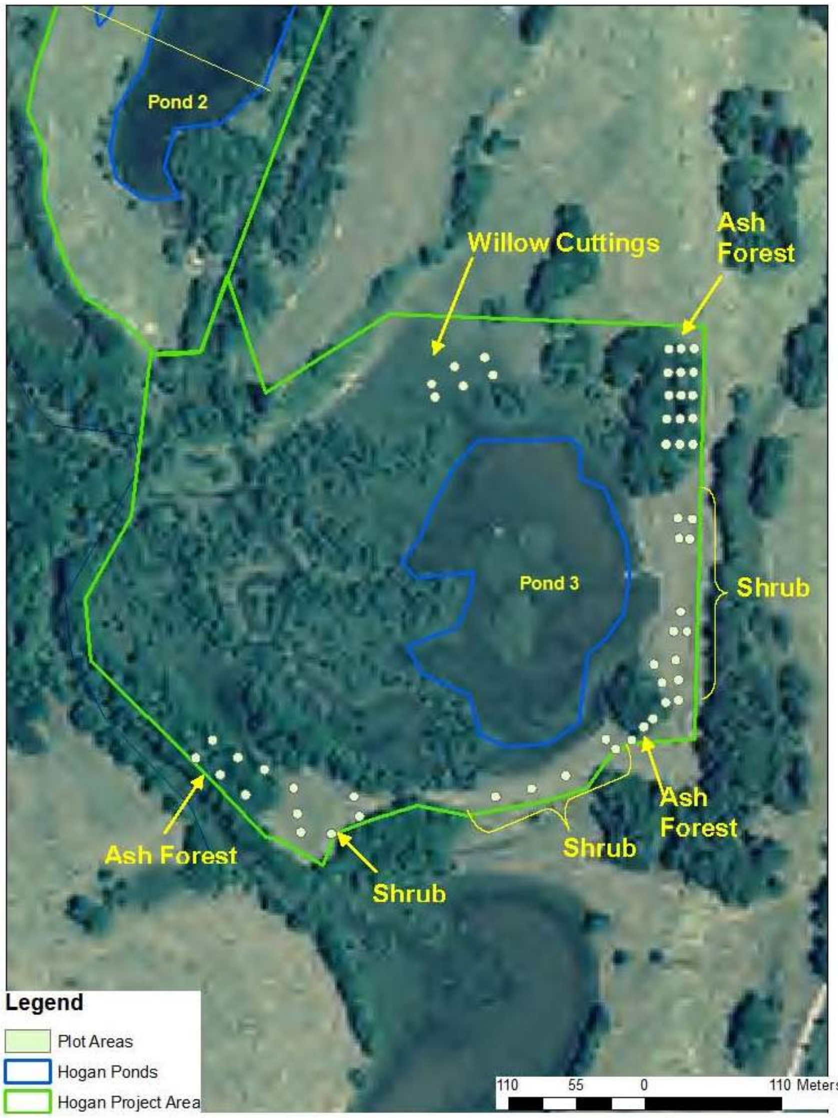
Total planting survival was calculated as the total number of living plants divided by the total number of installed plants. Vigor was assessed qualitatively in the field. Average planting density (APD) was the average of the density of plantings in each plot (plants/m^2).



30~~Figure 5-3~~ Location of plots for monitoring vegetation survival on Hogan Ranch Pond #3.

5.2.6 Vegetation Community Monitoring at Hogan Ranch

The composition of the vegetation communities at Hogan Ranch were examined to describe changes in plant community following ecological restoration activities in three tidal freshwater ponds. SBWC staff assessed vegetation communities along transects running across the ponds (29~~Figure 5-2~~). On each transect, they identified the communities based on vegetation gradients. The simple basin topography of

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each pond leads to clear bands of vegetation ringing a central depression, as vegetation communities transition along the hydrologic gradient to the center of the pond. From high to low elevations, the vegetation transitions from a mix of upland and facultative pasture grasses ("FACU grass and forbs"), to a band of facultative wetland grass with a sparse willow over story ("FACW grasses/forested fringe), to an obligate wetland marsh edge community ("Marshy shore"), to the submerged and floating vegetation in the wetted area of the pond ("Wetted area"). This pattern was consistent on both sides of the pond. Transects intersect each of the outer rings of vegetation twice. These communities were recorded separately in the field, but then combined for the purposes of data analysis when no significant differences were found between pond sides.

In 2004 (3 years prior to restoration), five transects were established and permanently marked. Subsequent monitoring in 2005 (two years before restoration efforts), 2008 and 2009 (one and two years after construction phase) used the same transects. Plot locations differ between years because the plot quadrats were placed with random tosses at each sampling event. The number of plots in each community also varied between years as community widths changed in response hydrology (**Error! Reference source not found.**~~Table 5-1~~).

Within each identified community, SBWC randomly placed an appropriate number of 50 cm x 100 cm plots (plot frame size) within a band extending 2 m on both sides of the transect line. Plots were determined by randomly tossing the plot frame along the transect with closed eyes. Number of plots per community were proportional to the area of the community along transect. The width of each community along transects was recorded in 2004 and 2008 and 2009. In 2009 the FACW grasses/forested fringe and marshy shore communities were not distinguishable in ponds 2 & 3 and vegetation plots were categorized under the marshy shore community. This is possibly due to the lack of a willow/shrub plant community and an increase in the abundance of reed canary grass around these ponds. When deep water and/or mud made central areas of the ponds inaccessible, staff estimated the community composition and width of inaccessible area visually from pond edges. In each plot, they recorded the estimated percent cover of every rooted species. Plot vegetation cover was summed and averaged by plant community to determine the overall percent cover represented by each plant in the plant communities for each pond. When estimated cover was less than 1%, they recorded it as 0.5% (vs. classifying it as "trace"). Species with total cover less than 1% were recorded as "trace" in the final data table after all calculations were complete.

Data were analyzed by calculating the total cover for each species in each community at each pond. In addition. In addition, SBWC used the USDA PLANTS database was used to categorize each species' native status and wetland indicator status when possible. This allowed SBWC to look for changes in native species richness and wetland status across the three years. Additionally, they compared the widths of the communities along the transects, both to explain observed changes in vegetation and to document hydrologic changes associated with restoration on Ponds #1 and #2.

25~~Table 5-1~~. Sampling effort associated with each vegetation community at the Hogan Ranch ponds.

Pond	Community	No. plots 2009	No. plots 2008	No. plots 2005	No. plots 2004
1	FACU grasses and forbs (I and C)	12	8	5	5
	FACW grasses/ forested fringe (H and D)	6	6	4	4
	Marshy shore (G and E)	9	4	5	7
	Wetted area (F)	8	6	1	0
2	FACU grasses and forbs (I and C)	10	7	5	6

	FACW grasses/ forested fringe (H and D)	0*	1	2	2
	Marshy shore (G and E)	8	5	2	3
	Wetted area (F)	9	7	1	5
3	FACU grasses and forbs (I and C)	4	1	3	0
	FACW grasses/ forested fringe (H and D)	0*	3	1	3
	Marshy shore (G and E)	4	2	1	4
	Wetted area (F)	4	1	0	2

5.3 Results

Based on the Wardrop & Brooks scale of hydrologic alterations, Ponds #1 and #2 receive a ranking of 10 (denoting intermediate alterations) whereas Pond # 3 a ranking of 1 (denoting low impact). All three ponds have functional hydrology, but past intense grazing has occurred around Ponds #1 and #2. Emergent wetland species in Pond # 3 are rebounding and growing following cattle exclusion.. Grazing has negatively impacted the native plant communities, compacted the soil, and eroded the stream banks. Since cattle have been excluded from this area, the emergent plant communities are showing a fast positive response. Simultaneously, the invasive species reed canary grass is becoming more prevalent now at the site without control by grazing or other means. Since the expansion of invasive species like reed canary grass is of concern, SBWC is observing invasive species at the site and considering their management in long-term restoration strategies.

5.3.1 Photo Points

The SBWC is compiling photos points collected in 2009 and previous years to assess environmental changes at these sites relative to surrounding lands outside the project area. In 2008, high water levels from spring to summer prevented collection of photo points for all seasons. 31Figure 5-3 provides an example of a photo point series for one location along Lower Scappoose Creek in January and July 2009.

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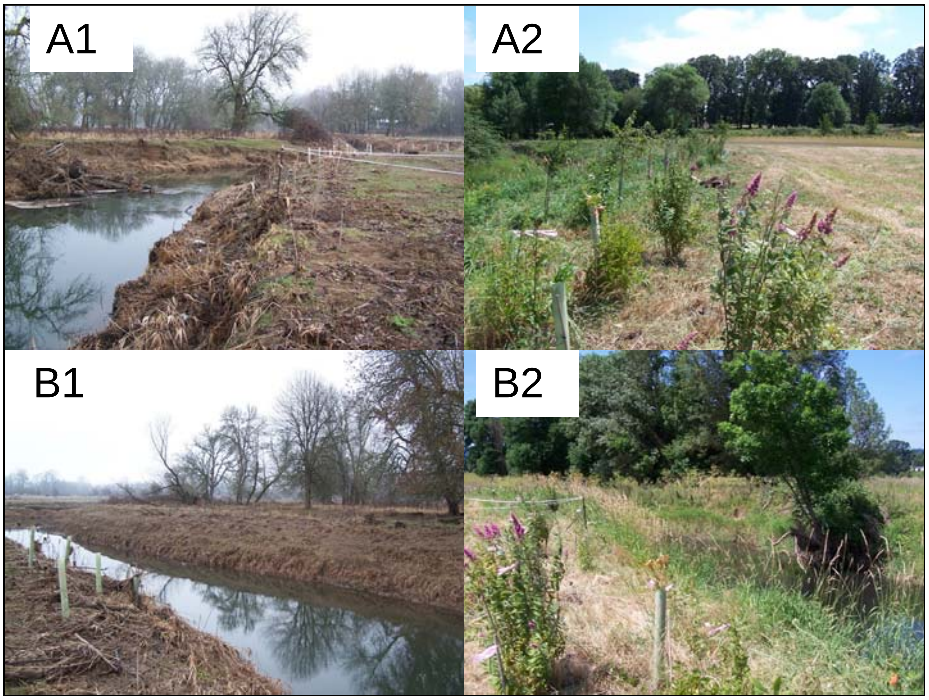

31Figure 5-4. Photo point example showing seasonal changes between January and July 2009 at one location (photo point #2) along Lower Scappoose Creek A1 and A2 taken to East, B1 and B2 taken to West of photo point.

5.3.2 Monthly Water Quality and Depth Monitoring

For Lower Scappoose Creek, 2009 trends in monthly water quality conditions varied by sampling time and parameter (**Error! Reference source not found.**Table 5-2) but remained consistent with data from 2008 and 2007. Across years, the pH has remained close to neutral; turbidity is below 7.0 for the entire sampling year, after the first initial rains in fall. The dissolved oxygen is consistently near or above 10.0 ppm. Conductivity remains between 65 and 100 mhod/cm except during the lowest water levels. In all three years, water temperature in the summer months exceeds 20 degrees C, which is outside the desired temperature range for salmonid habitat. Due to mechanical difficulties, SBWC was not able to retrieve the HOBO loggers from the site in 2009. HOBO data will be included in the 2010 report.

For Hogan Ranch, values for water quality parameters measured monthly were much more variable than Scappoose Creek and differed by pond (**Error! Reference source not found.**Table 5-3; 35Figure 5-5 A-G). For water temperature in the summer months (June-August), the lowest temperatures in 2007 were observed in August, June in 2008 data and July in 2009 (35Figure 5-5 A). In all three years, temperatures were generally comparable between ponds throughout the sampling period though a wider range of temperatures and depth was observed in 2008 (35Figure 5-5 A and B). In all three years, water temperature in the summer months exceeds 20 degrees C, which is outside the desired temperature range for salmonid habitat.

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Dissolved oxygen was higher in August 2009, for all three ponds, than in both 2007 and 2008 (35~~Figure 5-5~~ C). In 2009, dissolved oxygen in Ponds #1 and #2 decreased initially, and then peaked in August. Pond #3 had the highest dissolved oxygen among years and ponds in both July and August 2009.

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Turbidity in all three years of sampling varied between ponds and sampling date. In contrast with the 2007 data, the 2008 and 2009 turbidity observations increased at all ponds over the summer sampling period (**Error! Reference source not found.**~~Table 5-3~~; 35~~Figure 5-5~~ D). Turbidity values in June 2008 and 2009 were consistently lower than 2007 values taken prior to cattle exclusion and replacement of the water control structures. Currently, the ponds hold more water, allowing increased plant growth and water filtration. This plant growth helps stabilizes the fine sediment within the ponds that can be easily disturbed. Turbidity levels rose sharply after the water levels dropped in late July and August 2008 and 2009 (35~~Figure 5-5~~ D).

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Conductivity values increased over the summer sampling period in all three years (35~~Figure 5-5~~ E). The highest conductivity values were in 2009 in Pond #3, where they spiked in July and August.

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The pH in 2009 was similar to 2007 and 2008 in Ponds #1 and #2, but was elevated in Pond #3 in July and August. During these two months, the pH in Pond #3 fell into a range (>9.0) considered stressful for salmon. Values in all three ponds increased from June to August.

In 2008 and 2009, SBWC collaborated with the City of Scappoose to complete monthly bacteria counts in the Hogan Ranch ponds. No data are available for 2007 (35~~Figure 5-5~~ G and H). The results from 2008 and 2009 suggest that tests with a higher colony capacity are needed for this sampling because colony counts were above the limits of the tests. The tests came back showing an increase in coliform counts with lower water levels in Ponds # 2 and # 3. There is a difference in sedimentation load and vegetation density in the ponds which may account for some of the bacteria level differences. Even with livestock excluded from the area, bacteria counts increased as water levels dropped and the ponds became stagnant.

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Water levels in 2009 were not as high as in 2008, but were still higher than average until dam releases decreased in late June. Values for estimated water depths varied by pond and sampling time (**Error! Reference source not found.**~~Table 5-3~~; 35~~Figure 5-5 B~~). In 2009, water depth stayed high through August in Pond #1, decreased sharply after July in Pond #2 and after June in Pond #3. In 2007, estimated depths for all three ponds peaked in July and dropped in August for Ponds #2 and #3. In 2008, estimated depths peaked in June and decreased throughout the summer And Pond #1 retained more water than Ponds #2 and #3 in August.

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26~~Table 5-2~~. Water quality and depth data collected monthly for Scappoose Creek.

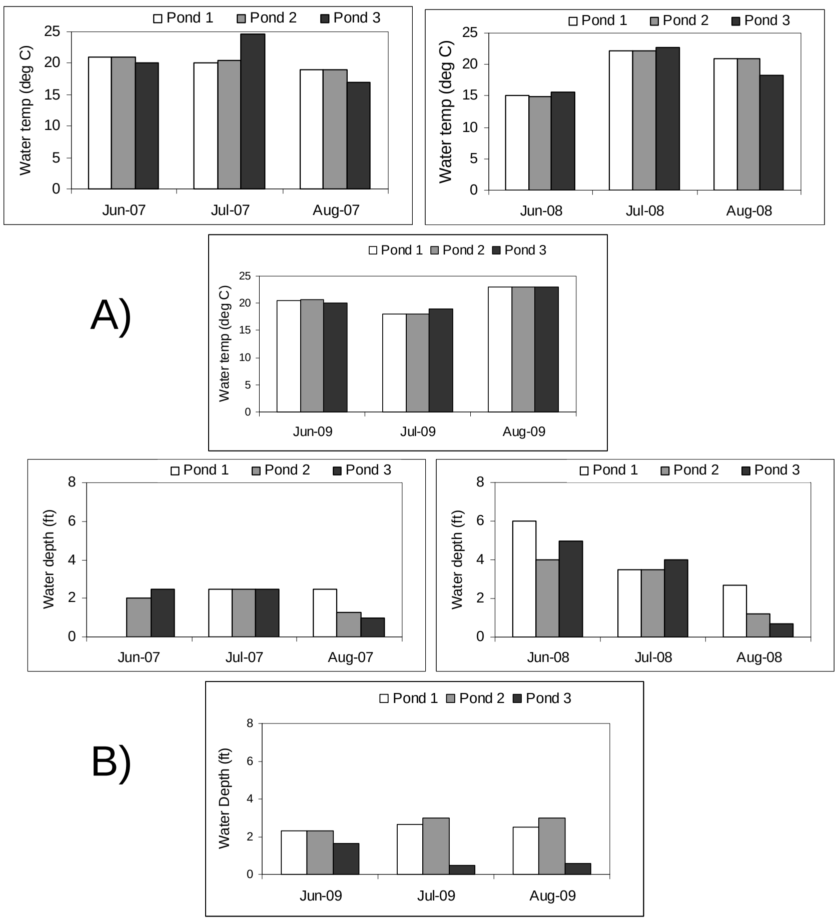
Date	GIS Site	Time	Water Depth (ft)	Air Temp (C°)	Water Temp (°C)	DO (ppm)	Turbidity (NTU)	Conductivity (mhod/cm)	pH
10/02/2008	SSCA05	12:15	1.3	21.7	17.0	10.19	2.20	123.6	7.35
	SSCA01	12:00	1.8	21.3	15.1	8.88	2.12	123.8	7.41
11/13/2008	SSCA05	14:30	3.0	12.0	13.0	9.84	17.40	n/a	7.14
	SSCA01	13:45	6.0	12.7	11.0	9.76	15.00	n/a	7.24
1/29/2009	SSCA05	11:30	3.5	1.6	3.0	13.14	3.80	75.6	6.47
	SSCA01	11:00	5.0	0.8	3.0	12.80	3.70	73.6	6.35
2/23/2009	SSCA05	15:00	4.0	8.0	6.0	12.36	6.64	67.6	7.54

	SSCA01	15:15	5.0	8.0	5.6	12.50	6.60	67.4	7.49
3/05/2209	SSCA05	14:00	4.0	10.8	11.0	11.72	4.11	67.2	7.52
	SSCA01	13:30	5.0	11.3	7.4	11.66	4.01	67.9	7.51
4/30/2009	SSCA05	17:00	3.0-5.0	17.1	16.0	11.06	2.57	59.3	7.68
	SSCA01	17:45	3.0-5.0	16.9	16.0	11.08	2.83	59.3	7.59
5/29/2009	SSCA05	12:15	4.0	27.7	21.0	8.64	3.38	65.7	7.40
	SSCA01	11:45	5.0	25.0	18.0	7.98	3.84	66.7	7.24
6/25/2009	SSCA05	14:30		20.5	19.0	9.44	1.99	78.5	7.46
	SSCA01	15:15		20.0	18.0	9.58	3.24	77.3	7.14
7/14/2009	SSCA05	12:00	1.0	24.0	20.0	10.46	2.21	99.4	7.80
	SSCA01	12:00	2.0	22.7	18.0	9.66	2.06	99.9	7.36
8/14/2009	SSCA05	11:39	1.3		25.0	10.70	1.86	106.5	7.23
	SSCA01								

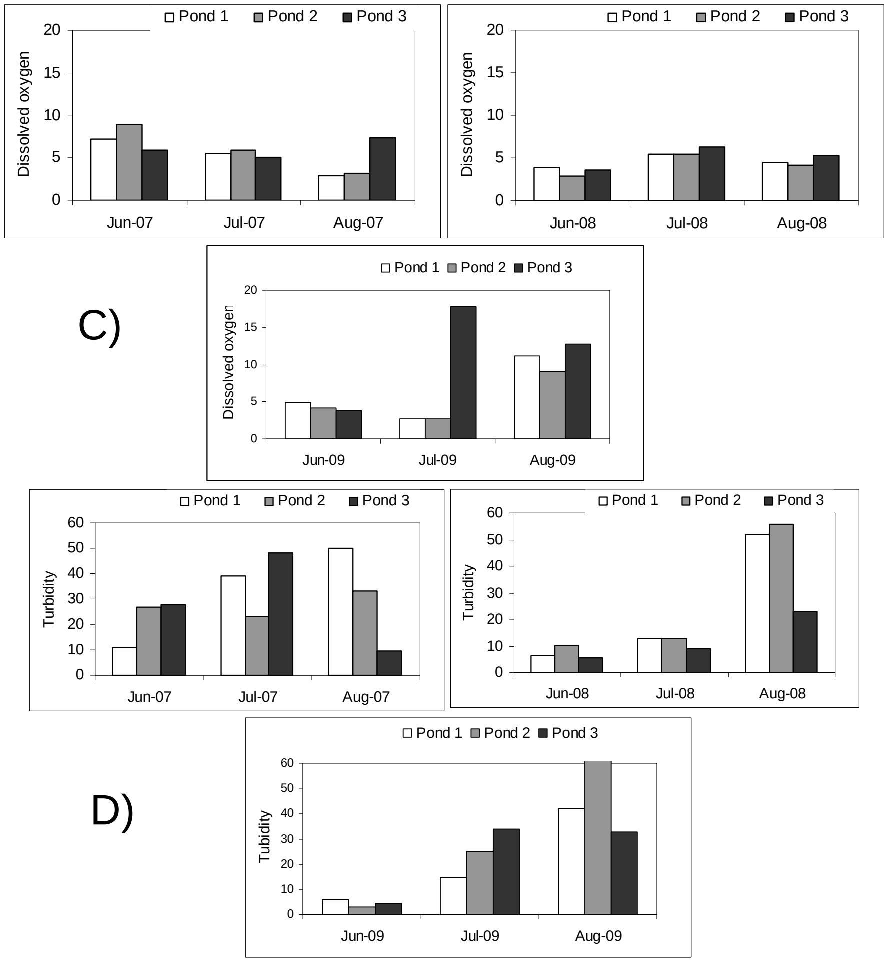
27~~Table 5-3~~. Water quality and depth data collected monthly for Ponds #1, 2, and 3 at Hogan Ranch.

Site	Date	Time	Sample #	Air Temp (C°)	Water Temp (C°)	Water Depth (feet)	DO (ppm)	Turbidity (NTU)	Conductivity (mhod/cm)	pH	E. coli	Bacteria count *Total Coliform Bacteria /100 ml
Pond #1	9/10/08	11:30AM	1	19.3	15.8	9"	6.84	23.8	205.8	7.2	5.2	>2419.6
	11/13/08	12:30 PM	1	13.1	13	1'	5.1	3.95	n/a	6.96	n/a	
	1/15/09	12:10 PM	1	4.7	6	30"	7.2	12.6	61	6.02	2	
			2				6.96					
	2/16/09	2:50 PM	1	10.7	7	1.7'	9.06	6.85	68	6.76	4.1	
			2					6.75		6.76		
	5/29/09	10:45 AM	1	23.5	24	2.3'	3.74	27.4	81.5	6.75	all	0.2419
			2									
	6/10/09	12:45 PM	1	19.6	20.5	28"	4.86	5.73	103.6	6.81	6804	>2419.6
	7/14/09	9:00 AM	1	16.2	18	32"	2.67	14.9	126.7	6.74		920.8
			2				2.74	14.8	126.7	6.22		
	8/12/09	5:15 PM	1	21.9	23	30"	11.12	42	141	7.08	67.7	
			2					42				
Pond #2	9/10/08	11:00 AM	1	18	17	6"	6.06	11.5	146.5	7.37	40.4	1203.3
	10/4/08	10:30 AM	1	16.8	16.8	23"	7.06	54.6	141.1	7.23	613	2420
	11/13/08	12:15 PM	1	14	14	16"	6.64	12	n/a	7.02	285.1	
	1/5/09	12:40 PM	1	4.7	6		7.64	16.8	62.9	6.36	12.2	
	2/16/09	2:25 PM	1	11.9	8	1.5'	11.04	9.33	73.5	6.77	8.6	
	5/29/09	10:45 AM	1	23.5	20.6	3.2'	n/a	n/a	78.3	7.00		
	6/10/09	12:40 PM	1	19.6	20.7	28"	4.18	3.01	102.7	6.56	41.4	>2419
	7/14/09	9:15 AM	1	16.2	18	36"	2.76	25.2	118.7	6.81	387.3	
	8/12/09	5:00 PM	1	21.9	23	3'	9.06	83.3	111.2	7.26	156.5	
Pond #3	9/10/08	8:10 AM	no water to sample	12.3								
	10/2/08	9:00 AM	1	15.6	15.1	5"	5.2	10.3	36.6	7.15	1203	2420

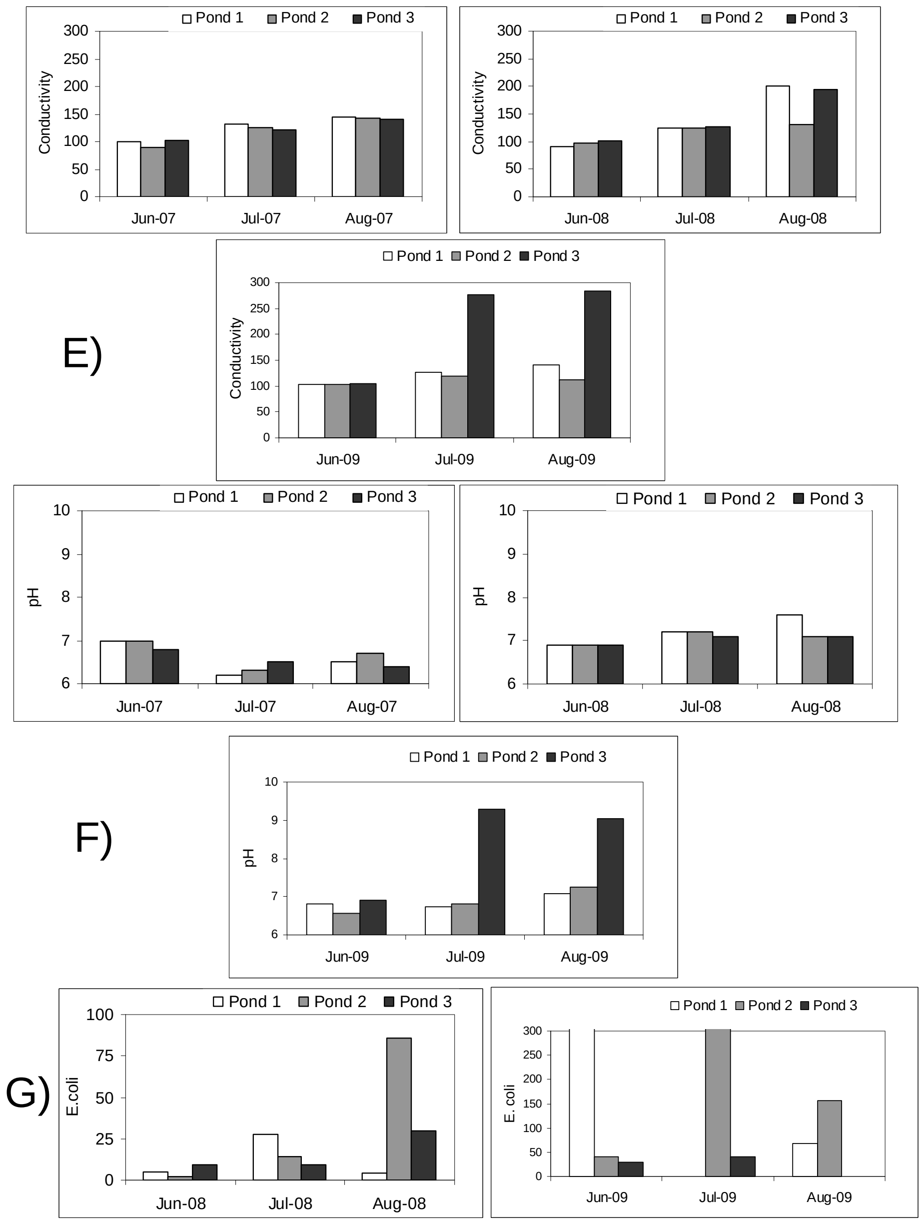
11/13/08	9/;30 AM	1	10.5	11	2'	5.96	8.7	n/a	7.21	57	151.5
1/15/09	7:55 AM	1	0.8	5	22"	7.56	10.2	60.4	6.79	15	18.7
		2				7.52					
2/16/09	1:30 PM	1	10.3	9	8"	14.1	21.5	89.2	6.53	3	3.1
		2				14.08					
5/29/09	9:55 AM	1	22.6	21	2.3'	4.82	22.7	80.9	6.51	26	33.6
		2				4.94	19.4	81.4	6.46		
6/10/09	11:00 AM	1	15.3	20	20"	3.84	4.33	105.6	6.91	29.9	1986.3
		2				3.28	4.87	105	7.02		
7/14/09	10:50 AM	1	17.3	19	6"	17.76	33.9	277.3	9.3	40.1	
8/12/09	4:04 PM	1	22.6	23	7"	12.7	32.7	283.4	9.05		648.8
						12.64	19.6	100.4	9.08		



32~~Figure 5-5~~. Monthly water quality and depth samples for Ponds #1, 2, and 3 at Hogan Ranch. A) Temperature; B) Water Depth.

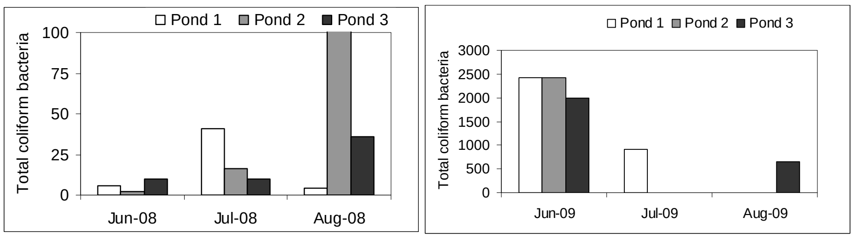


33~~Figure 5-5~~. Monthly water quality and depth samples for Ponds #1, 2, and 3 at Hogan Ranch C) Dissolved Oxygen; D) Turbidity.



34Figure 5-5. Monthly water quality and depth samples for Ponds #1, 2, and 3 at Hogan Ranch. E) Conductivity; F) pH; G) E.coli.

H)



35Figure 5-5. Monthly water quality and depth samples for Ponds #1, 2, and 3 at Hogan Ranch. H) Total coliform bacteria per 100 mL.

5.3.3 Success of Vegetation Plantings

The overall survival rate of plantings on the Wilson/LaCombe property was 77% with an APD of 0.33 plants/m^2 (1,349 plants/acre). On Hogan Ranch the overall survival was 89% with an APD of 0.16 plants/m^2 (650 plants/acre). Survival and vigor of plantings on both sites was comparable to the previous year's survival findings (Table 5-4). The largest difference seen between years was at Hogan Ranch in 2009, with an increase in the number of high vigor plants (Table 5-4). This difference arose from an inter-planting which occurred on Hogan Ranch in the spring of 2009. This additional planting of willows and flood resistant shrubs was deemed necessary after high mortality of plantings during high water events in previous years. Hogan Ranch had a larger portion of high vigor plantings in 2009. In general similar proportions of each planting fell into each vigor category both years. Total survival and APD varied slightly.

28Table 5-4 Vigor of plantings, total survival & APD on two sites for both 2008 & 2009.

Site	High	Medium	Low	Dead	Total Survival	APD (Plants/m^2)
Hogan Ranch 2008	25%	38%	17%	20%	83%	0.33
Hogan Ranch 2009	42%	35%	12%	11%	89%	0.16
Wilson/LaCombe 2008	25%	42%	16%	17%	80%	1.3
Wilson/LaCombe 2009	24%	32%	21%	23%	77%	.33

On the Hogan Ranch site, the shrub communities had the highest survival, followed by the ash (*Fraxinus latifolia*) forest community (Table 5-5). The APD was lowest in the ash forest and highest in the shrub areas (Table 5-5). The dominant plant in the herbaceous layer was reed canarygrass (*Phalaris arundinacea*) in all three communities for both 2008 and 2009. The shrub community had a significantly higher survival as compared to the previous year (2008) with a similar APD (Table 5-5). This difference is likely due to the 2009 inter-planting (flood mortality mitigation) and random variation in survey plot location from year to year.

29Table 5-5. Survival and APD in three communities on Hogan Ranch 2008-2009

Community	Survival (%)	APD (plants/m2)
Ash Forest 2008	86	0.19
Ash Forest 2009	82	0.12

Shrubs 2008	79	0.35
Shrubs 2009	92	0.14
Willows 2008	72	0.29
Willows 2009	83	0.21

Hogan Ranch individual species survival was high (89% and above) with only a small percent (3%) of the dead plantings were recorded as unidentifiable (Table 5-6). Species such as Red-osier dogwood (*Cornus sericea*) and twinberry (*Lonicera involucrata*) which underperformed in 2008 were not found during the 2009 survey (Table 5-6). The survival rate for cascara (*Rhamnus purshiana*) was up from the previous year but made up only a small percent (2%) of the total plantings (Table 5-6). The significant increase in the number of pacific willow (*Salix lucida* ssp.) and ash (*Fraxinus latifolia*) plantings reported between 2008 and 2009 can be explained by the 2008/2009 inter-planting (Table 5-6, 5-7). The willow community had overall good survival but survival variation between willow planting types was significant. In the willow community the large pole cuttings of willow had a survival rate of only 22% compared to standard willow plantings which had a survival rate of 93%.

30~~Table 5-6~~. 2009 Survival by species of plantings on Hogan Ranch, *Note the larger total number of plants from 2009 – this can be attributed to the 2009 inter-planting and the larger number of plots evaluated.

Hogan Ranch Species 2009	Total	Dead	Survival (%)	Proportion of total (%)
Red-osier dogwood	0	0	0	0
Black hawthorn	12	1	92	2
Oregon ash	81	9	89	15
Twinberry	0	0	0	0
Cottonwood	1	0	100	0
Western crabapple	8	0	100	1
Cascara	10	0	100	2
Cluster rose	6	0	100	1
Mixed willow	352	32	91	65
Douglas spiraea	11	0	100	2
Unknown	17	15	12	3
Total	**498***	.		

31~~Table 5-7~~. 2008 Survival by species of plantings on Hogan Ranch

Hogan Ranch Species 2008	Total	Dead	Survival (%)	Proportion of total (%)
Red-osier dogwood	5	3	40	2
Black hawthorn	26	1	96	9

Oregon ash	65	12	82	23
Twinberry	11	7	36	4
Cottonwood	9	1	89	3
Western crabapple	10	0	100	4
Cascara	13	4	69	5
Cluster rose	12	1	92	4
Mixed willow	100	17	83	35
Douglas spiraea	21	0	100	7
Unknown	11	11	0	4
Total	**283**	.		

The riparian planting on the Scappoose Creek site is composed of only one community. All planted species performed satisfactorily on this site, survival only decreasing 3% between 2008 and 2009 (Table 5-8, Table 5-9). The herbaceous community on this site is composed of a diverse mix of introduced grasses and forbs typical of recovering pasture areas, including species such as reed canarygrass, oxeye daisy (*Leucanthemum vulgare*), curly dock (*Rumex crispus*), and Canada thistle (*Cirsium arvense*).

32~~Table 5-8~~. 2009 survival by species of plantings on Scappoose Creek

Scappoose Creek Species 2009	Total	Dead	Survival (%)	Proportion of total (%)
Western serviceberry	4	0	100	2
Red-osier dogwood	27	1	96	14
Oregon ash	21	1	95	11
Indian plum	3	0	100	2
Ninebark	37	0	100	19
Ponderosa pine	12	1	92	6
Western crabapple	2	0	100	1
Thimbleberry	0	0	0	0
Cluster rose	8	0	100	4
Cascara	8	1	88	4
Mixed willows	6	0	100	3
Douglas spiraea	13	0	100	7
Snowberry	15	1	93	8
Unknown	43	41	5	22
Total	**200**			

33~~Table 5-9~~. 2008 survival by species of plantings on Scappoose Creek

Scappoose Creek Species 2008	Total	Dead	Survival (%)	Proportion of total (%)
Western serviceberry	11	2	82	4

Red-osier dogwood	41	2	95	16
Oregon ash	20	5	75	8
Indian plum	4	1	75	2
Ninebark	59	11	81	23
Ponderosa pine	16	4	75	6
Western crabapple	7	0	100	3
Cluster rose	5	0	100	2
Thimbleberry	7	0	100	3
Cascara	17	0	100	7
Mixed willows	14	2	86	6
Pacific willow	2	0	100	1
Douglas spiraea	18	0	100	7
Snowberry	18	0	100	7
Unknown	14	14	0	6
Total	**253**			

5.3.4 Vegetation Communities at Hogan Ranch Wetlands

Plant community widths

In Ponds #1 and #2 the increase in water level caused by the water control structures (installed in 2007) has continued to increase the width and overall area of the marshy shore and wetted area plant communities on these sites. The most dramatic difference observed in plant communities' composition on ponds #1 and #2 was seen between 2004 and 2008; however, 2009 showed a continued expansion of both the marshy shore and wetted area plant communities for both ponds (Table 5-10). The plant community widths on Pond 3 did not vary significantly between 2008 and 2009, except for the FACW and marshy shore plant communities on the north end of the pond. The differences in plant community widths observed on Pond 3 are possibly due to both an abundance of reed canary grass and a lack of forest cover along the transect, which can make it difficult to distinguish between these plant communities.

34~~Table 5-10~~. Widths of vegetation communities along five transects in three ponds.

Pond 1, Transect #1	**2009 community width (m)**	**2008 community width (m)**	**2004 community width (m)**
FACU grasses and forbs	34	36	39
FACW grasses/forested	5		6
Marshy shore	10	4.5	45
Wetted area	53		2.5
Marshy shore	9		8
FACW grasses/forested	19		29
Total:	**130**		**130**
Pond 1, Transect #2			
FACU grasses and forbs	60	80	80
Marshy shore	32	17	24
Wetted area	54	50	3.5
Marshy shore	18	5	51
FACW grasses/forested	32	44	39

Total:	**196**	**196**	**198**
Pond 2, Transect #3			
FACU grasses and forbs	26	26.5	73
Marshy shore	9	22.1	77
Wetted area	154.3	142.1	40.7
Marshy shore	9	12	
FACU grasses and forbs	4.5		12
Total:	**203**	**203**	**203**
Pond 2, Transect #4			
FACU grasses and forbs	19	28	77
Marshy shore	24	12	53
FACU grasses and forbs	35	39	
Wetted area	104	103	50
FACW grasses/forested	10	10	12
Total:	**192**	**192**	**192**
Pond 3, Transect #5			
FACU grasses and forbs	16	26	
Marshy shore	10	10	
Wetted area	260	255	
Marshy shore	42	7.5	32
FACW grasses/forested	51	80.5	62
Total:	**379**	**379**	

Ponds # 1 and # 2 Plant Communities

Wetted Area

In 2008 and 2009 the wetted pond center community in Ponds #1 and #2 was dominated by water purslane (*Ludwigia palustris*) and water pepper (*Polygonum hydropiper*), these species appear to be increasing in cover. In 2009, Yellow pond lily (*Nuphar polysepala*) and reed canarygrass (*Phalaris arudinacea*) were also found in the wetted area of Pond #1. The Pond #2 wetted area plant community has shown an increase (5%) in reed canarygrass (*Phalaris arudinacea*) and (4%) eurasian watermilfoil (*Myriophyllum spicatum L.*). It was noted that the eurasian watermilfoil was present in great abundance in areas not crossed by the transects and possibly miss-identified as native western water milfoil (*Myriophyllum hippuroides*) in 2008.

Marshy Shore

Between 2004 an 2009 the width of the marshy shore community on Pond #1 and #2 continues to show a trend of increasing and the community composition is showing a shift to more dominance by reed canarygrass (*Phalaris arudinacea*). The marshy shore zone of Pond 1 has gone from 6% reed canarygrass in 2004 to 71% reed canarygrass in 2009. The 2009 vegetation survey showed no distinct difference between the FACW and marshy zone plant communities on Pond 2. The marshy shore zone of Pond 2 showed an increase in reed canarygrass cover from 5% to 47%, a 9% decrease in water purslane (*Ludwigia palustris*), a 5% increase in creeping spike rush (*Eleocharis palustris*) and 7% increase in water smartweed (*Polygonum amphibium*) from 2008 to 2009. Very little clover (*Trifolium* sp) and no spatula leafed loosestrife (*Lythrum portula*) was reported in 2009. On both ponds this area continues to show an increase in facultative wetland plant cover with little change in the overall diversity of the community.

FACW grasses/forested

Ponds #1 and #2 are ringed by a zone dominated by reed canarygrass, sparsely forested in places (FACW grasses/forested). It appears the width of this zone is decreasing, especially in Pond #2. This zone remains more distinct and diverse on Pond #1. In 2005 it was dominated by white clover but has since returned to reed canarygrass (2008 & 2009), increasing by 25% from 2008 to 2009 in Pond #1. In addition to the reed canarygrass, this zone includes creeping spikerush, yellow flag iris (*Iris Pseudacorus*), water purslane and moneywort (*Lysimachia nummularia*).

Facultative Upland

In 2009, the facultative upland community on Ponds #1 and #2 was composed mainly of reed canarygrass, pasture grasses (Fescue sp), moneywort, pennyroyal (*Mentha pulegium*), and english plantain (*Plantago lanceolata*). This zone continues to have high species richness, but consists mostly of introduced species. Reed canarygrass cover in this zone also appears to be increasing, showing a 34% increase on Pond 1 and a 19% increase on Pond #2 from 2008 to 2009. It is unclear if this change is a result of increased water levels, cattle exclusion, or site disturbance during installation of the water control structures. It appears that this change is going to persist until an overstory canopy can be established; we will continue to monitor the reed canarygrass on the site for possible changes.

Pond 3

In 2008, Pond 3 showed dramatic changes in plant community composition as a result of cattle exclusion. In 2009, 2 years after exclusion, Pond #3's central wetted area continues to be dominated by wapato (*Sagittaria latifolia*- 54% cover) and creeping spike rush (*Eleocharis palustris*- 36% cover). Before cattle exclusion this area was dominated by jointed rush (*Juncus articulatus*—55% cover) and American speedwell (*Veronica americana*—40% cover). The 2009 vegetation survey also found an increase in reed canarygrass (5%) and hard stem bulrush (*Scirpus acutus* -5%) in this plant community.
The marshy edges of the Pond #3 have showed a dramatic increase in reed canarygrass cover and have become hard to distinguish from the FACW grasses/forested plant community. In 2008 this zone was reported as being co-dominated by wapato (75%) and creeping spike rush (53% cover), in 2009 reed canarygrass (76%) was the most dominate plant with only a small percent of wapato (7%) and creeping spike rush (16%) cover. Some of this reported change in plant composition may also be due to differences in year to year water-level at the time of monitoring, causing differences in plant community zone characterization. The grassy outer ring of Pond 3 continues to be dominated by reed canarygrass. The diversity of these communities has decreased since the first sampling period and reed canarygrass is becoming more dominant. We will continue to carefully monitor the reed canarygrass and take action if appropriate. The grassy edges of Pond 3 make up a relatively short distance along the transect compared to the wetted pond center area (Table 5-10), and so represent a small area of this site.

5.4 Conclusions

At the Scappoose Creek site, water quality in 2009 was comparable to 2008 and 2007, with pH, turbidity, dissolved oxygen , and conductivity within the range of acceptable conditions for salmon, except during the lowest water levels in late summer. In all three years (2007-2009) water temperature in the summer months exceeds 20 degrees C, which is outside the desired temperature range for salmonid habitat. Water temperatures at the site were not over 20 degrees Celsius until late July, however, when many juvenile salmonids may already have passed through the system.

At the Hogan Ranch site, once water temperatures reached 20 degrees Celsius in late May, pH increased. In 2009, the dissolved oxygen, turbidity, conductivity and pH in Pond #3 in July and August, were higher than in past years, with pH over 9.0. The growth of algae in the pond could be contributing to this issue.

The plantings along Lower Scappoose Creek have a survival of 77 % and at Hogan Ranch have an overall have survival of 89%. Both sites had survival that was comparable with previous years. The Hogan Ranch site had higher survival and vigor than in 2008, which can be explained by the additional plantings that were more flood resistant plants such as willow and ash. On the Hogan Ranch site, the shrub communities had the highest survival, followed by the ash (*Fraxinus latifolia*). On the Scappoose Creek site, plantings are in good condition with most species persisting at similar rates.

Two years post cattle exclusion, the Hogan Ranch site continues to show signs of recovery. Wapato dominates a large area of Pond 3, providing a food resource for waterfowl and other wildlife. On Ponds 1 and 2, the wetted area is increasing and the vegetation reflects this change. One unintended consequence of the restoration has been an apparent increase in the dominance of reed canarygrass on the outer and marshy edges of the ponds. Monitoring has made us aware of this potential issue and we will continue to work to make sure that this does not become a long-term outcome of this project.

6.0 Salmon, Salmon Prey, and Habitat Monitoring at Scappoose Bottomlands and Fort Clatsop

6.1 Introduction

In 2008 and 2009, the Estuary Partnership contracted the Columbia River Estuary Study Taskforce (CREST) to monitor the fish community and salmonid prey resources at Hogan Ranch in Scappoose Bottomlands and the Fort Clatsop restoration and reference sites (Estuary Partnership Contract #28-2008). CREST also monitored habitat conditions at the two Fort Clatsop sites. In addition to data collection, CREST processed salmonid prey samples collected at Scappoose Bottomlands and Fort Clatsop and those collected by NOAA Fisheries at Mirror Lake (See Section 3 for more information on the samples collected by NOAA Fisheries). A conceptual model for AEM at Fort Clatsop is presented in Appendix ~~Appendix 2~~.

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6.1.1 Monitoring Sites

Hogan Ranch

See Section 5 for a more detailed description of the Hogan Ranch site at Scappoose Bottomlands and associated restoration activities. Hogan's Ranch is located in the floodplain of Multnomah Channel, a branch of the Willamette River located four miles upstream of the Willamette's convergence with the Columbia, and borders Scappoose Bay (36~~Figure 6-1~~). As one of the last remaining tidally connected wetland complexes in the Scappoose Bottomlands, the ranch is a top priority for conservation and restoration. Creeks and channels that connect the ranch with Scappoose Bay, support salmon seeking food, space for rearing, and shelter from predators and high water velocity. Furthermore, although baseline fish community monitoring revealed little species diversity, salmonids that inhabit nearby wetlands demonstrate the need for a more comprehensive monitoring approach. Finally, sheeting events that occur when elevated river flow volumes breach channel banks, temporarily flood the property, potentially entrapping salmon.

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Despite the ecological benefits of these tidally influenced bottomlands, human impacts to the ecosystem may hinder salmonid survival. Water control structures, previously installed by Ducks Unlimited (DU), artificially regulate flow to the lower ponds on the property (36Figure 6-1). Though waterfowl had a prolonged presence, the structures introduced an unintended potential for salmon stranding. Debris deterring grates and wooden water barriers associated with the structures are rarely removed, preventing volitional fish passage. Livestock have degraded the vegetative under story and trampled the riparian zones, and their fecal run-off degrades water quality.

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Water levels varied widely, subject to seasonal extremes, dam spill and to some degree the tide. Given these parameters, initial fish community monitoring was experimental as efforts were adjusted based on site conditions.

36Figure 6-1. Hogan's Ranch conservation site illustrating proximity to Scappoose Bottomlands wetlands complex, Multnomah Channel, lower, middle and upper pond areas, water control structure location, and sample sites, 1 through 6.

Fort Clatsop South Slough

For the first half of the twentieth century, dairy farming drove deforestation, floodplain diking, and marsh drainage in the Lower Columbia River Estuary. Despite the abandon of local logging practices like clear-cutting and splash-dams, on-going erosion results in turbid water and silted spawning beds. Agricultural activities produce pesticide and fertilizer run-off, while off-shore pollutants come in with the tide, collectively depleting water and habitat quality. NOAA fisheries have placed a conservation emphasis on the oligohaline and brackish aquatic transition zone because of its role in acclimating sub-yearling salmon to salt water. Estuarine wetland impacts are most felt in the Young's Bay watershed, necessitating restoration of critical habitat for endangered salmonids, seeking refuge and sustenance before ocean entry.

In 2007, LCREP reconnected 45 acres of diked pasture with the river and tide at Lewis and Clark National Historic Park's Fort Clatsop South Slough (Fort Clatsop restoration site) when they replaced a failing tide-gate with a bridge (37~~Figure 6-2~~). A standard culvert would have deterred fish by maximizing water velocity, while larger concrete versions would sink in the substrate. Unencumbered tidal-connectivity would maximize potential for estuarine habitat enhancement restoring opportunities for fish use and community enrichment.

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In 2008 and 2009, ecological benefits were quantified by monitoring biological and physical parameters like fish community structure, water quality and channel cross-sections, before and after restoration. The final summary report for the Otter Point Phase I Project (Estuary Partnership Contract #06-2008) compares fish communities after the bridge installment at South Slough, to those monitored outside the failing tide-gate, and to those on the Lewis and Clark mainstem. This report highlights results from post-restoration fish community monitoring at South Slough, and investigates prey availability and utilization as well.

Fort Clatsop Reference Slough

The Fort Clatsop reference site was selected based on the proximity to the restoration site, a history of tidal connectivity, and having environmental conditions that could support salmonids (37~~Figure 6-2~~). Side channels yield space, surrounding spruce trees provide shade, riparian zones of native vegetation keep water in good condition, all of which should promote salmon usage. In 2008, monitoring efforts expanded beyond fish communities, to prey availability and utilization, to qualify salmonid feeding behavior. In 2009, CREST began to collect water quality data as well. These data will be directly compared to results from the restoration site.

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37~~Figure 6-2~~. Otter Point restoration site located on the mainstem Lewis and Clark River, including the Fort Clatsop restoration site ("South Slough") and nearby reference slough.

6.2 Methods

All sample gear and fishing techniques were consistent with the methods described in "Monitoring Protocols for Salmon habit Restoration Projects in Lower Columbia River and Estuary" (Roegner et al., 2009). In 2009, CREST monitored habitat, salmon and salmon prey monthly between February and July at both restoration sites and the reference sites, coincident with the spring migration period (Estuary Partnership Contract #06-2008). An extra sampling event in April at Ft. Clatsop allowed for a trap modification that improved handling conditions. A single sampling event occurred at Hogan's Ranch in November of 2009 as a single salmon had been sited there in November 2008.

6.2.1 Fish Community

At the Hogan Ranch restoration site, Teal Slough (Figure 6-1, site 1) was the only trap net site. Seining occurred at sites 3 and 4, in an effort to explore the potential for salmon stranding after high-flow sheeting events.

At the restoration site at Fort Clatsop, a trap-net was employed at the off-channel restoration site, whereby two ¼ in mesh, 50 ft wings that corral the fish into a 3/16 in mesh net sanctuary bag, leading to a 2 ft by 3 ft by 1 ft live box. Typically, the trap was checked every 45 min, for consistency and to minimize stress. The live-box, designed to handle up to 400 fish, could be left unattended for longer periods of time. Sampling began at high tide to low tide, capturing individuals going out to the main channel on the ebb. At the nearby control site (Ft. Clatsop Reference Slough), extremely low water velocity inhibited initial attempts to trap-net there in 2007. Without a swift current, the sanctuary bag will collapse on itself, releasing the catch. In 2008, a beach seine proved a more effective method for sampling, but the reference slough is inaccessible via motor boat, so crewmembers walked to set the net. In 2009, the aforementioned live-box set-up was successfully employed.

During all fish sampling events, aerated black buckets of clean water were used to keep the catch cool and comfortable while handling fish one dip-net full at a time. After separation for priority processing, CREST anesthetized the salmon individually with a buffered tricaine methanesulfonate (MS222) solution. CREST identified all fish to species, measured and counted them, and weighed the salmon. Chinook pelvic fin clips taken will provide genetic information for comparison to Mirror Lake populations upon future lab analysis.

6.2.2 Salmonid Prey

For prey availability, CREST deployed insect fall-out traps made of 30 qt rectangular plastic tubs and filled with an inch of soapy water. These traps captured bugs that land by disrupting their flight ability. Five trap sites were selected near each trap site concurrent with fishing events. After 48 hours of exposure in the marsh, CREST collected the samples and preserved them for later lab analysis. Results qualify and to some degree quantify prey taxa, demonstrating what the marsh offers salmon to eat.

CREST anesthetized salmonids (> 60 mm) in order to sample their diet using a non-lethal gastric lavage method. The tip of a sprayer containing filtered water was inserted down the salmon's throat and minimal pressure was applied to evacuate their stomach contents into a clean sieve. After rinsing the macro-invertebrates into a jar, CREST preserved them with 95% ethanol for future in house analysis and comparison to prey availability.

6.2.3 Sediment Accretion

At the Fort Clatsop restoration site, two level stakes were placed one meter apart and the distance measured incrementally from there to the ground, occasionally throughout the sample season accumulatively reveal temporal and spatial shifts in sedimentation.

6.2.4 Channel Morphology

Immobile stakes planted at the vegetation line on each stream bank served as points to measure bathymetry at Fort Clatsop South Slough. Distance from a tape stretched between the two stakes, measured in 0.5 m increments, yielded points for plotting the channel morphology. The reference slough results will be made available with results from the Cumulative Effects study.

6.2.5 Landscape Change

Subtle changes in landscape can be measured using rudimentary time-lapse photography, where consistency is crucial. After using global positioning coordinates (GPS) combined with compass readings to establish the location and ensure photo-point replication ability, CREST recorded the restoration site and the reference site on film, twice during the sample season.

6.3 Results

6.3.1 Fish Community

At Hogan's Ranch in 2009, a single wild subyearling coho was caught at Teal Slough, in March, measuring 90 mm and weighing 8.07 g. A gut content sample was obtained to coincide with prey availability samples collected that same day. Fish species composition was similar to 2008 though numbers of Goldfish and Stickleback were considerably higher in 2009 (Table 6-1 and 6-2).

35~~Table 6-1~~. 2009 Salmonid season totals and species composition for Hogan's Ranch by site and date.

	Site and Date						
	1				3	4	Species
Fish Common Name	**3/18**	**4/15**	**7/3**	**11/5**	**6/23**	**6/23**	**Total**
Coho	1						1
Goldfish	1		9,582	22	65	15	9,685
Cottid			2				2
Stickleback	5,670	78	1,164	1,071	63	50	8,096
Banded Killifish	4		2,024	46	18	3	2,095
Pumpkinseed Sunfish	11						11
Black Crappie	1		630	17			648
Shiner Perch	1						1
Bullhead Catfish			849				849
Dojo Loach			12		1		13
Peamouth Chub	58		921	2,060			3,039
Largescale Sucker	11			39			50

Dace	4							4
Gobe				2				2
Daily Total	5,762	78	15,184	3,257	147	68		24,496

36Table 6-2. 2008 salmonid season totals and species composition for Hogan's Ranch by site and date

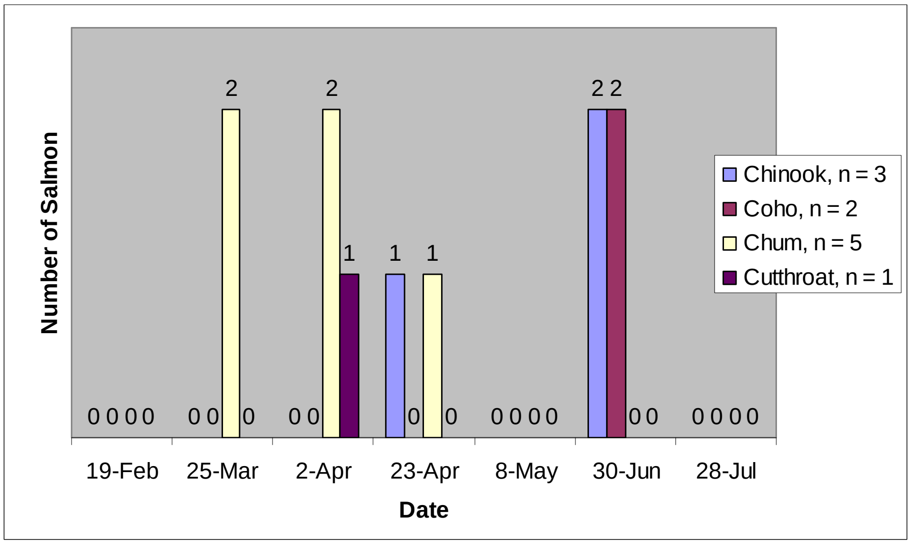
	Site and Date									
	1				2	3	4	5	6	
Fish Common Name	**6/18**	**7/16**	**8/8**	**11/19**	**7/18**	**7/18**	**7/9**	**7/6**	**7/16**	**Species Total**
Coho				1						1
Northern Pikeminnow		8	33	1						42
Goldfish	22	26	412	19		642	44	80	30	1,275
Sculpin					1					1
Stickleback		30	24	3,457	1	67	2	23	30	3,634
Banded Killifish		1	615	79		94			18	807
Mosquito fish			56	3						59
Pumpkinseed Sunfish		4		3	19	619			1	646
Black Crappie			150	126		3	31	112		422
Largemouth Bass			2							2
Bullhead			174						1	175
Dojo Loach			1							1
Peamouth Chub		8	172	207			76	59	30	552
Large-scale Sucker			224	27						251
Dace			3	5						8
Lamprey				1						1
Daily Total	22	77	1,866	3,929	21	1,425	153	274	110	7,877

Fort Clatsop South Slough

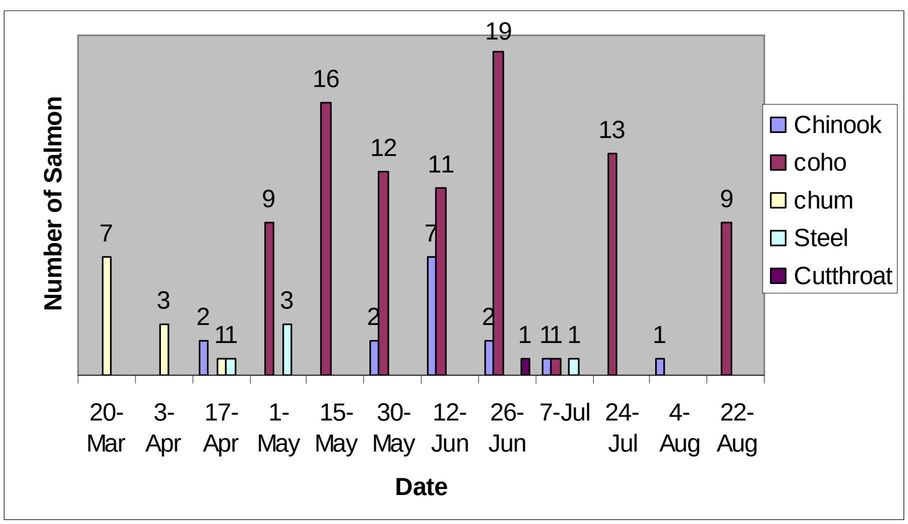
At the Fort Clatsop restoration site, temporal patterns of salmonid distribution at the restoration site reflect documented life history strategies (Dawley et al., 1986). Salmonids were absent during January and February, then observations steadily increased from March through June. Initially, chum used the Slough exclusively, and then disappeared with the arrival of Chinook, and then coho. Cutthroat were somewhat later to arrive on the scene than last year; steelhead were not observed. Coho and Chinook were quicker to leave the system than they were in 2008. Bycatch species diversity was similar to previous years (Table 6-3).

Two hatchery Chinook were observed using the South Slough restoration habitat in 2009 (Figure 6-3). Chum averaged between 48 and 55 mm, making them too small to be hatchery stock. Adipose fin-clips used to mark hatchery stock were absent from all yearling sized coho and Chinook observed in 2008 and 2009.

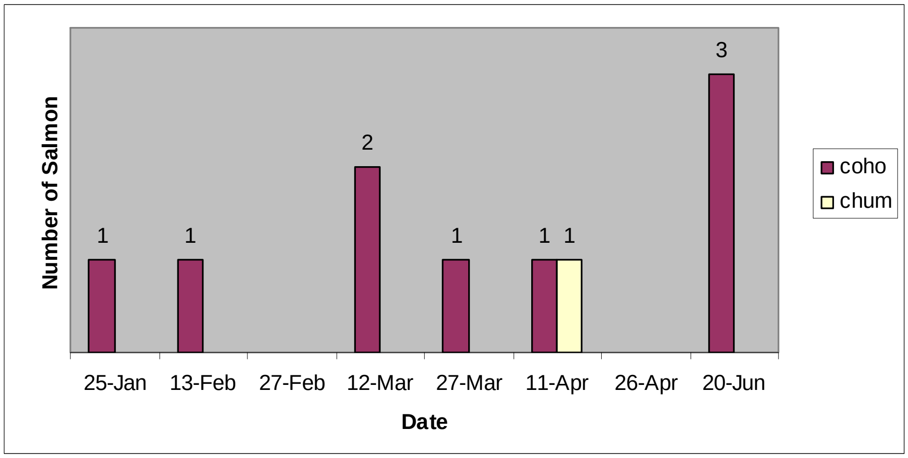
Salmonids were more abundant and diverse in 2008 than in 2009 or in 2007, when restoration had not yet occurred (Figure 6-3, 6-4 and 6-5**Error! Reference source not found.**). In 2007, only 10 salmon were found inside the failing tide-gate, whereas, 122 were recorded in 2008 after the tide-gate was removed and the bridge installed. In 2008 diversity increased as Chinook salmon, steelhead and cutthroat trout began using South Slough, in addition to the coho and chum found there since 2007. Monthly sampling, as opposed to bi-weekly events likely limited the number of salmon sampled in 2009.



38~~Figure 6-3~~. Total number, species composition and temporal distribution of salmonids observed at Ft. Clatsop South Slough, 2009.



39~~Figure 6-4~~. Total number, species composition and temporal distribution of salmonids observed at Ft. Clatsop South Slough, 2008.



40Figure 6-5. Total number, species composition and temporal distribution of salmonids observed at Ft. Clatsop South Slough, 2007.

37Table 6-3. Relative abundance and seasonal distribution of bycatch species observed at Ft. Clatsop Reference Slough, 2009

Date	Stickeback	Banded Killifish	Cottid	Peamouth Chub	Shad	Large Scale Sucker	Lamprey	Shiner Perch
2-Apr	26	0	1	0	0	0	0	0
23-Apr	30	1	0	17	0	1	0	0
8-May	113	0	0	4	0	0	0	0
30-Jun	410	4	1	9	0	0	0	3
28-Jul	11	1	0	1	0	0	0	1
Totals	**590**	**6**	**2**	**31**	**0**	**1**	**0**	**4**

In 2009, as with year's past, the mean length distribution for salmon demonstrated that subyearling sized individuals use the restoration site more than the yearlings (Tables 6-3, 6-4, 6-5 and 6-6). A single yearling Cutthroat was observed using the restoration site in April. Overall, the total catch was similar to last year and dominated by the threespine stickleback (*Gasterosteus aculeatus*). Other species caught included: peamouth chub (*Mylocheilus caurinus*), sculpin (*Cottus* sp.), banded killifish (*Fundulus rathbuni*), and lamprey ammocoetes. This community structure is typical of estuarine and some warmer, fresh-water environments.

38Table 6-4. Salmonid mean length distribution, post-restoration, Ft. Clatsop South Slough, 2009. Lengths representing a single fish are noted with an asterisk.

Date	Chinook salmon	Chum	Coho	Cutthroat Trout
25-Mar		48		

2-Apr		52		155*
23-Apr	**77***	55*		
8-May				
30-Jun	92		66	
28-Jul				

39~~Table 6-5~~. Mean salmonid lengths following restoration at the Fort Clatsop South Slough, 2008. Lengths representing a single fish are denoted with an asterisk.

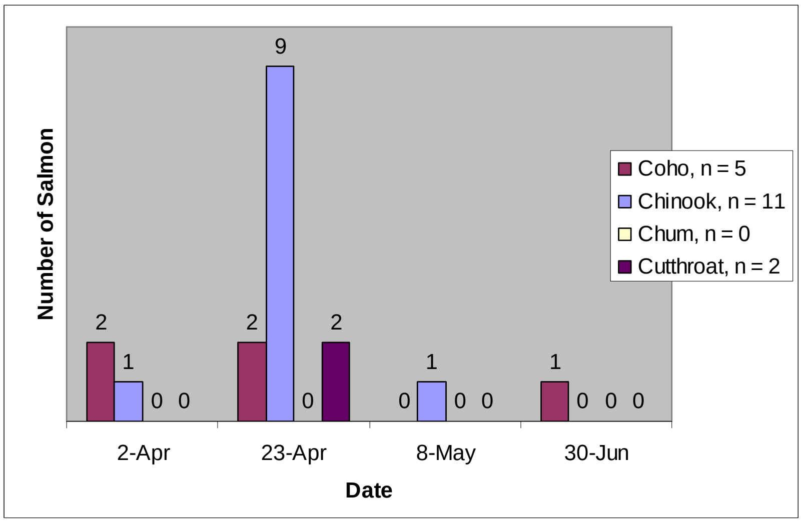
Date	Chinook Salmon	Chum	Coho	Steelhead	Cutthroat Trout
3/6		43*			
3/20		38			
4/3		32			
4/17	104	50*		192*	
5/1			40	119	
5/15			43		
5/30	46		51		
6/12	50		56		
6/26	55		59		139
7/7	51*		73*	78*	
7/24			69		
8/4	127*				
8/22			69		

40~~Table 6-6~~. Salmonid mean length distribution, pre-restoration, Ft. Clatsop South Slough, 2007. Lengths representing a single fish are noted with an asterisk.

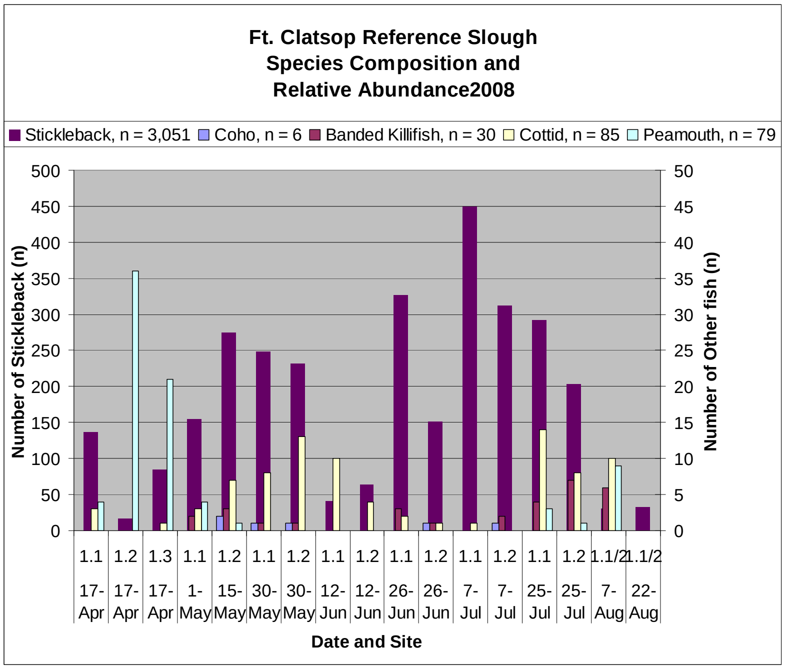
Date	Chinook salmon	Chum	Coho	Cutthroat Trout
25-Jan			114	
13-Feb			87	
27-Feb				
12-Mar			46	
27-Mar			51	
11-Apr	46		59	
26-Apr				
20-Jun			80	

Fort Clatsop Reference Slough

Species diversity was similar between years at the Ft. Clatsop reference slough, though fishes were more abundant in 2009 and 2008 than 2007 (Figures 6-6 and 6-7; Tables 6-7 – 6-9). More salmon were observed as well in 2009. Yearling sized individuals were seen more often at the reference site than the restoration site, whereas sub-yearling sized salmon were most frequently seen at the restoration site.



41~~Figure 6-6~~. Relative abundance and seasonal distribution of salmonids observed at Ft. Clatsop Reference Slough, 2009.



42~~Figure 6-7~~. Species composition and relative abundance for fish observed at Ft. Clatsop reference slough, by date and seine site location, 2008.

41~~Table 6-7~~. Ft. Clatsop Reference Slough, salmonid mean length distribution, 2009.

Date	Yearling Chinook salmon	Subyearling Chinook salmon	Chum	Yearling Coho	Subyearling Coho	Cutthroat Trout
25-Mar						
2-Apr				130		
23-Apr	128	70		116		
8-May		62*				163
30-Jun					55*	
28-Jul						

42~~Table 6-8~~. Ft. Clatsop Reference Slough, salmonid mean length distribution, 2008.

Date	Yearling Chinook salmon	Subyearling Chinook salmon	Chum	Yearling Coho	Subyearling Coho	Cutthroat Trout
17-Apr						

1-May					69	
30-May					49	
26-Jun					57*	
7-Jul					62	

43Table 6-9. Ft. Clatsop Reference Slough, salmonid mean length distribution, 2007.

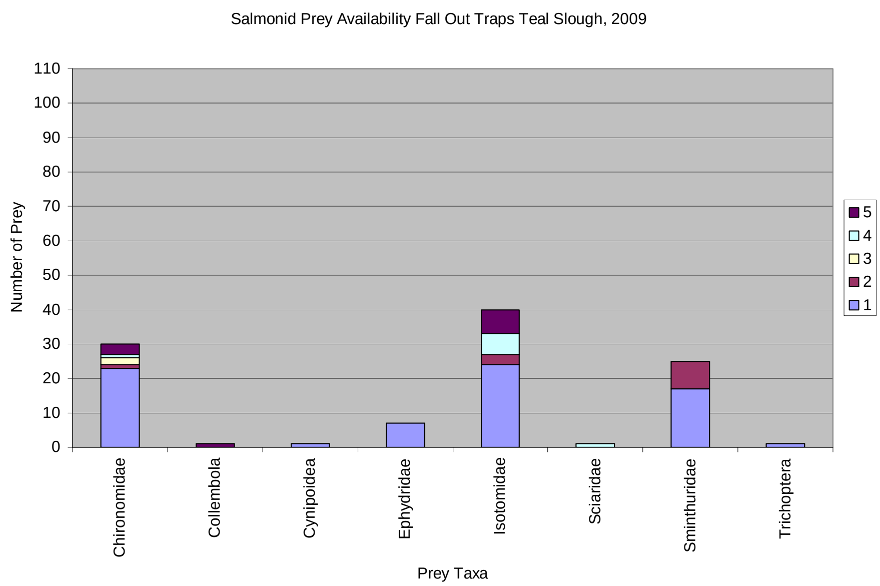
Date	Yearling Chinook salmon	Subyearling Chinook salmon	Chum	Yearling Coho	Subyearling Coho	Cutthroat Trout
11-Apr						
26-Apr						
25-May		70*			47*	
21-Jun						

6.3.2 Prey-Availability

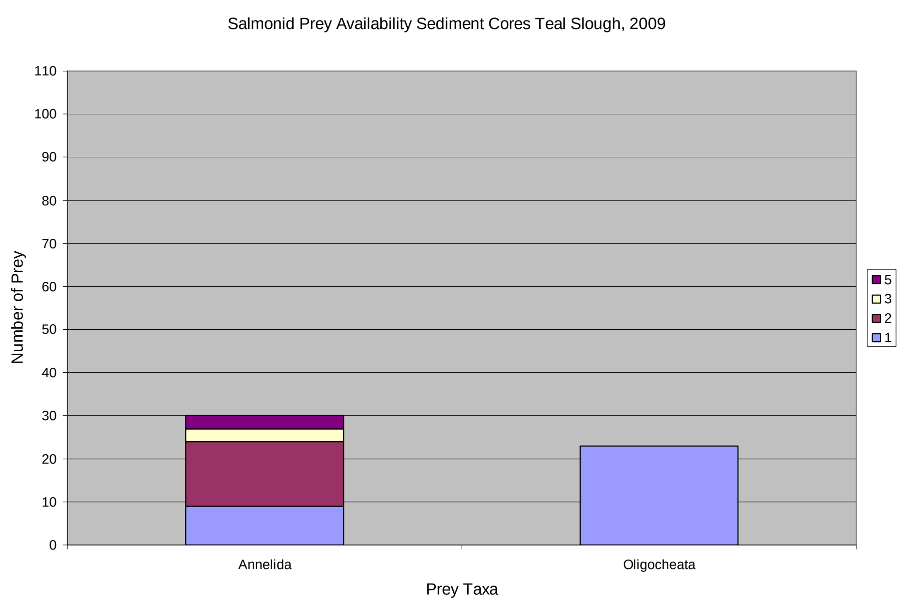
Hogan's Ranch

At Hogan's Ranch, CREST obtained fall-out trap and benthic core samples from the trap net site on the Hogan's Ranch property. We sampled five prey locations coincident with fishing dates at Teal Slough (1, N 45° 4816.7 W 122°4959.0; 2, 45° 4815.9 W 122°4959.2; 3, 45° 4815.7 W 122°4958.9; 4, 45° 4815.7 W 122°4958.7; 5, 45° 4815.1 W 122°4958.4). Prey samples from dates with corresponding salmon diet composition samples were analyzed (Figures 6-8 and 6-9).

The first fall-out trap demonstrated the highest species diversity among the five traps, with macroinvertebrates from all prey taxa observed represented and the highest abundance per trap. Chironomids, isotomids and sminthurids were more abundant than other prey taxa. Similar intra-site variation occurred in benthic core macro-invertebrates sampled between trap locations.



43~~Figure 6-8~~. Salmonid Prey Availability, Hogan's Ranch (Teal Slough) Fall Out Traps, 18 March, 2009.

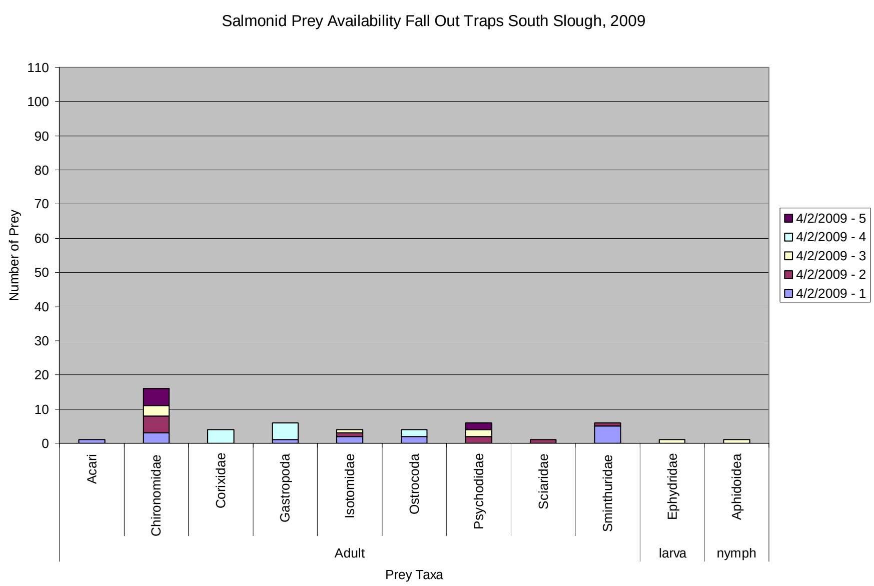


44~~Figure 6-9~~. Salmonid Prey Availability, Hogan's Ranch (Teal Slough) Sediment Cores, 18 March, 2009.

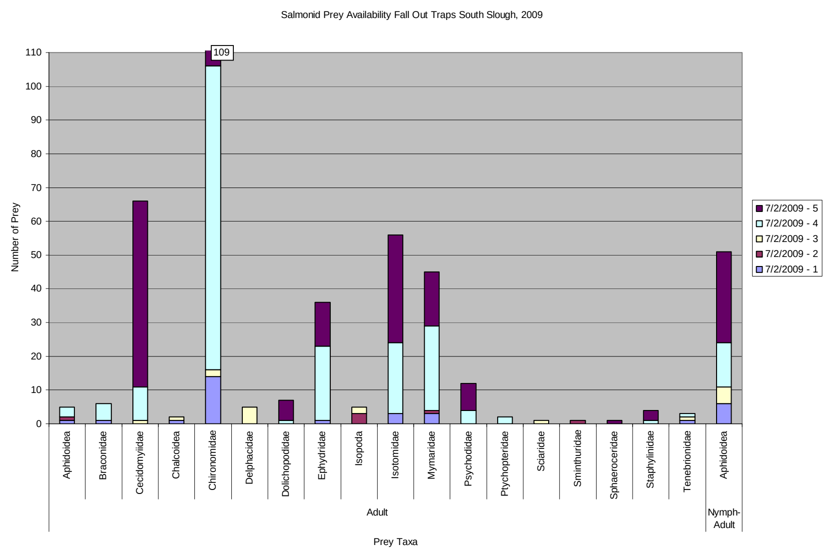
Fort Clatsop South Slough

At the Fort Clatsop South Slough, CREST collected prey from fall-out trap and benthic core samples at the restoration site, two of which corresponded to gut content samples taken from salmonids on the same date. Two prey availability dates between March and July (twice in April) correspond directly to dates when CREST collected diet samples from salmonids.

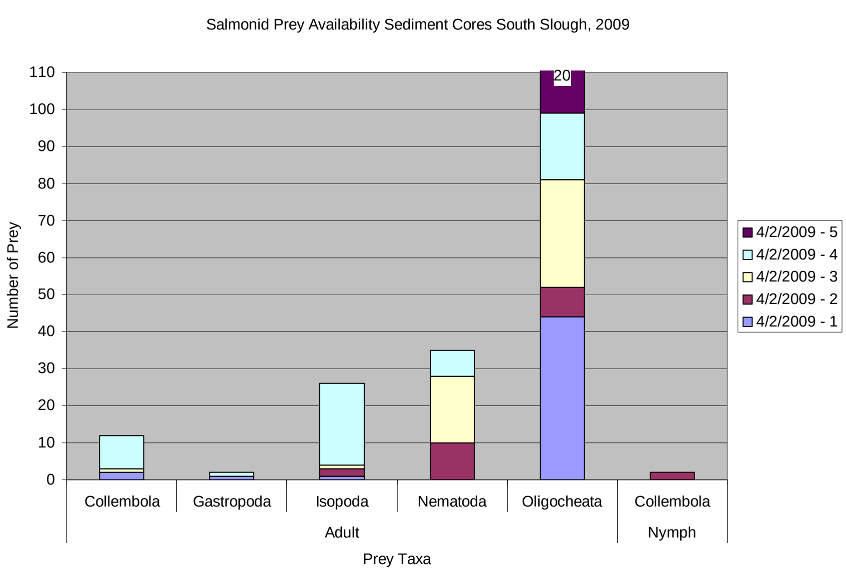
By in large, prey utilization samples showed that salmon diets consisted primarily of adult insects, like Chironomids, than other life history stages (e.g. pupae, larvae, or nymphs). Species readily available for consumption were primarily representative of the Homopteran and Dipteran orders of insects. Chironomids (order Diptera) were more abundant than other insect prey taxa. Trap 5 was most productive in terms of the number of individuals, in 2008 and 2009,, and trap 4 was most productive in terms of species richness (less species rich in 2008; Figures 6-10 – 6-13).



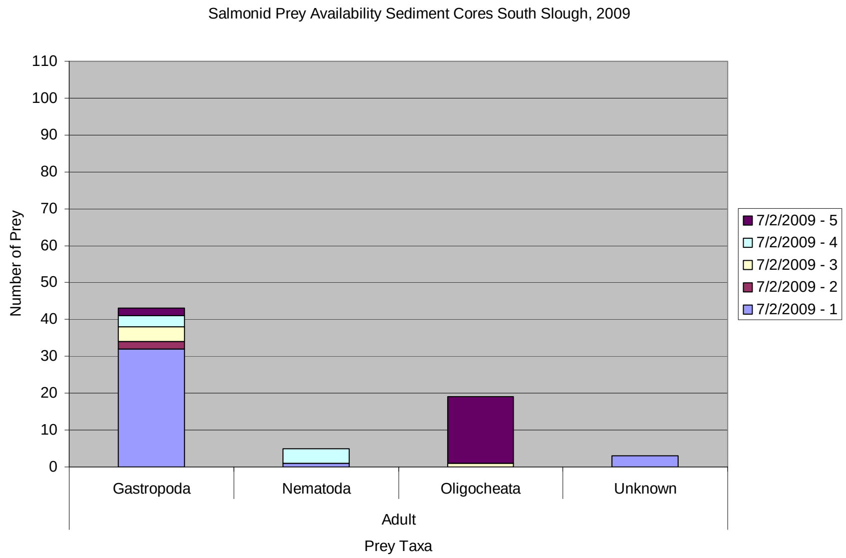
45~~Figure 6-10~~. Salmonid Prey Availability, South Slough Fall Out Traps, 02 April, 2009.



46Figure 6-11. Salmonid Prey Availability, South Slough Fall Out Traps, 02 July, 2009.



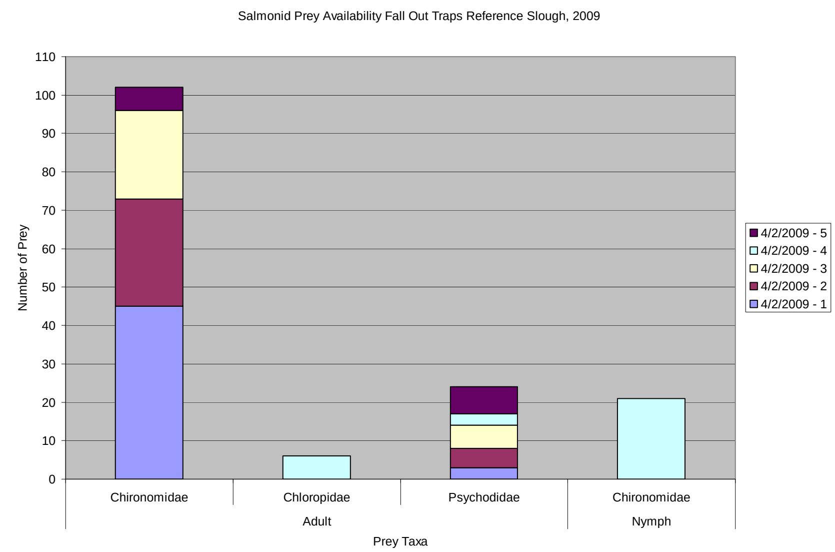
47Figure 6-12. Salmonid Prey Availability, South Slough Sediment Cores, 02 April, 2009.



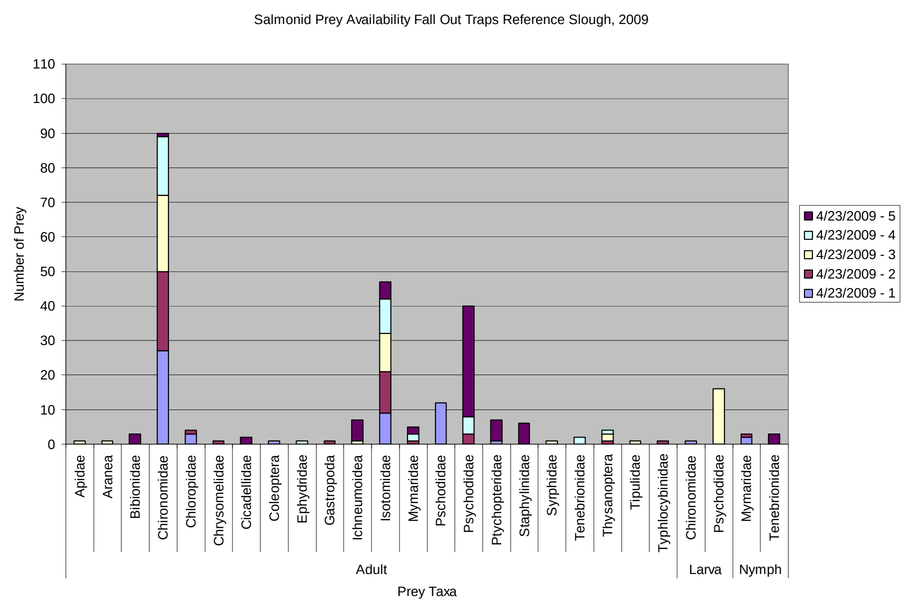
48~~Figure 6-13~~. Salmonid Prey Availability, South Slough Sediment Cores, 02 July, 2009.

Fort Clatsop Reference Slough

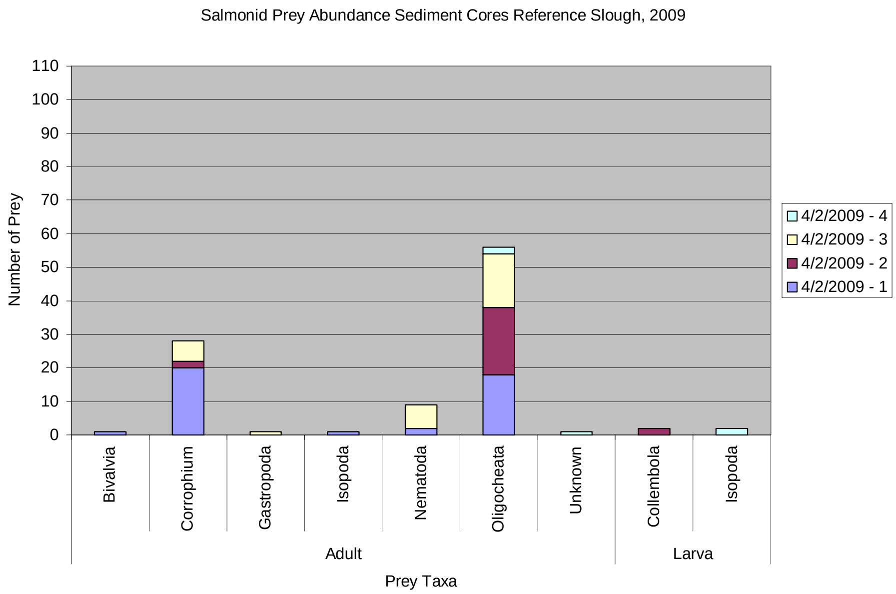
Four salmon that were collected at the reference slough this year were large enough for the gastric-lavage procedure (at least 55 mm). Diet composition was analyzed along with prey availability samples that were obtained on those same two fishing dates in April (Figures 6-14 – 6-17). The invertebrate species present in the samples was more diverse in late April (Figure 6-14) than in early April (Figure 6-15).



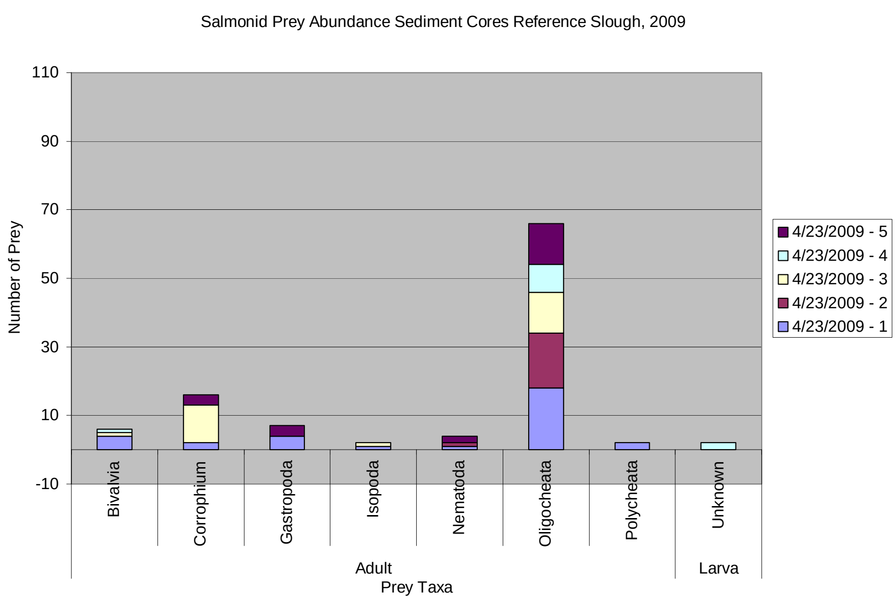
49~~Figure 6-14~~. Salmonid Prey Availability, Reference Slough Fall Out Traps, 02 April, 2009.



50~~Figure 6-15~~. Salmonid Prey Availability, Reference Slough Fall Out Traps, 23 April, 2009.



51~~Figure 6-16~~. Salmonid Prey Availability, Reference Slough Sediment Cores, 02 April, 2009.

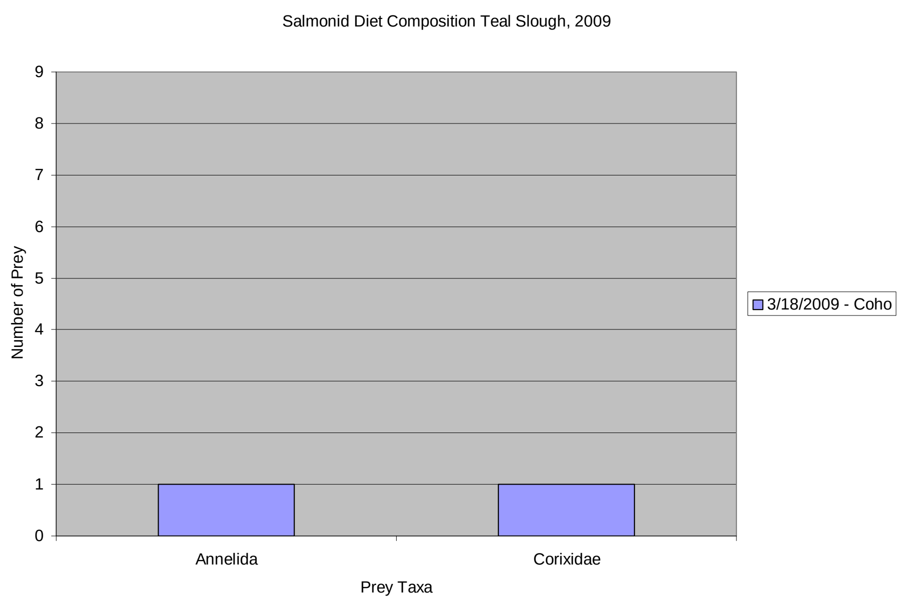


52~~Figure 6-17~~. Salmonid Prey Availability, Reference Slough Sediment Cores, 23 April, 2009.

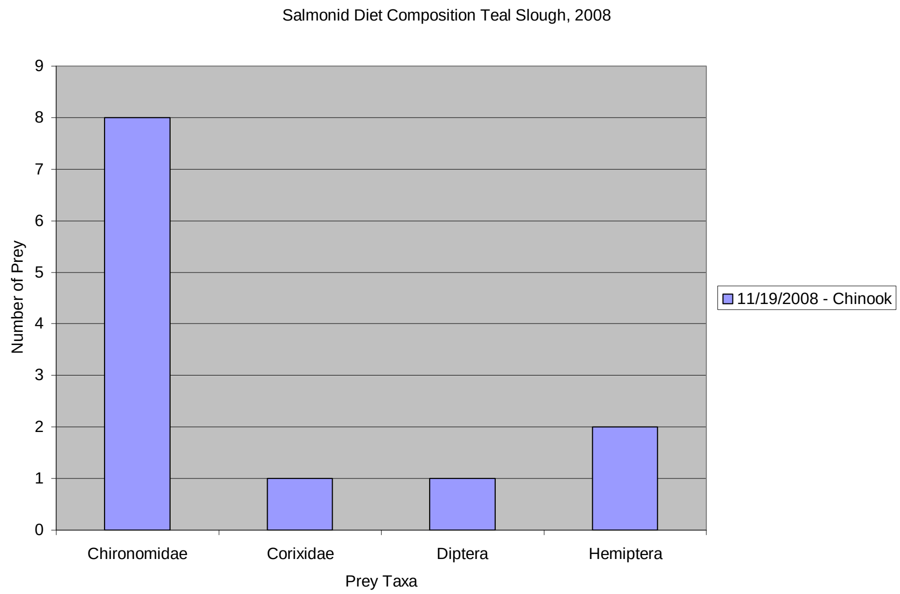
6.3.3 Prey Utilization

A single wild Coho was observed at Hogan Ranch (Teal Slough) and sampled for stomach contents in March 2009 (Figure 6-18). Gut contents were also analyzed from the single wild Chinook salmon that had been sampled in November of 2008 (116 mm, 12.19 g), and mistakenly reported in the final summary report that same year as a Coho (Figure 6-19). No salmon were seen on site during a single sampling event in November of 2009.

Salmon diets were similar between years for Hogan Ranch (Teal Slough). Corixids were a preferred prey item between years and species. Consumption results also reflected concurrent prey availability patterns. The Chinook diet was more diverse than the Coho in terms of both species richness and abundance. The Chinook salmon did not feed on benthic prey unlike the Coho.



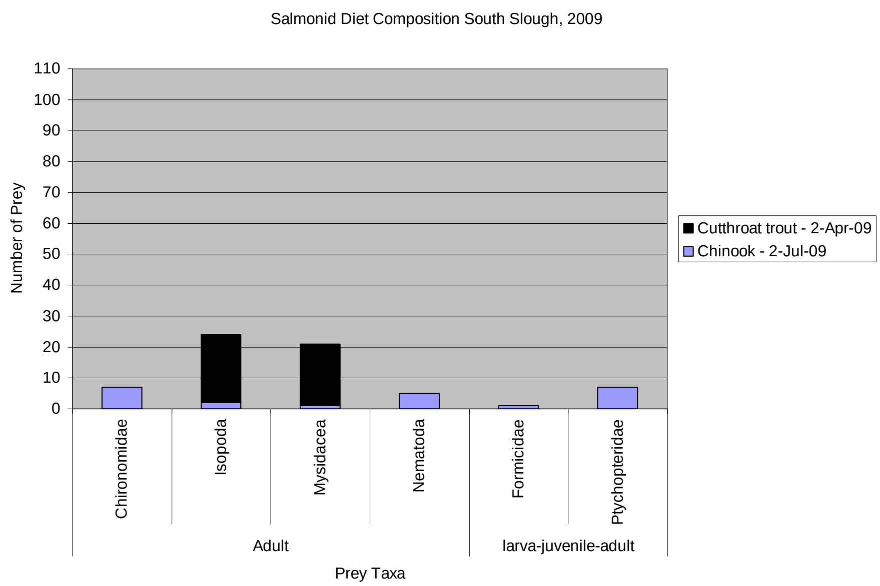
53~~Figure 6-18~~. Salmonid Diet Composition, Hogan's Ranch (Teal Slough), 18 March, 2009.



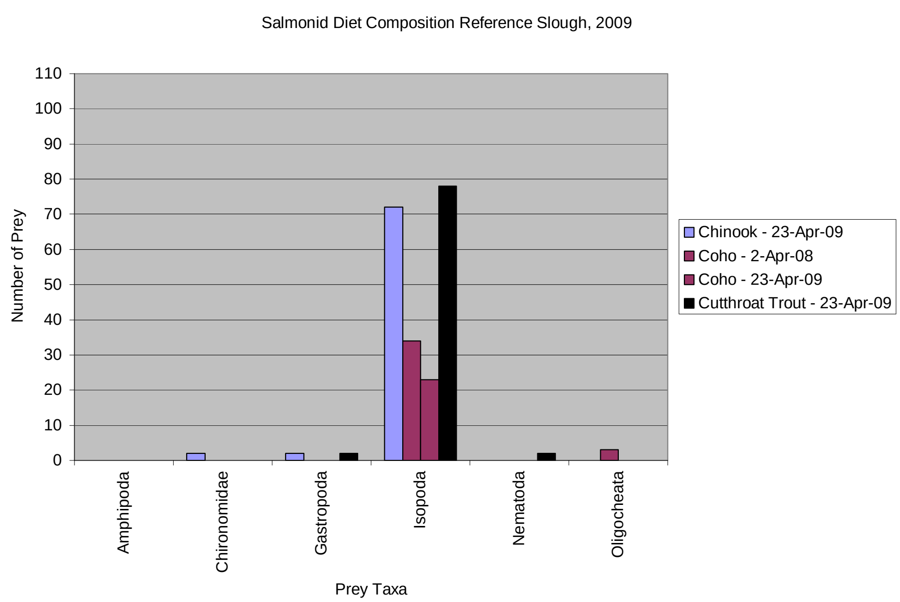
54~~Figure 6-19~~. Salmonid Diet Composition, Hogan's Ranch (Teal Slough) 19 November, 2008.

At Ft. Clatsop South Slough, a single wild yearling Cutthroat trout was sampled for diet contents in April and one wild subyearling Chinook salmon in July of 2009 at the restoration site (Figure 6-20).

At Ft. Clatsop Reference Slough, two yearling Coho, one natural and one artificial, were sampled for gut contents in April of 2009 at the reference site (Figure 6-21). A single yearling hatchery Chinook salmon was sampled there that month as well, along with four wild yearling Chinook salmon and one wild yearling Cutthroat trout.



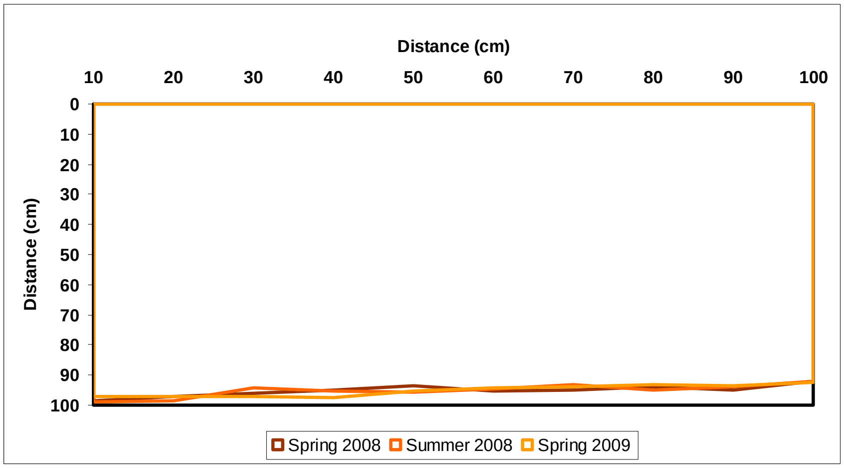
55~~Figure 6-20~~. Salmonid Diet Composition, South Slough, 02 April/02 July, 2009.



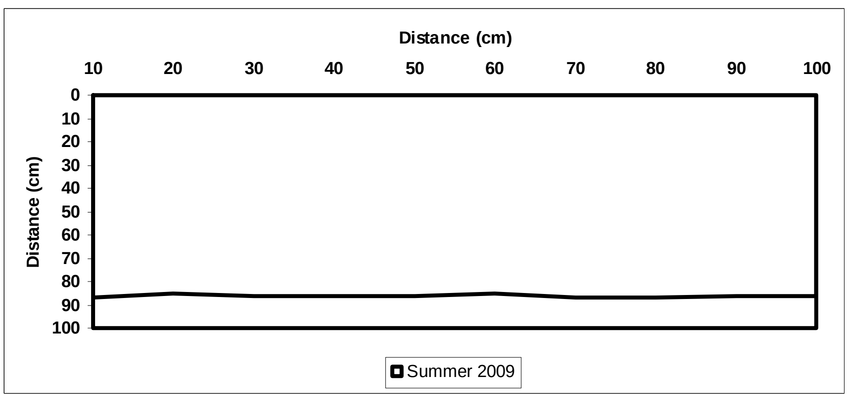
56~~Figure 6-21~~. Salmonid Diet Composition, Reference Slough, 02/23 April, 2009.

6.3.4 Sediment Accretion

Sediment accretion measurements from South Slough revealed shifts in sedimentation since additional data points have been collected for comparison (Figure 6-22 and 6-23).



57Figure 6-22. Sediment Accretion Measurements, 10 cm (upstream) to 100 cm (downstream), Fort Clatsop South Slough, 2008 and 2009.

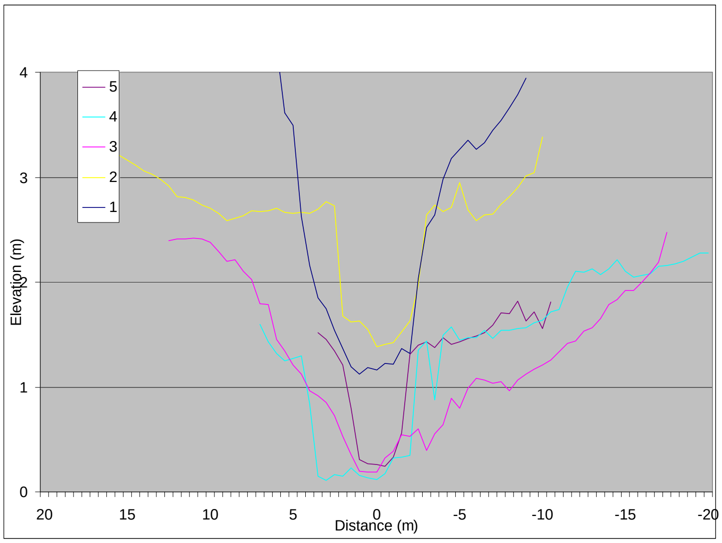


58Figure 6-23. Sediment Accretion Measurements, 10 cm (upstream) to 100 cm (downstream), Fort Clatsop Reference Slough, 2009.

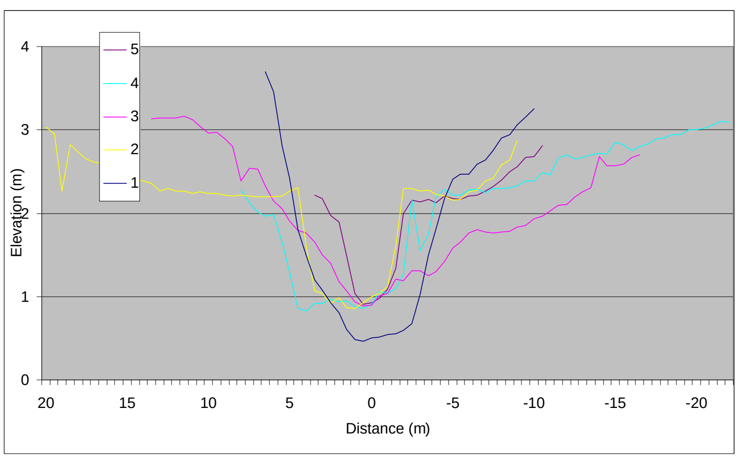
6.3.5 Channel Morphology

In 2008, bathymetry at South Slough revealed the thalwag to be proportionally higher in elevation near the site of restoration (points 1 and 2), with reference to the upstream cross-sections (points 3 through 5;

Figure 6-24). In 2009, the opposite was true; the thalwag was lowest in elevation nearest the restoration site (point 1; Figure 6-25).



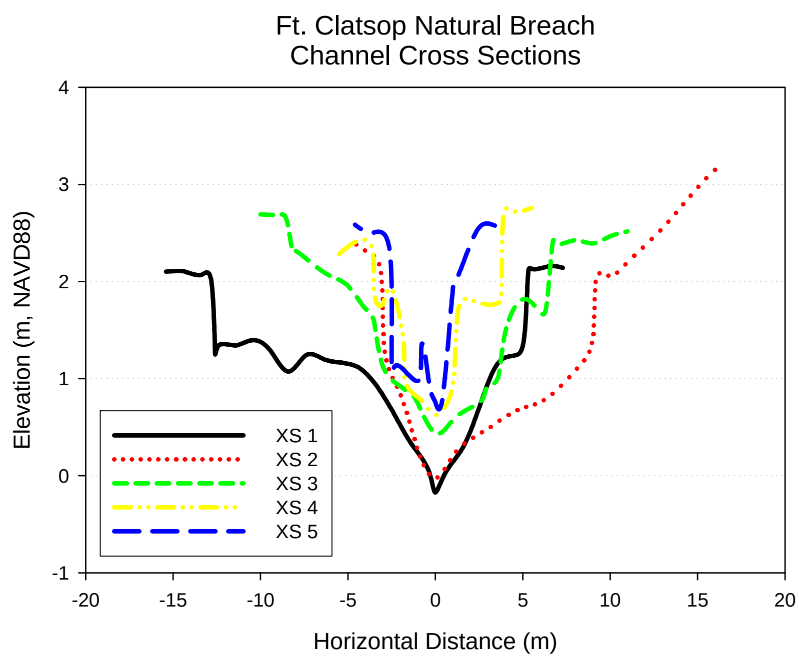
59~~Figure 6-24~~. Channel Profile, Cross Section Transects 1 (downstream) through 5 (upstream), Fort Clatsop South Slough, 2008.



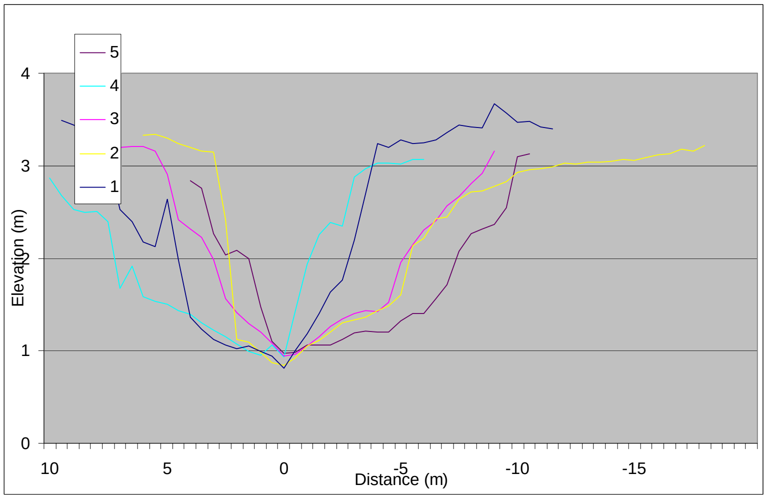
60~~Figure 6-25~~. Channel Profile, Cross Section Transects 1 (downstream) through 5 (upstream), Fort Clatsop South Slough, 2009.

In 2008 and 2009, bathymetry at the reference slough revealed the thalwag to be proportionally lower in elevation nearest the natural breach site (downstream) (points 1 and 2), with reference to the upstream cross-sections (points 3 through 5) (Figure 6-26 and 6-27) (Borde A., Battelle, Pers. Comm., 2009). In

2009, despite the knowledge of exact gps coordinates for the five 2008 transects, instrumental error of up to 20 ft more than likely biased the results by comparison, especially where points 1 and 2 are concerned. Similarly, the survey benchmark of known elevation is to date an estimate pending confirmation from the national parks system. Nonetheless, the thalwag is evident as is the apparent sloughing of the channels edge in some cases.



61~~Figure 6-26~~. Channel Profile, Cross Section Transects 1 (downstream) through 5 (upstream), Fort Clatsop Reference Slough, 2008.



62~~Figure 6-27~~. Channel Profile, Cross Section Transects 1 (downstream) through 5 (upstream), Fort Clatsop Reference Slough 2009.

6.3.6 Landscape Change

Pre-restoration photo points are not available for comparison, but subtle landscape changes at South Slough appear in photos taken during the summer and fall of 2009 and the spring and summer of 2008. The Northward shots reveal the invasive reed canary grass that has somewhat dried-up in the foreground by fall, while the native bull rush remains prevalent in the background, bordering the sloughs edge (Figures 6-27 and 6-28). The Southward shots show the Bull Rush thriving on the near bank, and the Reed Canary grass in the foreground getting taller by fall (Figures 6-29 and 6-30). The shots facing up the restoration stream by comparison show the vegetation has been visibly reduced by the beginning of fall (Figures 6-31 and 6-32).

Despite the designation of the reference slough as healthy habitat, riparian vegetation is still dominated by reed canary grass at this site as well (64~~Figure 6-22~~).

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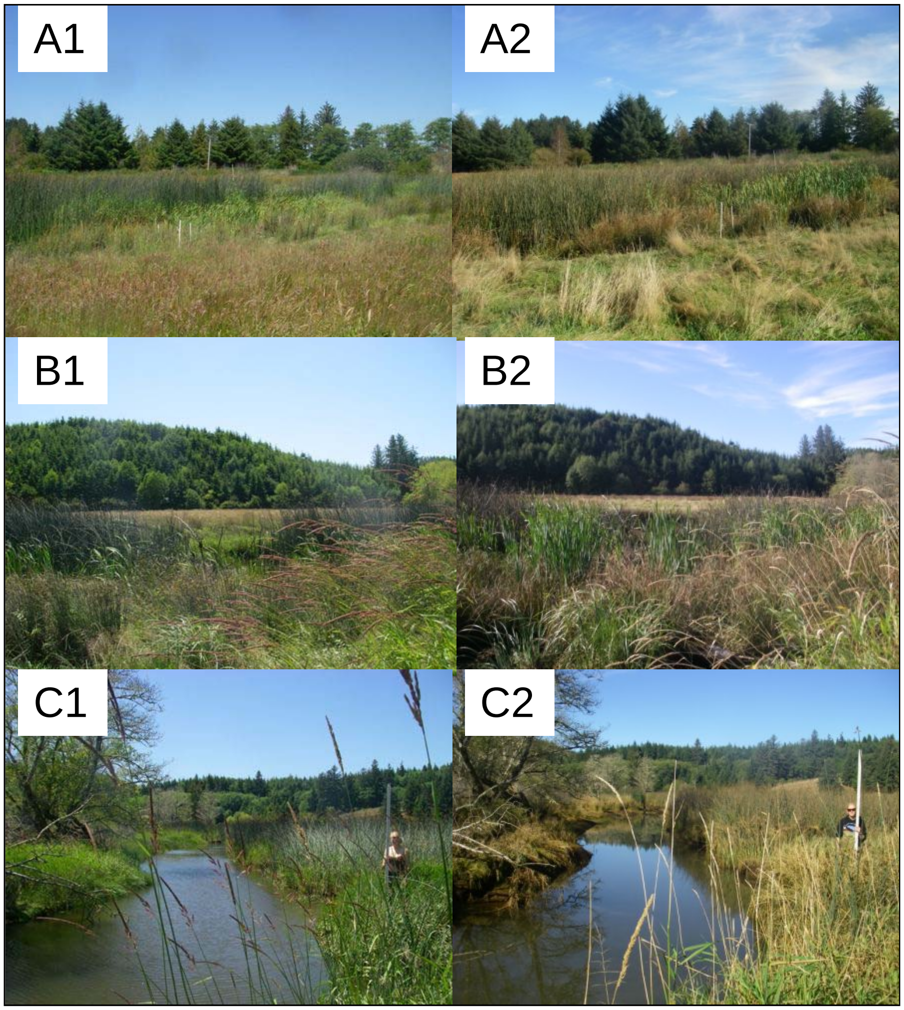
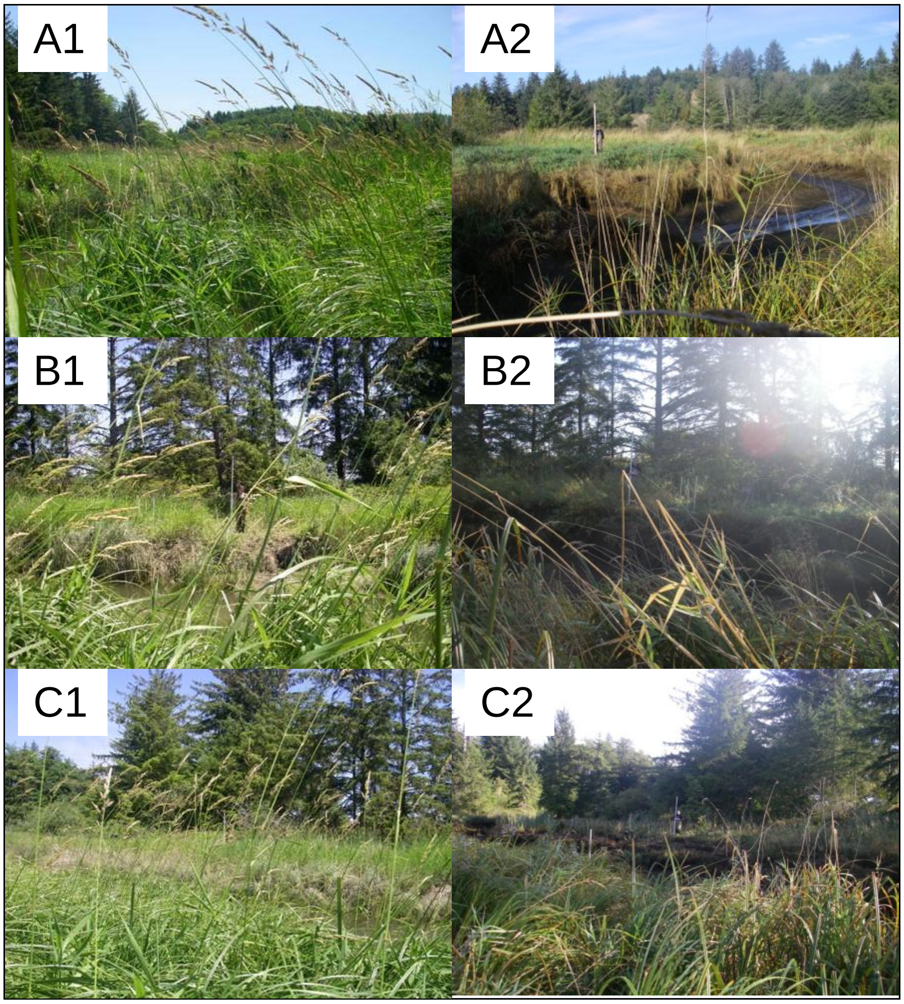


63~~Figure 6-28~~..Photo points taken at Fort Clatsop South Slough. Photo point 1 at N 46° 0743.4, W 123° 5244.8, 360° North in: A1) May 2009 and A2) September 2009. Photo point 2 at N 46° 0744.7, W 123° 5247.7, 180° in: B1) May 2009 and B2) September 2009. Photo point 3 at N 46° 0743..7, W 123° 5244.3, 250,° in: C1) May 2009 and C2) September 2009.



64Figure 6-27: Photo points taken at Fort Clatsop Reference Slough. Photo points at: A) N 46° 0753.5, W 123° 5244.8, 210/250°: A1) May 2009, A2) September 2009, B) N 46° 0753.5, W 123° 5244.8, 70° B1) May 2009 and B2) September 2009, and C) N 46° 0753.5, W 123° 5244.8, 10°, C1) May 2009, and C2) September 2009.

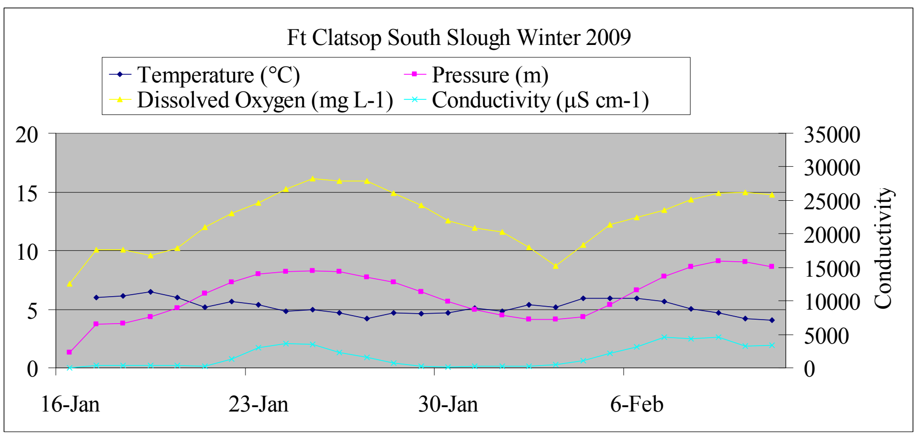
6.3.7 Water Quality

Discreet water quality measurements taken coincident with fall fishing at Hogan's Ranch revealed low temperatures and intermediate dissolved oxygen levels as compared to other salmon restoration sites. . Scappoose Bay Watershed Council collect water quality data on site that demonstrate similar trends (Rita Beaston, Scappoose Bay Watershed Council, 2010).

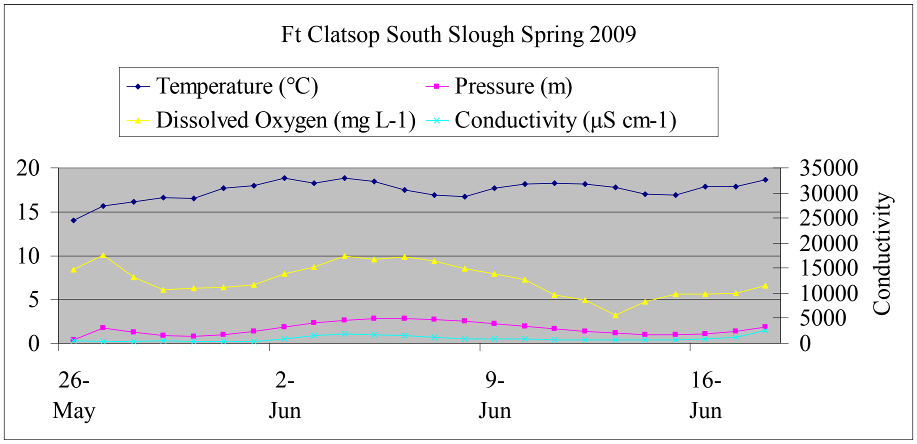
Chemical water quality parameters recorded on site, namely salinity and dissolved oxygen, fluctuated according to the tide primarily. Specific conductivity which represents salinity, increases in the summer/fall, and decreases in the winter/spring. Conductivity ranges according to tidal inundation. Tidal reconnection of the brackish influence of the Pacific Ocean at the restoration site located on the Lewis and Clark River resulted in some fluctuation in salinity, directly correlated with the season and the tidal cycle. The intertidal zone should benefit in terms of increased native and decreased invasive plant types. Dissolved oxygen increased and decreased similarly, in tandem with the seasons and the tide.

Physical water quality parameters included temperature and depth. Temperature increased continuously during the sampling season, between the winter and the summer. Water temperature was lower and oxygen levels were higher in the winter versus the spring at the restoration site in 2009 (Figures 39 and 40). Dissolved oxygen has an inverse relationship with temperature so as the slough warmed up, oxygen levels dropped.

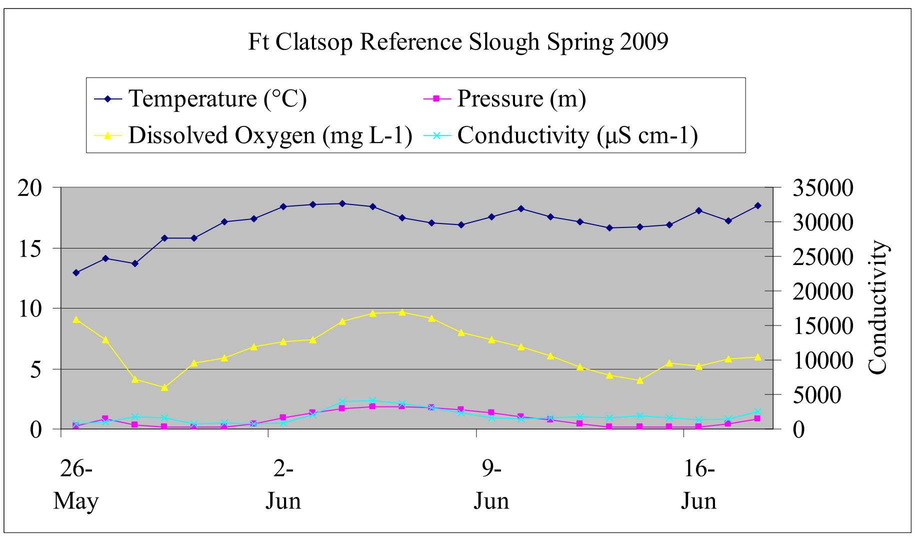
Reference site temperature and dissolved oxygen levels showed similar seasonal and tidal trends to the restoration site (Figures 6-31 and 6-32), but conductivity was much higher in the summer than spring at the restoration site. Depth data for the reference site has not been adjusted for atmospheric pressure or probe elevation.



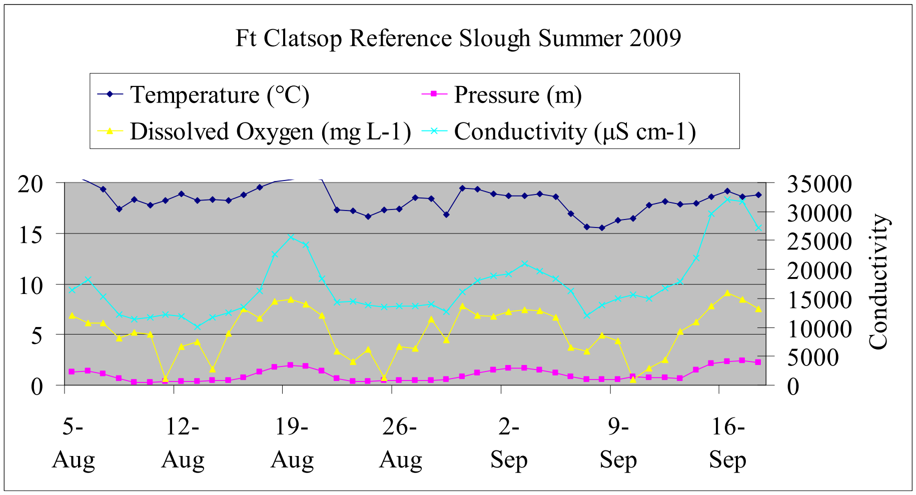
65~~Figure 6-29~~. Winter water quality results for Fort Clatsop South Slough, 2009.



~~66~~**Figure 6-30**. Spring water quality results for Fort Clatsop South Slough, 2009.



~~67~~**Figure 6-31**. Spring water quality results for Fort Clatsop Reference Slough, 2009.



68~~Figure 6-32~~. Summer water quality results for Fort Clatsop Reference Slough, 2009.

6.4 Discussion

6.4.1 Hogan's Ranch

Opportunistic sampling at Hogan's Ranch revealed similar fish community structure and size/temporal distribution as in 2008. Given the characteristic radical water elevation changes, consistent with weather and hydroelectric spill regimes, the small salmon sample size is not surprising. However, the sample rate of one salmon in five events of 4 to 5 hours each, and the repeatability between years, provides evidence of salmonid presence and demonstrates the potential for prolonged post-restoration use of the site. Salmon stranding following sheeting events remains a reality, despite the presence of salmonids in the ponds. Subsequent efforts will employ electro-fishing techniques, given the physical constraints of pulling a seine through submerged plant material.

Spring 2009 prey availability results from Hogan's Ranch and Ft. Clatsop South Slough revealed similarities in species composition. Given the availability of preferred salmon prey items, food is not a limiting factor in terms of salmon usage of the restoration sites. Considering mean length distributions at South Slough, salmon may also be actively feeding and rearing in the restored marshes. Residual yearling Chinook salmon may also be taking refuge in the marsh briefly after overwintering somewhere in the estuary. Summer 2009 prey samples were not analyzed since no salmon were captured during that season. Despite optimum water temperature and oxygen levels in November of 2009, we were not able to duplicate our fall 2008 efforts, when a single wild yearling Chinook was sampled (mislabeled as Coho in 2008 report).

Discreet water quality tests on Hogan's Ranch, coincident with fishing events, demonstrated comparatively higher temperatures and lower oxygen levels at Hogan's Ranch than Ft. Clatsop South Slough. With little flow reversal, warmer water temperature and lower oxygen levels develop. Combined with the lack of proximity to the estuary, environmental and geographic conditions at Hogan's Ranch preclude increased salmon usage.

6.4.2 Ft. Clatsop South Slough

Monthly sampling at Ft. Clatsop South Slough in 2009, demonstrated similar species composition and temporal distribution as in 2008. Although the total number of salmon sampled this year is less than 10 percent of what it was the first year following restoration (2008), when steelhead were observed, overall species diversity in 2009 continues to exceed pre-restoration sampling. In 2008, all 122 salmon observed either had an intact adipose fin or were too small to be of hatchery decent or both. In 2009, however, nearly 10% of the catch were from hatcheries (Chinook). Of the hatchery fish, subyearling salmon were still more prevalent than yearlings.

Yearling sized individuals continue to solicit this site more substantially than once believed, although, yearling Chinook that were present in spring of 2008 were absent in 2009 (no August sampling available for comparison in 2009). Stock source information will be made available to NOAA for comparison to the Mirror Lake Chinook population, for another LCREP funded estuarine restoration project. Comparisons did not occur in 2007 because no Chinook were trapped that year.

Continued observations of wild sized chum at Ft. Clatsop South Slough indicate healthy salmon habitat, given their absence from the system for some decades. Yearling chum, however, have yet to be observed. Chum numbers and patterns of temporal and size distribution were similar between years.

Coho catches in 2009 were a third that of 2008, but would have likely been similar had biweekly sampling occurred in 2009. Low numbers were likely an artifact of reduced sampling. South slough Coho inhabitants visit the site for far longer into the season than do other species, consistent with their life history strategy and increased temperature resiliency.

Steelhead trout were only observed in 2008 thus far, although other trout continue to visit the restoration site. Yearling cutthroat trout were observed later in the season this year than last and subyearling cutthroat have yet to be observed.

Insect fall-out traps demonstrated variable diversity amongst insect prey taxa, with a potential bias towards adult versus other life history stages. There were shifts in temporal and spatial distributions of prey available for consumption between seasons. Prey taxa diversity was higher in spring than summer, consistent with peak riparian vegetation growth, which may contribute to the greater number of fish caught in spring versus summer.

The only diet samples were obtained from the individual yearling Cutthroat trout and two hatchery yearling Chinook, during spring and summer, respectively. The wild yearling Cutthroat trout was displaying characteristic rearing behavior, coincident with peak marsh productivity. The diets from two yearling Chinook trapped during summer do not reveal any information that contributes to our understanding of general salmonid behavior, considering their hatchery origin and artificial release date.

Salmonids at South Slough fed on more winged insects than benthic macro-invertebrates, eating a majority of Chironomids, followed by Isopods and Amphipods. Furthermore, gut content insects were of the same prey taxa captured in fall-out traps, suggesting that the salmon fed in the slough, and that they are opportunistic feeders. Insect and macro-invertebrate sampling on the mainstem would be necessary to determine whether or not Ft. Clatsop South Slough salmonids are feeding in the marsh exclusively.

Water quality has improved overall as a direct result of tidal reconnection at Ft. Clatsop's South Slough. Salmon and other species leave the system by summer's end, as typical of their life histories and concurrent with physiological constraints; Coho were seen later in the season then were other salmonid species, given their temperature resiliency. Sampling in the fall and early winter could capture residual yearling Chinook salmon who have overwintered in the estuary.

Depth or surface water elevation was not corrected for atmospheric pressure. Surface water elevation has not shifted much relative to sea level, but photo points reveal tidal inundation outside the intertidal zone during the fall, when the south side of the channel is now completely submersed during high tides, since the restoration.

The south slough restored channel is evolving similarly to other tidal reconnection sites in that the profile is becoming deeper near the actual restoration site and more shallow upstream (Heida Diefenderfer, Battelle, 2010, pers. comm.). Similarly, sediment accretion rates, recorded at the fish trap location/channel cross-section transect 3, revealed accretion upstream and erosion downstream, consistent with early post-restoration channel morphology.

Shifts in landscape features were revealed through photo points, taken during different seasons; summer and fall. Weather patterns pre-determine vegetation but to some extent, the restoration site is becoming a tidal wetland instead of the largely freshwater system behind a failing tide-gate. Large changes in the channel profile will also appear as more time passes since the restoration event, namely, a sinuous network of channels is developing.

6.4.3 Ft. Clatsop Reference Slough

Monthly sampling at the Ft. Clatsop reference slough, coincided with Ft. Clatsop South Slough sampling in 2009, which allowed for direct comparisons with the restoration site. Biweekly events in 2008 were less productive in terms of salmon totals, not doubt due to better sampling methodology. Gear modifications that simplified sampling at the restoration site maximized efficient sampling at the reference site.

Species composition in 2009 was more diverse than in 2008 and species demonstrated temporal distribution typical of their life history strategy. Chum continue to be absent from the Lewis and Clark River, despite their presence at the restoration site. Yearling Coho predominate in the reference slough whereas subyearling coho frequent the restoration site more often. Subyearling Chinook salmon were observed this year for the first time since 2007. Yearling Chinook salmon and cutthroat trout were seen at the reference slough for the first time this year but subyearling cutthroat have yet to be recorded at either site. The reference slough retains Coho inhabitants later into the season than any other species, consistent with their life history strategy and increased temperature resiliency, though late summer sampling is not available for comparison to 2008.

Insect fall-out trap and benthic core samples in the reference site demonstrated a higher diversity of insect prey taxa available for salmon to consume (e.g. Corophium) than the restoration site. Like the restoration slough, there was a potential bias towards adult versus other life history stages, though more non-adult stages were found at the reference site by comparison. Terrestrial invertebrates documented in the fall out traps were more numerous later in the spring than earlier whereas aquatic invertebrate results from the benthic sediment cores were more similar over time. Gut content samples were not obtained in summer like the restoration site, so no conclusions can be drawn concerning the prevalence of yearling sized fish being correlated with summer peak riparian vegetation production. Yearlings dominate this system independent of time of the year.

Diet samples were obtained from not only Coho (Ft. Clatsop South Slough site), but Chinook and cutthroat trout as well, allowing for inter-species comparisons. All salmon species sampled fed on Isopods, whereas only Chinook consumed Chironomids. The coho sampled did not eat Gastropods but was the only species to consume Oligocheates. Only the cutthroat trout ate Nematodes. Salmonids at the Ft. Clatsop reference slough fed on more benthic macro-invertebrates than winged insects. Gut content invertebrates were of the same prey taxa captured in the benthic core samples, suggesting that the salmon fed in the Ft. Clatsop reference slough, primarily on aquatic invertebrates. Insect and macro-invertebrate sampling on the mainstem would be necessary to determine whether or not Ft. Clatsop reference slough salmonids feed in the marsh exclusively. These results may reflect prey selectivity by salmon for aquatic invertebrates over terrestrial invertebrates at the Ft. Clatsop reference slough (opposite of the Ft. Clatsop restoration site), but more likely opportunistic feeding behavior, based on intra- and inter-site prey availability.

Inter-annual variation in physical metric results at the reference site also coincided with the tide and season, however, little intra-annual variability exists. Reference site channel morphology has remained static between years (Amy Borde, Pacific Northwest National Laboratories, 2009) as have sediment accretion rates and landscape features. The photo-points demonstrate inter-site variation in foliage which can be attributed to the time of year, whereas intra-site variation documented is directly correlated to site history. The reference site has remained relatively unharmed by human activities, unlike South Slough; former pasture-land returned tidal wetland.

7.0 AEM Conclusions

This report documents AEM activities implemented in Winter, Spring and Summer 2009 under the Estuary Partnership's Habitat Restoration Program. Parametrix, NOAA Fisheries, ACFM, SBWC, and CREST reported on their efforts during a January 2009 Science Work Group meeting at the Estuary Partnership. Since AEM data collected over multiple years is necessary to evaluate project success, the Estuary Partnership contracted with these partners to conduct complementary AEM activities from September 2008 – August 2010 at the Mirror Lake, Sandy River Delta, Scappoose Bottomlands, and Fort Clatsop sites.

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Appendix 1: Large Wood Debris Cross Sections

Appendix 2: AEM Conceptual Models

Invasive Species and Native Vegetation Reforestation

Mirror Lake. During the early 1900's Young Creek's riparian corridor was cleared and subsequently farmed for approximately 100 years. Once farming/grazing ceased, invasive species replaced the bottomland hardwood forest that previously inhabited the site and prevented its reestablishment (Figure A1). This degraded riparian area poses a stressor that affects numerous controlling factors within the creek, e.g., hydrodynamics, bathymetry, and substrate. These controlling factors define the structure of the stream channel, as well as the wetland bench that flanks it, and help maintain its simplified structure. The homogenized channel affects several ecosystem processes within the site. These range from food web interactions to sediment supply and trapping, with habitat formation and productivity perhaps being the most significant. These altered ecosystem processes negatively affect salmonid performance.

Two controlling factors (temperature and light) will be monitored to assess the effectiveness of restoration actions at improving ecosystem processes, primarily habitat formation. Two stressors (riparian condition and invasive species) also will be monitored to assess the effectiveness of restoration actions at improving their condition, i.e., improving the riparian area's structure and increasing its species diversity.

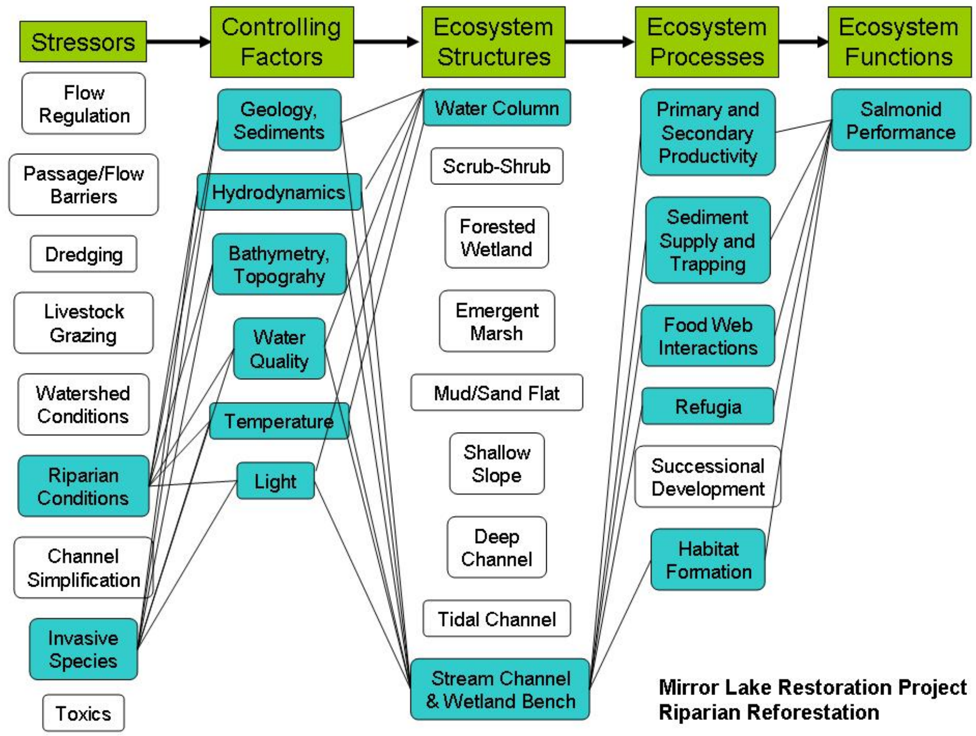

Figure A1: Conceptual model for riparian reforestation actions at Mirror Lake.

A similar conceptual model is applicable for planting at Sandy River Delta and Scappoose Bottomlands, though the "Ecosystem Structures" for Scappoose Bottomlands would include "emergent marsh" and "tidal channel" in addition to "water column" and "stream channel."

Cattle Exclusion at Scappoose Bottomlands

Restoration actions at Scappoose Bottomlands include the installation of fencing to exclude cattle so that sensitive wetland areas can recover from cattle impacts without active replanting of emergent wetland species. The riparian areas, on the other hand, require active management because the understory conditions have been significantly degraded by grazing and invasive species introduction. The purpose of the effectiveness monitoring was to determine the level of success of the work completed in the project area to date.

Our assumptions were that once cattle were excluded from the sites, the emergent wetland plant communities would be influenced by the sediment supply, topography, hydrodynamics, water quality, temperature, and available light. Changes in the plant communities would affect mud flats, tidal channels, water column conditions and various wetland types including emergent, shrub-scrub, and forested. We were unable to develop assumptions about benefits to salmonids due to a lack of data on potential use of the site, but expect that salmonid populations are apt to benefit from improved water quality and habitat conditions resulting from cattle exclusion.

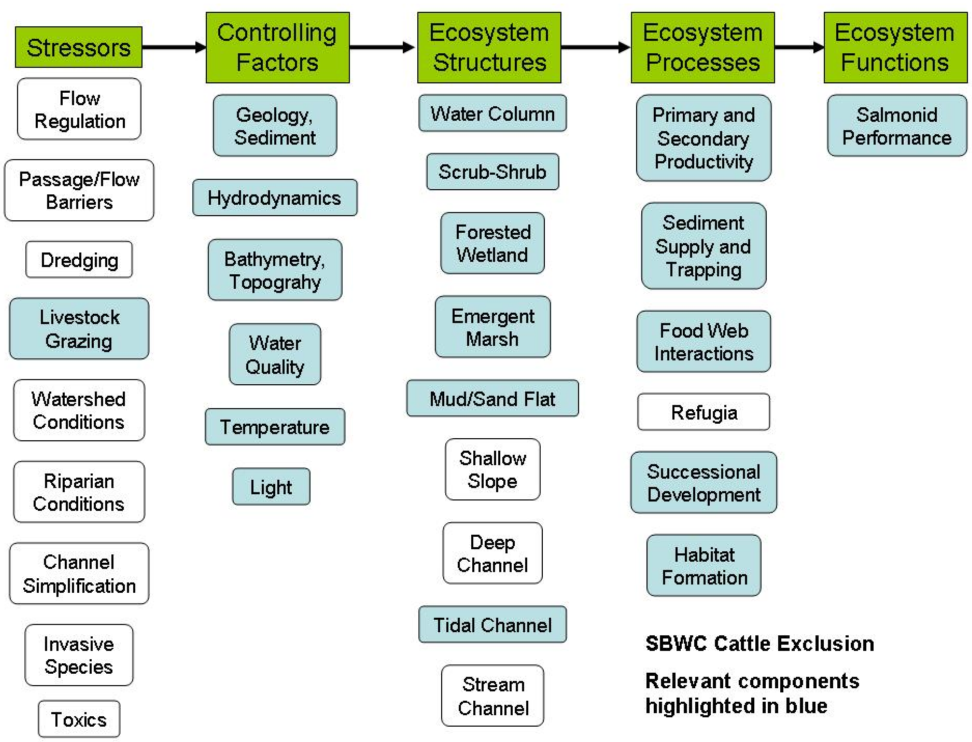

Figure A2: Conceptual model for cattle exclusion actions at Scappoose Bottomlands.

Culvert Replacement at Fort Clatsop

At the Fort Clatsop restoration site, the roadway and culvert posed an obstacle ("Passage/Flow Barrier" stressor) to fish passage that affected five controlling factors within South Slough: sediment, hydrodynamics, bathymetry/topography, water quality and temperature (Figure A3). Secondarily, livestock grazing impacted the topography and channel bathymetry of the site resulting in a simplified channel network, and degraded water quality. The tide gate that was only minimally passable during specific tidal stages made for suboptimal in-stream habitat conditions and modified hydrodynamics. Tidal reconnection improvements have increased hydrodynamic interactions with the site, enhancing the water column and promoting emergent marsh, more complex tidal channels, and other habitats on the periphery of the marsh (e.g. forested wetland, scrub-shrub and upland stream channel). The tidal reconnection will also improve nutrient and sediment flux, thus enhancing the following ecosystem processes: primary and secondary productivity in the water column, food web interactions, sediment supply and trapping, habitat formation, and refuge for fish and wildlife. Ultimately, these improvements in ecosystem processes should fuel improvement in salmonid performance, which can be quantified with specific monitoring metrics over time.

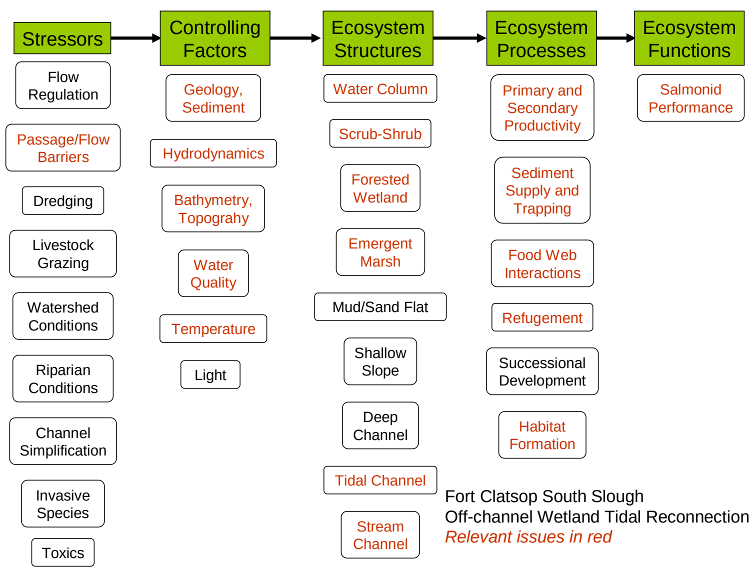

Figure A3: Conceptual model for culvert replacement actions at Fort Clatsop.

Appendix 3: Species Cover on Hogan Ranch, 2004-2009. % cover values greater than 25% are highlighted in yellow. "T" denotes trace cover.

Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
1	Wetted area	Water Starwort	*Callitriche stagnalis Scop.*	Introduced	OBL				T
1	Wetted area	Water purslane	*Ludwigia palustris*	Native	OBL			24%	36%
1	Wetted area	Water pepper	*Polygonum hydropiper*		OBL			12%	27%
1	Wetted area	Yellow pond lily	*Nuphar polysepala*	Native	OBL				7%
1	Wetted area	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW				6%
1	Wetted area	Algae						13%	
1	Wetted area	Water smartweed	*Polygonum amphibium*	Native	OBL			2%	
						T = Trace, <1% Cover			
1	Marshy shore	Water Starwort	*Callitriche stagnalis Scop.*	Introduced	OBL				T
1	Marshy shore	Broad leaf wapato	*Sagittaria latifolia*	Native	OBL				T
1	Marshy shore	Common Duckweed	*Lemna minor L.*	Native	OBL				T
1	Marshy shore	Unknown Rush							T
1	Marshy shore	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW	6%	24%	48%	71%
1	Marshy shore	Creeping spike rush	*Eleocharis palustris*	Native	OBL			3%	4%
1	Marshy shore	Water purslane	*Ludwigia palustris*	Native	OBL	79%			3%
1	Marshy shore	Water pepper	*Polygonum hydropiper*		OBL	41%		T	2%
1	Marshy shore	Moneywort	*Lysimachia nummularia*	Introduced	FACW		13%	13%	2%
1	Marshy shore	Yellow pond lily	*Nuphar polysepala*	Native	OBL	2%			
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
1	Marshy shore	Jointed rush	*Juncus articulatus*	Native	OBL	1%			
1	Marshy shore	Pennyroyal	*Mentha pulegium*	Introduced	OBL	T			
1	Marshy shore	White clover	*Trifolium repens*	Introduced	FAC*		31%		
1	Marshy shore	Poa	*Poa sp.*				8%		

1	Marshy shore	Three-square bulrush	*Scirpus americanus*	Native	OBL		5%		
1	Marshy shore	Fescue	*Festuca sp.*				4%		
1	Marshy shore	Birdsfoot trefoil	*Lotus corniculatus*	Introduced	FAC		3%		
1	Marshy shore	Tapertip Rush	*Juncus acuminatus*	Native	OBL		1%		
1	Marshy shore	English plantain	*Plantago lanceolata*	Introduced	FAC		T		
1	Marshy shore	Creeping bentgrass	*Agrostis stolonifera*	Introduced	FAC*			8%	
1	Marshy shore	Pointed rush	*Juncus oxymeris*	Native	FACW+			3%	
1	FACW grass/forested	Water pepper	*Polygonum hydropiper*		OBL	1%		T	T
1	FACW grass/forested	Horsetail	*Equisetum sp.*	Native	FAC			T	T
1	FACW grass/forested	Willow (Planting)	*Salix sp.*	Native	FACW				T
1	FACW grass/forested	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW	75%	1%	58%	93%
1	FACW grass/forested	Yellow Flag Iris	*Iris Pseudacorus*	Introduced	OBL				3%
1	FACW grass/forested	Water purslane	*Ludwigia palustris*	Native	OBL				2%
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
1	FACW grass/forested	Moneywort	*Lysimachia nummularia*	Introduced	FACW	70%	1%	4%	2%
1	FACW grass/forested	Jointed rush	*Juncus articulatus*	Native	OBL	10%			
1	FACW grass/forested	Pennyroyal	*Mentha pulegium*	Introduced	OBL	4%			
1	FACW grass/forested	Creeping spike rush	*Eleocharis palustris*	Native	OBL	4%		8%	
1	FACW grass/forested	White clover	*Trifolium repens*	Introduced	FAC*	1%	59%	T	
1	FACW grass/forested	Birdsfoot trefoil	*Lotus corniculatus*	Introduced	FAC	T	6%		
1	FACW grass/forested	Broadleaf plantain	*Plantago major*	Introduced	FACU+	T		T	
1	FACW grass/forested	Unk #1				T			
1	FACW grass/forested	Fescue	*Festuca sp.*				17%		
1	FACW grass/forested	Unk OBL plant					13%		
1	FACW grass/forested	Poa	*Poa sp.*				4%		

1	FACW grass/forested	Pointed rush	*Juncus oxymeris*	Native	FACW+		3%		
1	FACW grass/forested	Geranium	*Geranium sp.*				2%		
1	FACW grass/forested	Self heal	*Prunella vulgaris*	Native	FACU+		1%		
1	FACW grass/forested	Creeping buttercup	*Ranunculus repens*	Introduced	FACW		1%		
1	FACW grass/forested	Vetch	*Vicia sp.*				T		
1	FACW grass/forested	English plantain	*Plantago lanceolata*	Introduced	FAC		T		
1	FACW grass/forested	Small buttercup	*Ranunculus sp.*				T		
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
1	FACW grass/forested	Unk grass						T	
1	FACW grass/forested	Unk sedge	*Carex sp.*					T	
1	FACW grass/forested	Creeping bentgrass	*Agrostis stolonifera*	Introduced	FAC*			T	
1	FACW grass/forested	Small forget-me-not	*Myosotis laxa*	Native	OBL			T	
1	FACW grass/forested	Water smartweed	*Polygonum amphibium*	Native	OBL			T	
1	FACU grasses and forbs	Creeping buttercup	*Ranunculus repens*	Introduced	FACW	T		T	T
1	FACU grasses and forbs	English plantain	*Plantago lanceolata*	Introduced	FAC		1%		T
1	FACU grasses and forbs	Geranium	*Geraniumsp.*				T		T
1	FACU grasses and forbs	Sheep sorrel	*Rumex acetosella*	Introduced	FACU+			T	T
1	FACU grasses and forbs	Yellow Parentucellia	*Parentucellia viscosa (L.) Caruel*	Introduced	FAC-				T
1	FACU grasses and forbs	Ninebark (planting)	*Physocarpus opulifolius (L.)*	Native	FACW+				T
1	FACU grasses and forbs	Hairy cats ear	*Hypochaeris radicata*	Introduced	FACU*				T
1	FACU grasses and forbs	Willow Herb sp.	*Epilobium sp.*	Native	OBL				T
1	FACU grasses and	Pointed rush	*Juncus oxymeris*	Native	FACW+				T

Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
	forbs								
1	FACU grasses and forbs	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW	28%	1%	43%	77%
1	FACU grasses and forbs	Fescue	*Festuca sp.*			16%	40%		7%
1	FACU grasses and forbs	Moneywort	*Lysimachia nummularia*	Introduced	FACW	7%		1%	7%
1	FACU grasses and forbs	Swamp Rose (Planting)	*Rosa Palustris*	Native	OBL				4%
1	FACU grasses and forbs	White clover	*Trifolium repens*	Introduced	FAC*	31%	67%		3%
1	FACU grasses and forbs	Pennyroyal	*Mentha pulegium*	Introduced	OBL	T		1%	1%
1	FACU grasses and forbs	Colonial bentgrass	*Agrostis capillaris*	Introduced	FAC	36%		10%	
1	FACU grasses and forbs	Birdsfoot trefoil	*Lotus corniculatus*	Introduced	FAC	7%	3%	T	
1	FACU grasses and forbs	Jointed rush	*Juncus articulatus*	Native	OBL	2%			
1	FACU grasses and forbs	Unk #2				1%			
1	FACU grasses and forbs	Broadleaf plantain	*Plantago major*	Introduced	FACU+	T			
1	FACU grasses and forbs	Dandelion	*Taraxacum officinale*		FACU	T	T		
1	FACU grasses and forbs	Pointed rush	*Juncus oxymeris*	Native	FACW+	T		T	
1	FACU grasses and forbs	Thistle				T			
1	FACU grasses and forbs	Unk #4				T			
1	FACU grasses and forbs	Vetch	*Vicia sp.*			T			
1	FACU grasses and forbs	Water pepper	*Polygonum hydropiper*		OBL	T			

1	FACU grasses and forbs	Mix grass (Fescueand Poa)					3%	7%	
1	FACU grasses and forbs	Poa	*Poa sp.*				2%		
1	FACU grasses and forbs	Common velvet grass	*Holcus lanatus*	Introduced	FAC		1%		
1	FACU grasses and forbs	Unk sedge	*Carex sp.*				T		
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
1	FACU grasses and forbs	"small" Rush	*Juncus sp.*				T		
1	FACU grasses and forbs	Self heal	*Prunella vulgaris*	Native	FACU+		T		
1	FACU grasses and forbs	Pasture grasses						13%	
1	FACU grasses and forbs	Unk other grass						9%	
1	FACU grasses and forbs	Creeping bentgrass	*Agrostis stolonifera*	Introduced	FAC*			3%	
1	FACU grasses and forbs	Spatula leaf loosestrife	*Lythrum portula*	Introduced	NI			1%	
1	FACU grasses and forbs	Canada thistle	*Cirsium arvense*	Introduced	FACU+			T	
1	FACU grasses and forbs	Orchard grass	*Dactylis glomerata*	Introduced	FACU			T	
1	FACU grasses and forbs	Dock	*Rumex occidentalis*	Native	FACW+			T	
1	FACU grasses and forbs	Field bindweed	*Convolvulus arvensis*	Introduced				T	
1	FACU grasses and forbs	Water smartweed	*Polygonum amphibium*	Native	OBL			T	
2	Wetted area	Water smartweed	*Polygonum amphibium*	Native	OBL			6%	14%
2	Wetted area	Water pepper	*Polygonum hydropiper*		OBL	31%	10%	18%	10%
2	Wetted area	Water purslane	*Ludwigia palustris*	Native	OBL	87%	40%	21%	7%

2	Wetted area	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW			T	5%
2	Wetted area	Eurasian Watermilfoil	*Myriophyllum spicatum L.*	Introduced	OBL				4%
2	Wetted area	Creeping spike rush	*Eleocharis palustris*	Native	OBL				1%
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
2	Wetted area	Unk #6				25%			
2	Wetted area	Bur-reed	*Sparganium emersum*	Introduced	OBL	6%			
2	Wetted area	Broad leaf wapato	*Sagittaria latifolia*	Native	OBL	4%			
2	Wetted area	Rush				2%			
2	Wetted area	Western water milfoil	*Myriophyllum hippuroides*	Native	OBL			8%	
2	Wetted area	Moneywort	*Lysimachia nummularia*	Introduced	FACW			T	
2	Wetted area	Small forget-me-not	*Myosotis laxa*	Native	OBL			T	
2	Marshy shore	Eurasian Watermilfoil	*Myriophyllum spicatum L.*	Introduced	OBL				T
2	Marshy shore	Curly dock	*Rumex crispus*	Introduced	FAC+			T	T
2	Marshy shore	Horsetail	*Equisetum sp.*	Native	FAC				T
2	Marshy shore	Forget me not	*Myosotis laxa*	Native	OBL				T
2	Marshy shore	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW		45%	5%	47%
2	Marshy shore	Water purslane	*Ludwigia palustris*	Native	OBL	63%		24%	15%
2	Marshy shore	Creeping spike rush	*Eleocharis palustris*	Native	OBL			7%	12%
2	Marshy shore	Water smartweed	*Polygonum amphibium*	Native	OBL			T	7%
2	Marshy shore	Water pepper	*Polygonum hydropiper*		OBL	30%		1%	3%
2	Marshy shore	Broad leaf wapato	*Sagittaria latifolia*	Native	OBL	7%			3%
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
2	Marshy shore	Pennyroyal	*Mentha pulegium*	Introduced	OBL			T	3%
2	Marshy shore	Moneywort	*Lysimachia nummularia*	Introduced	FACW			1%	2%
2	Marshy shore	American speedwell	*Veronica americana*	Native	OBL	17%			
2	Marshy shore	Western water milfoil	*Myriophyllum hippuroides*	Native	OBL	15%		8%	

2	Marshy shore	Unk	*Guard pg 52A*			15%			
2	Marshy shore	Yellow pond lily	*Nuphar polysepala*			3%			
2	Marshy shore	Pointed rush	*Juncus oxymeris*	Native	FACW+	2%		T	
2	Marshy shore	Unk				2%			
2	Marshy shore	Fescue	*Festuca sp.*				20%		
2	Marshy shore	Self heal	*Prunella vulgaris*	Native	FACU+		5%		
2	Marshy shore	White clover	*Trifolium repens*	Introduced	FAC*		3%		
2	Marshy shore	Birdsfoot trefoil	*Lotus corniculatus*	Introduced	FAC		1%		
2	Marshy shore	Geranium	*Geranium sp.*				T		
2	Marshy shore	Small forget-me-not	*Myosotis laxa*	Native	OBL		1%		
2	Marshy shore	Spatula leaf loosestrife	*Lythrum portula*	Introduced	NI			36%	
2	Marshy shore	Wapato	*Sagittaria latifolia*	Native	OBL			T	
2	Marshy shore	Creeping bentgrass	*Agrostis stolonifera*	Introduced	FAC*			T	
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
2	FACW grass/forested	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW	40%	T	100%	
2	FACW grass/forested	White clover	*Trifolium repens*	Introduced	FAC*	31%	39%		
2	FACW grass/forested	Moneywort	*Lysimachia nummularia*	Introduced	FACW	13%	3%	1%	
2	FACW grass/forested	Water purslane	*Ludwigia palustris*	Native	OBL	13%			
2	FACW grass/forested	Unk				8%			
2	FACW grass/forested	Birdsfoot trefoil	*Lotus corniculatus*	Introduced	FAC	3%			
2	FACW grass/forested	Pennyroyal	*Mentha pulegium*	Introduced	OBL	3%			
2	FACW grass/forested	Tapertip rush	*Juncus acuminatus*	Native	OBL	3%			
2	FACW grass/forested	Unk #5				T			
2	FACW grass/forested	Fescue	*Festuca sp.*				45%		
2	FACW grass/forested	Bog Saint Johns wort?	*Hypericum anagalloides*	Native	OBL		8%		
2	FACW grass/forested	Sedge	*Carex sp.*				4%		

2	FACW grass/forested	Thistle					4%		
2	FACW grass/forested	Geranium	*Geranium sp.*				3%		
2	FACW grass/forested	Pointed rush	*Juncus oxymeris*	Native	FACW+		3%		
2	FACW grass/forested	Vetch	*Vicia sp.*				2%		
2	FACW grass/forested	Bugleweed	*Lycopus sp.*				1%		
2	FACW grass/forested	Northern starwort?	*Stellaria calycantha?*	Native	FACW+		1%		
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
2	FACW grass/forested	Self heal	*Prunella vulgaris*	Native	FACU+		1%		
2	FACW grass/forested	Water smartweed	*Polygonum amphibium*	Native	OBL		1%		
2	FACW grass/forested	Buttercup	*Ranunculus repens?*				T		
2	FACW grass/forested	Horsetail	*Equisetum sp.*				T		
2	FACW grass/forested	Small buttercup	*Ranunculus sp.*				T		
2	FACU grasses and forbs	Hairy cats ear	*Hypochaeris radicata*	Introduced	FACU*	5%	T	T	T
2	FACU grasses and forbs	Birdsfoot trefoil	*Lotus corniculatus*	Introduced	FAC	1%	3%		T
2	FACU grasses and forbs	Curly dock	*Rumex crispus*	Introduced	FAC+			T	T
2	FACU grasses and forbs	Yellow Parentucellia	*Parentucellia viscosa (L.) Caruel*	Introduced	FAC-				T
2	FACU grasses and forbs	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW	18%	18%	29%	48%
2	FACU grasses and forbs	Fescue	*Festuca sp.*				17%		14%
2	FACU grasses and forbs	Pennyroyal	*Mentha pulegium*	Introduced	OBL	1%		6%	10%
2	FACU grasses and forbs	English plantain	*Plantago lanceolata*	Introduced	FAC	6%	2%	4%	8%
2	FACU grasses and forbs	Moneywort	*Lysimachia nummularia*	Introduced	FACW	8%		2%	7%

2	FACU grasses and forbs	Clover sp.	*Trifolium sp.*	Introduced	FAC*				2%
2	FACU grasses and forbs	Self heal	*Prunella vulgaris*	Native	FACU+	1%	T	T	1%
2	FACU grasses and forbs	Horsetail	*Equisetum sp.*			T	T	2%	1%
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
2	FACU grasses and forbs	Creeping buttercup	*Ranunculus repens*	Introduced	FACW	T			1%
2	FACU grasses and forbs	Water purslane	*Ludwigia palustris*	Native	OBL	T			1%
2	FACU grasses and forbs	Field bindweed	*Convolvulus arvensis*	Introduced					1%
2	FACU grasses and forbs	White clover	*Trifolium repens*	Introduced	FAC*	45%	63%		
2	FACU grasses and forbs	Unk grass				5%	1%	T	
2	FACU grasses and forbs	Colonial bentgrass	*Agrostis capillaris*	Introduced	FAC	5%		4%	
2	FACU grasses and forbs	unk "barley grass"				2%			
2	FACU grasses and forbs	Unk (photos)				2%			
2	FACU grasses and forbs	Chicory	*Cichorium intybus*	Introduced		1%			
2	FACU grasses and forbs	Marsh speedwell	*Veronica scutellata*	Native	OBL	1%			
2	FACU grasses and forbs	Bugleweed	*Lycopus sp.*			T	2%		
2	FACU grasses and forbs	Small forget-me-not	*Myosotis laxa*	Native	OBL	T		T	
2	FACU grasses and forbs	Unk				T			
2	FACU grasses and forbs	Unk #11				T			
2	FACU grasses and	unk small violet flower				T			

Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
	forbs								
2	FACU grasses and forbs	Sedge	*Carex sp.*				3%		
2	FACU grasses and forbs	Unk #1					1%		
2	FACU grasses and forbs	Geranium	*Geraniumsp.*				1%	T	
2	FACU grasses and forbs	Creeping spike rush	*Eleocharis palustris*	Native	OBL		T		
2	FACU grasses and forbs	Poa	*Poa sp.*				T		
2	FACU grasses and forbs	Small buttercup	*Ranunculus sp.*				T		
2	FACU grasses and forbs	Annual chickweed	*Stellaria media*	Introduced	FACU		T		
2	FACU grasses and forbs	Cudweed	*Gnaphalium macrocephalum*	Native			T		
2	FACU grasses and forbs	Northern starwort?	*Stellaria calycantha?*	Native	FACW+		T		
2	FACU grasses and forbs	White puffball fungi					T		
2	FACU grasses and forbs	Creeping bentgrass	*Agrostis stolonifera*	Introduced	FAC*			12%	
2	FACU grasses and forbs	Spatula leaf loosestrife	*Lythrum portula*	Introduced	NI			10%	
2	FACU grasses and forbs	Meadow foxtail	*Alopecurus sp.*					T	
2	FACU grasses and forbs	Smartweed	*Polygonum sp.*					T	
2	FACU grasses and forbs	Dandelion	*Taraxacum officinale*		FACU			T	
2	FACU grasses and forbs	Meafow foxtail	*Alopecurus sp.*					T	
2	FACU grasses and forbs	Pointed rush	*Juncus oxymeris*	Native	FACW+			T	

2	FACU grasses and forbs	Timothy	*Phleum pratense*	Introduced	FAC-			T	
3	Wetted area	Wapato	*Sagittaria latifolia*	Native	OBL			50%	54%
3	Wetted area	Creeping spike rush	*Eleocharis palustris*	Native	OBL			30%	36%
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
3	Wetted area	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW	1%			5%
3	Wetted area	Hard stem bulrush	*Scirpus acutus*	Native	OBL			1%	5%
3	Wetted area	Jointed rush	*Juncus articulatus*	Native	OBL	55%			
3	Wetted area	American speedwell	*Veronica americana*	Native	OBL	40%			
3	Wetted area	Forget me not	*Myosotis laxa*	Native	OBL	15%			
3	Wetted area	Yellow pond lily	*Nuphar polysepala*	Native	OBL	15%			
3	Wetted area	Narrow leaf wapato	*Sagittaria cuneata*	Native	OBL	5%			
3	Wetted area	Water pepper	*Polygonum hydropiper*		OBL	5%			
3	Wetted area	Willow	*Salix sp.*					1%	
3	Wetted area	Narrow leaf wapato	*Sagittaria cuneata*	Native	OBL				
3	Marshy shore	Water pepper	*Polygonum hydropiper*		OBL	10%	20%		T
3	Marshy shore	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW	19%	40%	3%	76%
3	Marshy shore	Creeping spike rush	*Eleocharis palustris*	Native	OBL		20%	53%	16%
3	Marshy shore	Broad leaf wapato	*Sagittaria latifolia*	Native	OBL			75%	7%
3	Marshy shore	Water purslane	*Ludwigia palustris*	Native	OBL	34%	65%	1%	
3	Marshy shore	American speedwell	*Veronica americana*	Native	OBL	30%			
3	Marshy shore	Pennyroyal	*Mentha pulegium*	Introduced	OBL	9%			
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
3	Marshy shore	Rush				9%			
3	Marshy shore	Beak rush				6%			

3	Marshy shore	Narrow leaf wapato	*Sagittaria cuneata*	Native	OBL	4%			
3	Marshy shore	Moneywort	*Lysimachia nummularia*	Introduced	FACW	1%			
3	Marshy shore	Needle spike rush	*Eleocharis acicularis*	Native	OBL	1%			
3	Marshy shore	Scarlet pimpernel	*Analgallis arvensis*	Introduced	FAC	1%			
3	Marshy shore	Unk grass				1%			
3	Marshy shore	Tapertip rush	*Juncus acuminatus*	Native	OBL		20%		
3	Marshy shore	Bur-reed	*Sparganium emersum*	Introduced	OBL			1%	
3	FACW grass/forested	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW	88%	100%	98%	
3	FACW grass/forested	Moneywort	*Lysimachia nummularia*	Introduced	FACW	45%			
3	FACW grass/forested	Water purslane	*Ludwigia palustris*	Native	OBL	23%			
3	FACW grass/forested	Mountain sneezeweed	*Helenium autumnale*	Native	FACW	15%			
3	FACW grass/forested	Unk #9 or 10				4%			
3	FACW grass/forested	Broadleaf plantain	*Plantago major*	Introduced	FACU+	3%			
3	FACW grass/forested	Pennyroyal	*Mentha pulegium*	Introduced	OBL	3%			
3	FACW grass/forested	White clover	*Trifolium repens*	Introduced	FAC*	T			
Pond	Description	Common	Latin	Native	Wetland indicator	2004	2005	2008	2009
3	FACW grass/forested	Creeping spike rush	*Eleocharis palustris*	Native	OBL			1%	
3	FACW grass/forested	Water pepper	*Polygonum hydropiper*		OBL			T	
3	FACU grasses and forbs	Willow (planting)	*Salix sp.*	Native					T
3	FACU grasses and forbs	Horsetail	*Equisetum sp.*	Native	FAC				T
3	FACU grasses and forbs	Reed canarygrass	*Phalaris arundinacea*	Introduced	FACW		30%	90%	99%
3	FACU grasses and forbs	Fescue	*Festuca sp.*				33%		
3	FACU grasses and	Unk grass					24%		

	forbs								
3	FACU grasses and forbs	White clover	*Trifolium repens*	Introduced	FAC*		18%		
3	FACU grasses and forbs	Timothy	*Phleum pratense*	Introduced	FAC-		3%		
3	FACU grasses and forbs	Big red-stemmed moss					2%		
3	FACU grasses and forbs	Himalayan blackberry	*Rubus armeniacus*	Introduced	FACU		2%		
3	FACU grasses and forbs	Small buttercup	*Ranunculus sp.*				2%		
3	FACU grasses and forbs	Birdsfoot trefoil	*Lotus corniculatus*	Introduced	FAC		1%		
3	FACU grasses and forbs	Moneywort	*Lysimachia nummularia*	Introduced	FACW		T	2%	