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

Annual Report

BPA Project Number: 2003-011-00
Contract Number: 45815
Performance/Budget Period: September 15, 2009 – December 31, 2010

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May 2011

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1.0 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 45815.

The Estuary Partnership contracted NOAA Fisheries (NOAA), 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 2009/2010. 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 George, to saltwater intrusion in Reach A, near Astoria, Oregon).

<u>Summaries of AEM Results</u>

- NOAA Fisheries sampled fishes and macroinvertebrates monthly from April to August 2010 at 5 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 3.0 Fish-passage Improvement and LWD Monitoring AEM at Mirror Lake**). The two new fish sampling sites, were located at the confluence (of Youngs and Latourell Creeks), and in Latourell Creek, in order to assess fish use of those locations after large woody debris placement.
    - The Mirror Lake Complex, Mirror Lake, below culvert, Young Creek, Latourell Creek and confluence are being used by juvenile salmonids.
    - The time period when salmon were present at the Culvert site was longer in 2010 than in 2008 to 2009 (April through August vs. April through June).
    - At the culvert and lake sites, the dominant salmonid species varied from year to year. At the Culvert, Chinook were the dominant salmon species in 2010 and 2009, but coho were more abundant in 2008. At the Lake site, in contrast, Chinook were the most abundant salmon species in 2008 and 2009, but coho were dominant for the first time in 2010.
    - The relatively low condition factor observed in Chinook and coho salmon from the Culvert, observed in 2008 and 2009, was also seen in 2010.
    - Like several other indicators, mean daily growth rates, as determined from otoliths, showed no clear increasing or decreasing trends at the Mirror Lake sites.
    - In Youngs Creek, as in previous years, coho dominated the salmon catches and were present throughout the sampling period (88% of total catch in 2010). A small number of steelhead/trout were also collected. Although Chinook and Chum were not detected they may be present in June when water levels are highest but the site is not fishable.
    - Patterns of salmon occurrence at the Confluence and Latourell Creek were very similar to those observed at Young Creek. Coho were the dominant salmonid species; a small number of steelhead and/or rainbow trout were also captured at the Latourell Creek site. Neither of the sites were being utilized by Chinook or chum salmon at the times they were sampled; however, neither of these sites was sampled for the entire sampling season

- ACFM returned to 5 restoration sites to collect data at 185 vegetation plots across 259 acres at the Sandy River Delta and Mirror Lake restoration sites to assess the success of invasive vegetation removal and native vegetation plantings at these restoration sites (**Section 4.0 Planting Success AEM at Mirror Lake and Sandy River Delta**).
    - Overall density of native woody plants (stocking) increased at all sites, except Mirror Lake. Plant vigor also appeared to improve from 2008, but suppression from weeds increased from 2009 levels. Ratio of trees to total woody plants trended downward, possibly indicating succession of restoration sites toward target, reference site conditions.
    - Natural regeneration increased at all sites over 2008 and 2009 numbers, except at Sundial Island North. Because natural regeneration is a critical process in the restoration of self-sustaining, fully stocked natural stands, percent natural (non-planted) plants were analyzed as an indicator of restoration success. Natural regeneration was measured as difference in number of live, planted woody plants and total live woody plants. 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.

- 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 third year. In 2009, CREST began collecting water quality data at Ft. Clatsop restoration and reference sites. Fish and macroinvertebrates were sampled monthly between February and July at Scappoose Bottomlands and at the Fort Clatsop sites (**Section 5.0 Salmon, Salmon Prey, and Habitat AEM at Scappoose Bottomlands and Ft.Clatsop**.)

    - Tidal reconnection of the brackish influence of the Pacific Ocean to the South Slough resulted in fluctuation in salinity directly correlated with the diurnal tidal cycle.
    - The channel morphology reflects accretion nearest the restoration site, and channel deepening at subsequent upstream locations.
    - For the site at Scappoose Bottomlands, salmon totals for 2010 were higher than years' previous (one Chinook in 2008, one Coho in 2009 and four wild subyearling Coho and two wild subyearling Chinook in 2010) though still low. Fish species composition was similar to years' previous, for both salmon and other species. Chinook salmon were trapped on Teal Slough between May and July of 2010. Corixids were the preferred prey item for salmon captured at Teal Slough in Scappoose Bottomlands.
    - At the Fort Clatsop restoration site in 2010, Chinook salmon were observed until April and coho were observed through the sampling season. Unlike previous years, steelhead, cutthroat trout and chum were not observed in 2010. The number of observed salmon has varied annually since restoration (10 in 2007, 122 in 2008, 11 in 2009 and 47 in 2010. For both Chinook and Coho, adult isopods were the most abundant prey item sampled at the restoration site.
    - At the reference site in 2010, a total of four salmon were observed-- two presumably wild subyearling Coho and two presumably wild subyearling Chinook salmon. Salmon abundance and species composition has remained consistent between years at the reference site. Corophium, Chironomids and Amphipods were popular prey items at the reference slough in 2010, especially the adult life history stage.

- 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 6.0 Vegetation and Habitat AEM at Scappoose Bottomlands**.)

- Over the four-year study period no large changes in the local seasonal or inter-annual water chemistry were observed between sites. The largest parameter change observed was a decrease in E. coli levels in all ponds from an average range of 121.2 to 395 MPN/100mL in 2009 to an average range of 5.6 to 46.5 MPN/100mL in 2010. This drop in E. coli levels can be contributed to the livestock exclusion, which occurred on all of the sites in 2007. Throughout the study period water temperature, dissolved oxygen and turbidity levels fell within the "poor" water quality standard levels for all three ponds. Teal and Crooked Creek water temperatures were consistently high (>18°C) during the spring through early fall. Overall, these findings suggest the Ponds and Creeks on Hogan Ranch do not provide ideal habitat for salmonids, however these wetlands and streams are rich in wildlife and highly valued as waterfowl habitat. As the restoration plantings mature a decrease in stream and Pond temperatures and other water chemistry changes may be observed. Long-term observation is needed to determine the overall impacts of the riparian restoration on these ponds and streams water quality.
- The overall survival rate of plantings in 2010 on the Wilson/LaCombe property was 97% (73% when adjusted to account for missing/dead plants) with an APD of 0.25 plants/m2 (1,012 plants/acre). On Hogan Ranch the overall survival was 84% with an APD of 0.21 plants/m2 (850 plants/acre). The percent of high vigor of plantings within the riparian community increased from 24% in 2009 to 66% in 2010, while the percent of medium and low vigor plantings decrease.
- Three 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 water fowl 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 increase in the dominance of reed canary grass and a decrease in FACU and marshy shore plant community widths as the FACW community (reed canary grass zone) increases around the Ponds. However results from the 2010 vegetation survey indicate that reed canary grass cover is decreasing within some Pond 1 & 2 communities. This may be a consequence of higher water levels and longer periods of inundation caused by the installation of water control structures in 2007. Continued monitoring will allow us to track the changes of dominant invasive species in these Ponds (such as reed canary grass and Eurasian milfoil) to make sure this does not hinder the long-term outcome of this restoration project.

2.0 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.

2.1 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.

2.2 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 (Table 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.

EOS members recommended 4 projects for AEM (Mirror Lake, Sandy River Delta, Scappoose Bottomlands, and Fort Clatsop; highlighted rows in

Table 1 and green dots in Figure 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).

Table 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

Project Name	Restoration Activity	Year(s) When Restoration Occurred	Habitat Type	Reach	Baseline Monitoring
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

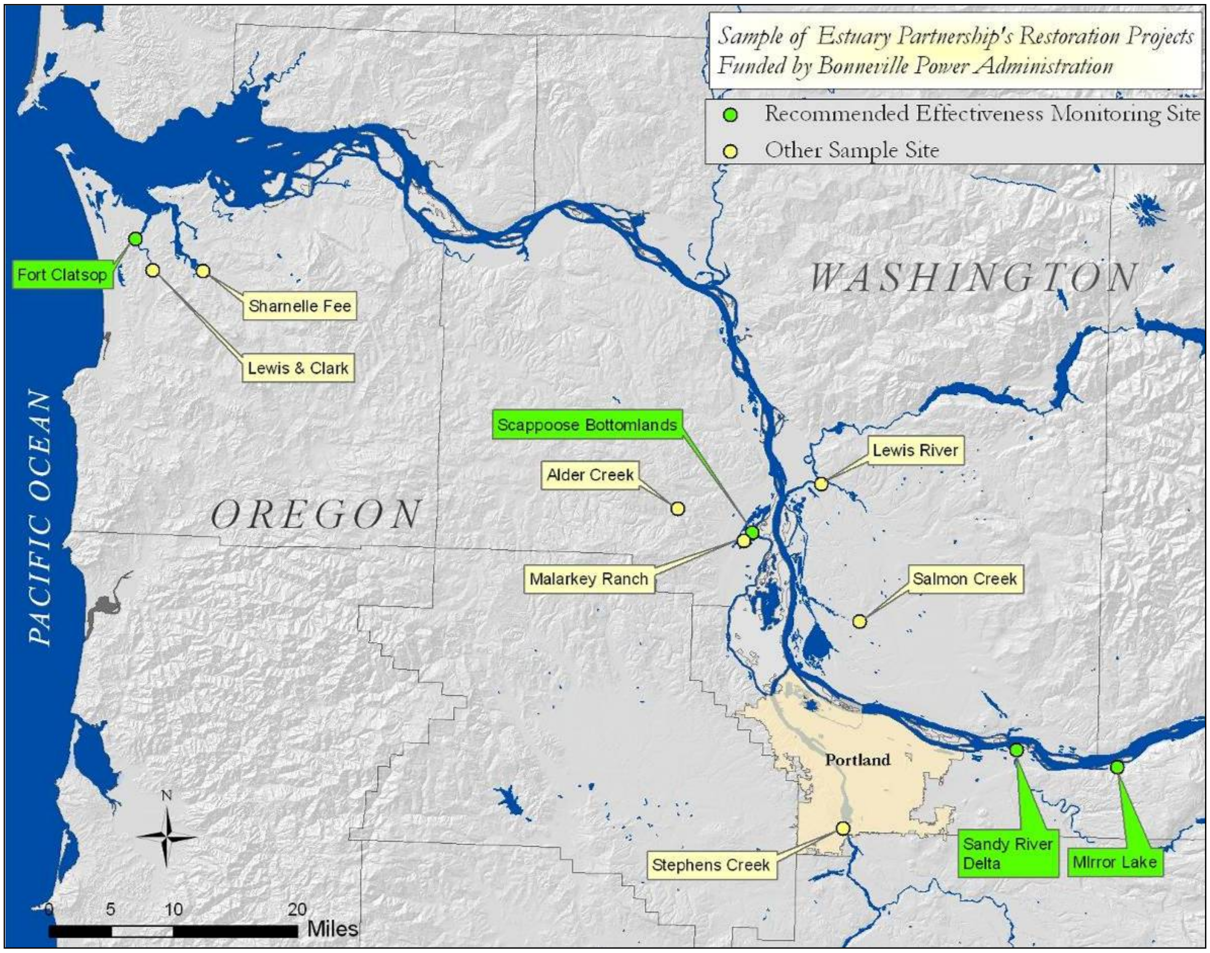


Figure 1. Sample of Estuary Partnership restoration projects funded by BPA presented as potential sites to EOS members. Sites that EOS members recommended for AEM are denoted by the green dots and boxes.

3.0 Fish-passage Improvement and LWD 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 focused on assessing temperature conditions and juvenile salmonid use of the site. In 2009, AEM efforts by Parametrix (Estuary Partnership Contract # 14-2009) focused on evaluating fish-passage culvert improvements connecting the Mirror Lake Restoration Site with the Columbia River, and 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

3.1 Site Description

The Mirror Lake project area is a part of Rooster Rock State Park, and is separated from the Columbia River by Interstate 84. The lake is used for fishing and recreation and the area contains some high quality emergent wetland habitats at its downstream end. Further upstream, wetland and riparian habitats are dominated by reed canary grass (*Phalaris arundinacea*), Himalayan blackberry (*Rubus discolor*), and other non-native species. These areas were historically subject to annual flooding from the Columbia River. Although the upstream connection to the site was severed by the freeway, a culvert under I-84 still allows for backwater from the Columbia to flood the site; however, flows are likely somewhat restricted compared to historical conditions. Modifications to the Columbia's hydrograph are the primary hydrologic impact to this site.

The area is currently undergoing restoration, and as part of the Lower Columbia River Estuary Partnership's Effectiveness Monitoring Program, NOAA Fisheries investigated prey availability, fish assemblages, and juvenile salmon habitat usage of the Mirror Lake area. As part of this effort, NOAA Fisheries focused on the following five work elements:

1.) A survey of prey availability and habitat use by salmon and other fishes at site;
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;
4.) Analyses of biochemical measures of growth and condition (e.g., whole body lipid content);
5.) Compilation of data and annual report preparation.

Figure 2 shows the five areas of focused fish sampling at the Mirror Lake project area as described below:

Culvert: This site is located immediately below the I-84 culvert and adjacent areas opposite the boat launch and associated docks (Figure 2, Figure 3 A, B). The area immediately below the culvert had very little to no vegetation associated with the banks or bottom. The banks are steep, and rocky, areas consisting of pebbles to small boulders. Bottom sediment was the same. The adjacent areas are dominated by grasses, with a steep bank (1.5 meter) that drops off quickly. The bottom sediments are 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.

Lake: This site is on the open water part of the lake near the I-84 culvert (Figure 2, Figure 3 C). 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.

Figure 2. Photo showing areas of fish collection at Mirror Lake. Photo provided by Google Earth.

Young Creek: This site is located upstream of the Mirror Lake site (Figure 2, Figure 3 D). The creek varies from about 1.5 meters wide at low water level to about 5 meters at high water. The riparian area is dominated by reed canary grass to the edge of the creek bed and in immediately 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, providing 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.

Confluence and Latourell Creek: In 2010, these two new sites were sampled and were surveyed intermittently for salmon observation. Confluence (Figure 3 E) is located at the confluence of Latourell

Creek and Young Creek, downstream of the Young Creek Site. Latourell Creek (Figure 3 F) is located 100 m downstream of Latourell Lake. Physical characteristics of both sites are similar to Young Creek. The bottom sediment is composed of very soft mud, and the banks are overgrown with tall grasses. Confluence was sampled in April, May, and July, while Latourell Creek was sampled once in early August prior to introduction of large woody debris into the creek in late August.

A)  B) 

C)  D) 

E)  F) 

Figure 3. Photos of fish sampling sites at the Mirror Lake project area. A) Culvert at high water, B) Culvert at low water, C) Lake, D) Young Creek, E) Confluence and F) Latourell Creek.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

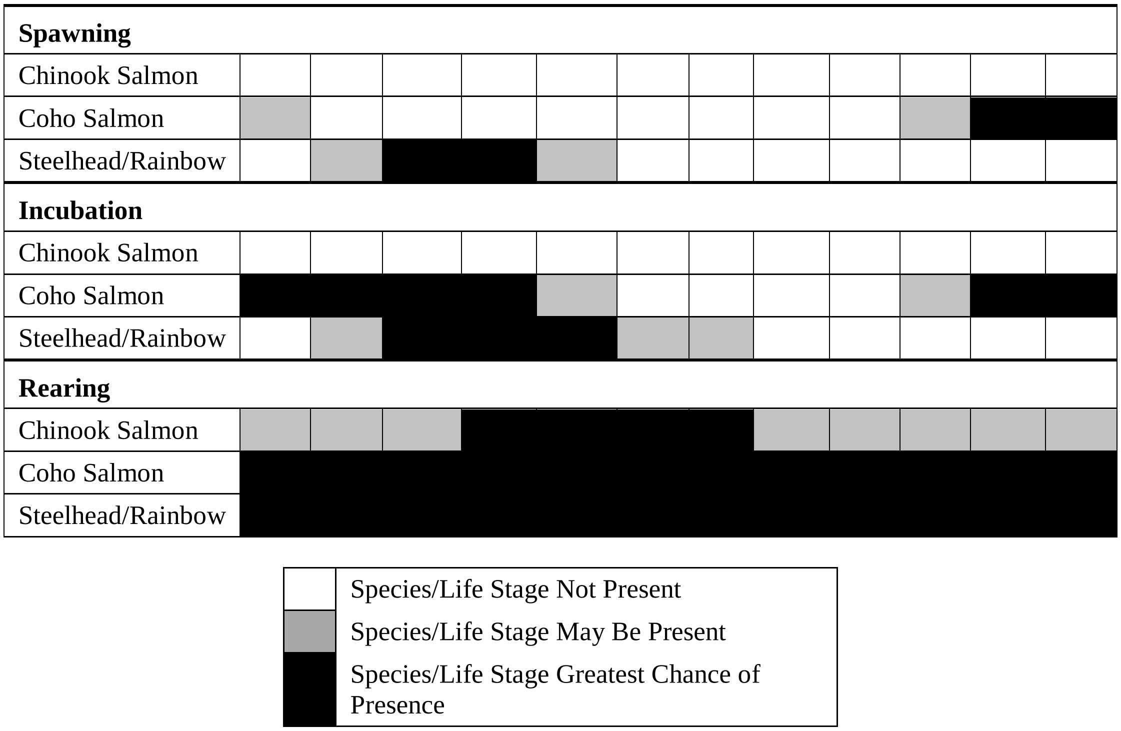


Table 2. Timing of salmonid use of Latourell and Young Creeks. Juvenile chum and sockeye salmon likely use this area as off-channel habitat during out-migration; however, their presence has not been documented

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			

Common Name	Scientific Name	*Above* Confluence	*Below* Confluence
Parametrix staff from 2004 through 2008			

Table 3. 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 and large woody debris (LWD) placement.

The 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 LWD in selected sections of Young Creek, creating a total of 13 separate structures.

3.2 Methods

3.2.1 Fish Sampling

Fish use of restoration sites was assessed by analysis of catch data, obtained using methods similar to Roegner et al. (2009). Fish were collected from April 2010 through August 2010. 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 4 shows the coordinate of each site, and Figure 2 is a map detailing sampling site locations.

Table 4**.** Coordinates of the sites sampled at Mirror Lake in 2010.

Site Name	Latitude	Longitude
Culvert	45° 32.606'N	122° 14.878'W
Lake	45° 32.562'N	122° 14.703'W
Confluence	45° 32.620'N	122° 13.727'W
Latourell Creek	45° 32.590'N	122° 13.190'W
Young Creek	45° 32.735'N	122° 12.275'W

Fish were collected using a Puget Sound beach seine (PSBS) (37 x 2.4 m, 10 mm mesh size), a modified PSBS (MPSBS, 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 x 1.5m, 10 mm mesh size) was used as a fish chase net.

PSBS sets were deployed using a 17 ft Boston Whaler or 9 ft inflatable raft. The 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 MPSBS 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. 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; and otoliths for aging and growth rate determination. Because sufficient fish were not available or could not be collected within the limits or our collection permit, bile for measurement of metabolites of polycyclic aromatic hydrocarbons (PAHs) and stomach contents for measurement of PAHs and POPs were not collected in 2010. Necropsy 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 70% ethanol. Fin clips for genetic analyses were collected and preserved in alcohol, following protocols described in Roegner et al. (2009). 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 5.

Table 5. Samples collected from juvenile Chinook salmon at Mirror Lake in 2010 as part of the Effectiveness Monitoring Program.

Site	Date	Number of fish	% Hatchery (marked)	Otoliths for growth rate	Stomach contents taxonomy (diet)	Body chemistry	Fin clips for genetics
Culvert	04/06/10	18	0	18	18	18	18
	05/17/10	10	0	10	10	10	10
	06/16/10	10	0	10	10	10	10
	07/06/10	23	30	23	23	23	23
	08/02/10	1	0	0	0	0	1
Lake	05/18	5	0	5	5	5	5

/10						
Total	67	10%	67	66	66	67

3.2.2 Prey Sampling

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

In 2010, NOAA Fisheries conducted the following types of invertebrate collections at the Mirror Lake project area:

1) Open water column Neuston tows (2-3 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 100 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 (2-3 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 10 m. The samples were then processed and preserved in the same manner as the open water tows.

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. The total amount of extractable lipid (percent lipid) in these composite samples 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 the Lake and Culvert were extracted and are now being processed for microstructural analysis of recent growth. Specifically, sagittal otoliths 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 sagittal otoliths 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 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, and organochlorine (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.

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.

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

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

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:

$K = [\text{weight (g)}/\text{fork length (cm)}^3] \times 100$

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. Figure 4 shows the water depth measured below Bonneville Dam on the Columbia River during this time period. During the 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 Mirror Lake sites were more constant and influenced by the elevation of the beaver dam at the I-84 culvert and flows in from Latourell and Young Creeks.

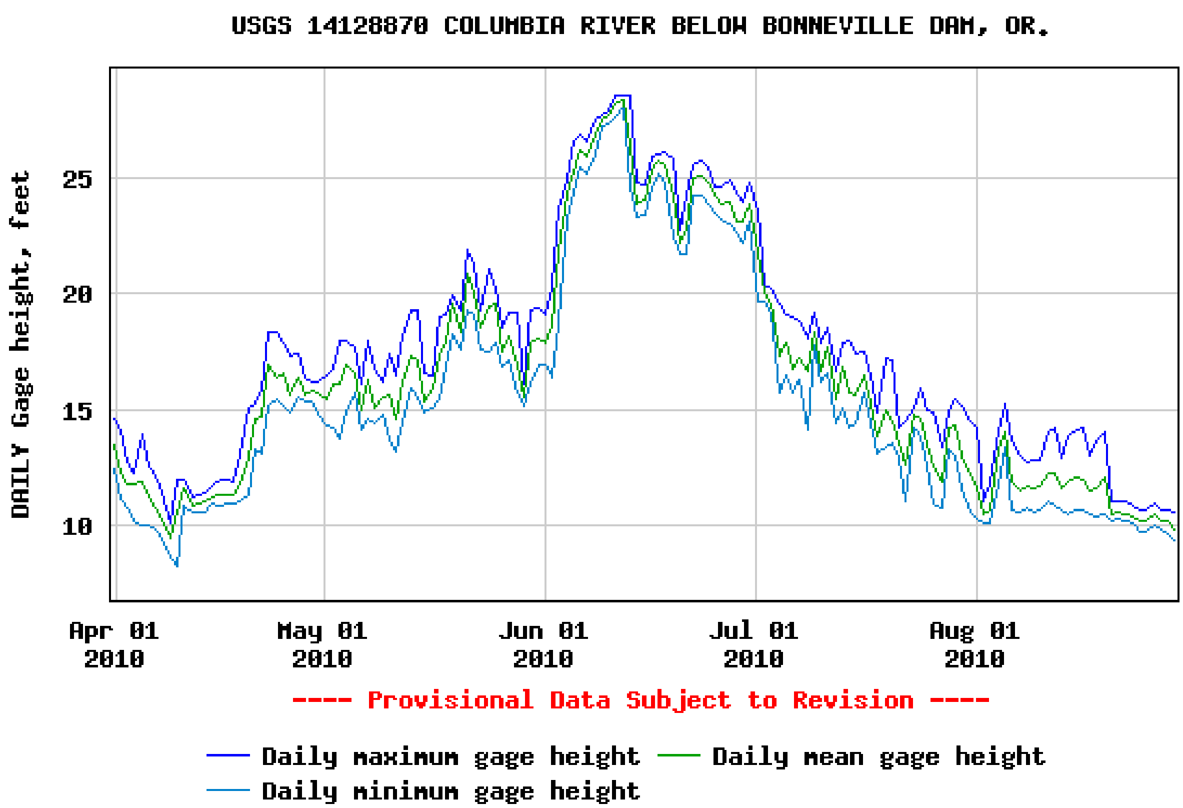


Figure 4. Water depth (ft) below Bonneville Dam (Lat 45° 38'00", long 121° 57'33"). Data provided by USGS.

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

- Culvert. At mid to higher water, the area immediately below the culvert and two adjacent areas were sampled with the PSBS. At low water, bottom substrate, which was comprised of very soft mud, prevented successful beach seining with the PSBS. In the month of August, the MPSBS was used to fish below the culvert and the adjacent area (Figure 5).


Figure 5. Low water level below the culvert, and fishing below the culvert using MPSBS.

- 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 6), thus the MPSBS was used then to sample the site from late July through August.


Figure 6. Fishing at high water with PSBS (note the absence of vegetation in water) vs site at low water (full of vegetation)

- Young Creek. The site was successfully fished in April-May and July-August using the MBN. The water level was extremely high in June, which prevented use of the MBN to fish this site (Figure 7).

Figure 7. Fishing with modified block net at lower water vs. sampling at relatively higher water levels (photograph from 2008).

3.3.2 Water Temperature

Intersite differences in water temperature were observed (Figure 8). These differences were likely associated with habitat conditions and time of sampling at a particular site. Typically, NOAA Fisheries sampled the Lake in the morning, Young Creek in the mid-morning through mid-afternoon, and the Culvert later in the afternoon. At all of the sampling sites, water temperature generally increased from April through August, although a slight decrease in water temperature was observed at the June sampling, which coincided with an increase in water level at the Mirror Lake project area. The water temperature was similar at all sites (8°C) in April, which increased substantially at the Lake and Culvert site, reaching a maximum of 22-24°C in August. An increase in water temperature was also observed at Young Creek, but water temperature remained lower, reaching a maximum of 13°C. The water temperature at Young Creek remained fairly stable from May through August, with values between 11 and 13°C. The limited temperature measurements from the Confluence and Latourell Creek were very similar to water temperatures at Young Creek at the same sampling times.

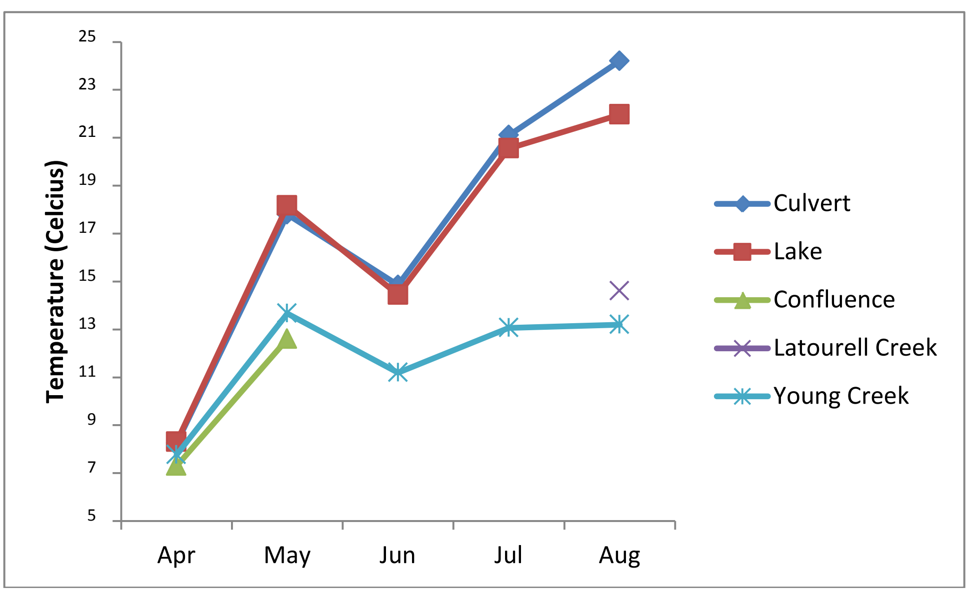


Figure 8. Water temperature (^{o}C) at Mirror Lake sites at the time of fish collection in 2010.

3.3.3 Fish Community Composition and Species Diversity

All five Mirror Lake sites were utilized by fish (Table 6). However, the number and type of fish present varied with time and site (Table 6, Figure 9). The total number of species captured was the lowest at Young Creek and Latourell Creek, where four different species each were collected. The total number of species captured at the Confluence was similar, with five species present. Coho salmon was the dominant species captured at Young Creek. At Latourell Creek, coho salmon and stickleback accounted for approximately equal proportions of the catch, while at the Confluence, stickleback was the dominant species.

The highest numbers of fish species (15 at both sites) were observed at the Lake and Culvert sites. Species composition differed somewhat between these two sites. Catches at the Lake were generally dominated by stickleback and killifish. At the Culvert, stickleback and peamouth were also common, but species, including Chinook and coho salmon and peamouth, made up significant proportions of the catch in certain months. The proportions of non-native species caught at the Culvert and the Lake were similar as well, comprising roughly 50% of the species present at both sites. At the Confluence, only one non-native species (killifish) was observed, while at Young Creek and Latourell Creek, no non-native species were observed.

Table 6. 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), MPSBS (modified PSBS), MBN (modified block net). NS = not sampled. Because of high water, the site could not be fished at this time.

Site	Date	Gear	No. of attempts	Number of species	Species caught (total number)
	04/06/10	PSBS	2	4	Chinook, coho, chum, steelhead/trout three spine stickleback, banded killifish, pumpkinseed, smallmouth bass, peamouth, chiselmouth, carp, pikeminnow, crappie, shad, sucker (15)
	05/18/10	PSBS	3	4	
	06/16/10	PSBS	2	11	
	07/06/10	PSBS	2	11	
Culvert	08/02/10	MPSBS	2	8	
	04/06/10	PSBS	3	4	Chinook, coho, steelhead/trout, small mouth bass, three spine stickleback, banded killifish, bluegill, sculpin, pumpkinseed, peamouth, chiselmouth, pike minnow, carp, crappie sucker(15)
	05/18/10	PSBS	3	11	
	06/16/10	PSBS	2	7	
	07/07/10	MPSBS	3	6	
Lake	08/03/10	MPSBS	3	8	
	04/06/10	PSBS	3	2	coho, killifish, lamprey, sculpin, three spine stickleback (5)
	05/18/10	PSBS	3	3	
	06/16/10	PSBS	0	0	
Confluence	07/07/10	MPSBS	3	5	
Latourell Creek	08/03/10	MPSBS	2	4	coho, sculpin, steelhead/trout, three spine stickleback (4)
Young Creek	04/05/10	MBN	3	3	coho, steelhead/trout, three spine stickleback, sculpin, (4)

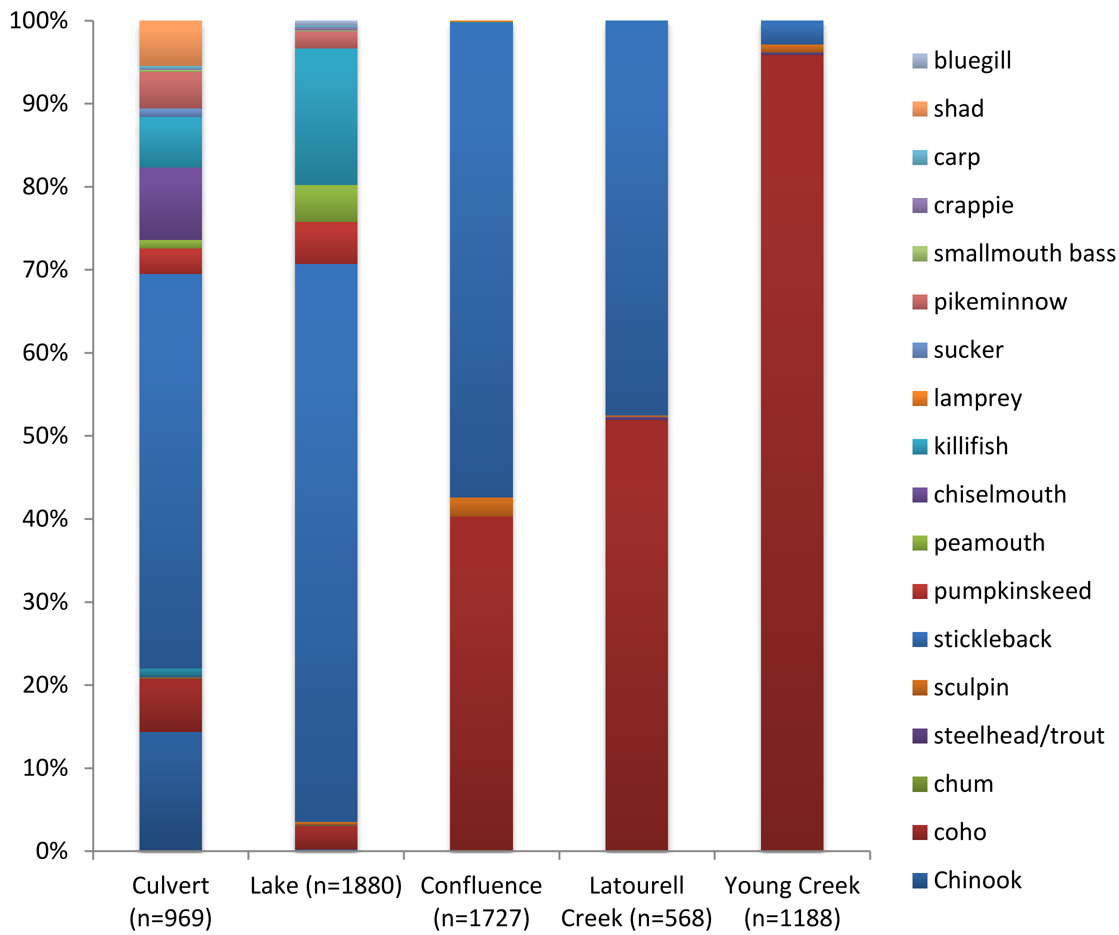


Figure 9. Percentage of each species in total catch at the Mirror Lake project area.

Table 7 shows the percentage of each species caught at each site by the month of capture. The percentages of species collected varied somewhat for the Culvert and the Lake, as counts of killifish, stickleback, and other species fluctuated between sampling events. At Young Creek, juvenile coho salmon, stickleback, and sculpin were consistently collected (though at varying levels) while steelhead, rainbow trout, and cutthroat trout were detected only in July (due to the small number of steelhead, rainbow trout, and cutthroat trout caught at these sites, and difficulty in identifying these fish in the field, the steelhead, rainbow trout, and cutthroat trout are referred to as steelhead/trout; e.g., see Table 7 and Figure 9). Similarly, at the Confluence, coho salmon, stickleback, and sculpin were consistently collected, with killifish and lamprey observed only in August. Latourell Creek was sampled in August only, so no temporal comparisons can be made.

Species diversity (Figure 10), as calculated by the Shannon-Wiener diversity index (Margalev 1958), was the lowest at Young Creek (0.12) and highest at the Lake (0.79). The index for the Culvert (0.73) was slightly lower than the Lake, but higher than the indices observed at the Confluence and Latourell Creek (0.41 and 0.52, respectively). The low indices observed at the Confluence, Latourell Creek, and Young Creek were due to the high number of individuals from a few dominant species captured (Table 6).

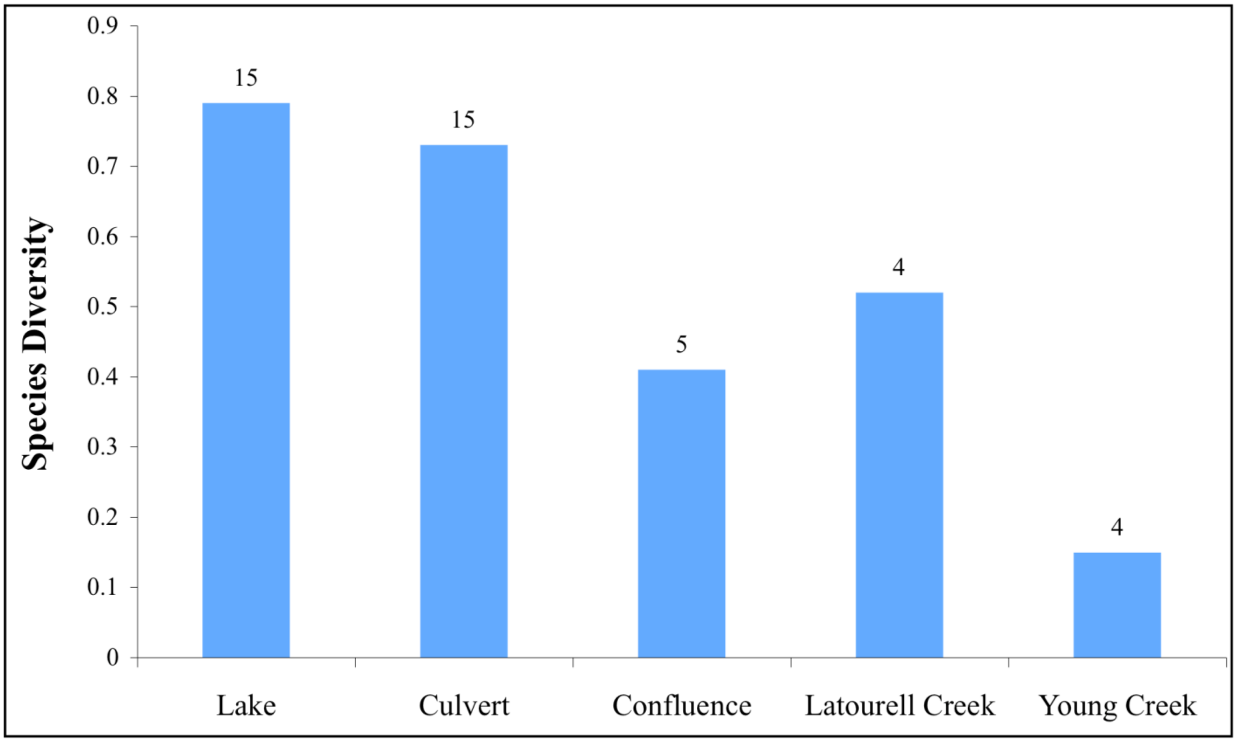


Figure 10. Fish species diversity (Shannon-Wiener Diversity Index) at Mirror Lake sites in 2010. Numbers above the bar represent numbers of species captured.

Table 7. Total number of each species captured as a percentage of the total number of all individual fish captured.

Site	Date	Chinook	Coho	Chum	Steelhead/ trout	Sculpin	Stickleback	Pumpkinseed	Peamouth	Chiselmouth	Killifish	Sucker	Pikeminnow	Small mouth bass	Carp	Shad	Others
	04/06/10	51.2	30.2	2.3			16.3										
	05/18/10	78.6	12.5				3.6				5.4						
	06/16/10	11.3	17.8		0.4		39.6	2.6	2.2	10.9	6.1		6.5		0.4	2.2	
	07/06/10	6.9	0.3				37.7	3.4	0.4	8.6	16.9		4.0	0.1	0.3	21.2	
Culvert	08/02/10	0.3					29.7		58.9		7.3	2.9		0.3	0.3		crappie (0.3)
	04/06/10		0.7				96.5	2.1	0.7								
	05/18/10	0.4	3.6			0.4	89.4	2.3	0.1		2.3		0.8		0.2		crappie (0.2)
	06/16/10		2.9		0.5		54.3	2.4	0.5	0.5	39.1						
	07/07/10						53.8	1.9			42.4		0.3	0.3			bluegill (1.4)
Lake	08/03/10					0.1	87.6	3.7	5.9		0.4	0.1	2.0		0.2		
	04/06/10					8.3	91.7										
	5/18/10		14.5			2.4	83.1										
Confluence	07/07/10		29.9			1.1	68.8				0.1						lamprey (0.1)
Latourell Creek	08/02/10		51.9		0.4	0.2	47.5										
	04/05/10		67.3			13.5	19.2										
	05/17/10		90.9			1.8	7.3										
	07/07/10		98.0		0.6	0.4	1.0										
Young Creek	08/03/10		96.5				3.48										

3.3.4 Salmonid Catch Composition and Catch per Unit Effort

The proportions of salmonids in the total catch for the Lake and the Culvert were 3% and 21%, respectively, while at Young Creek, the proportion of the total catch made up of salmonids was 96%. At the Confluence and Latourell Creek, proportions of salmonids were 40% and 52%, respectively. Chinook salmon were the dominant salmonid species caught at the Culvert, but at all other sites, coho salmon made up the greatest percentage of the salmonid catch (Figure 11). Coho salmon were present at all of the sampling sites, whereas Chinook salmon was present only at the Lake and Culvert. Small numbers of steelhead/trout were observed at all of the sites except the Confluence. Chum salmon were captured only at the Culvert.

Chinook salmon were collected at the Lake only in May, but at the Culvert they were present throughout the sampling season, from April through August (with the exception of June, when no Chinook were collected). Coho salmon were found throughout the sampling season at Young Creek, from April through June at the Lake, and from April through July at the Culvert. No coho were captured in April at the Confluence, but they were present when the site was sampled in May and July. Latourell Creek was sampled only in August, and a large number of coho salmon were found. Chum salmon were found in April only, while steelhead/trout were present sporadically in June, July, and August.

Catch per unit effort (CPUE) values for Chinook salmon at the Culvert and the Lake were 53 fish per 1000 m^2 and 1 fish per 1000 m^2, respectively. For coho salmon, CPUE was highest at Young Creek at 938 fish per 1000 m^2, and lowest at the Lake at 10.9 fish per 1000 m^2 (Figure 12). CPUE for chum at the Culvert was 0.4 fish per 1000 m^2, while CPUE for steelhead/trout was the highest at Young Creek at 3.3 fish per 1000 m^2.

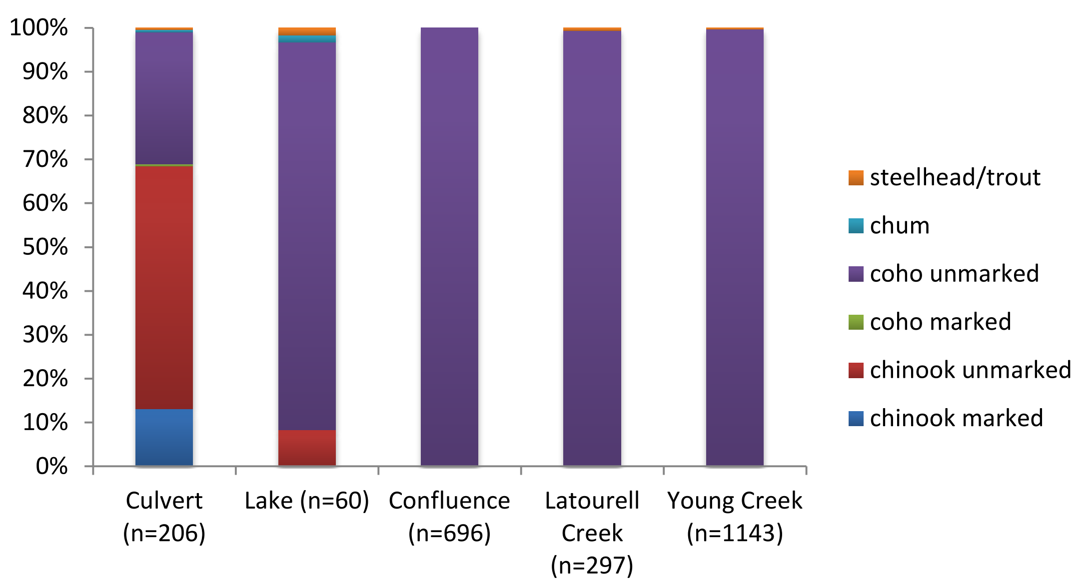


Figure 11. Proportions of different salmon species in 2010 catches at the Mirror Lake Complex sampling sites.

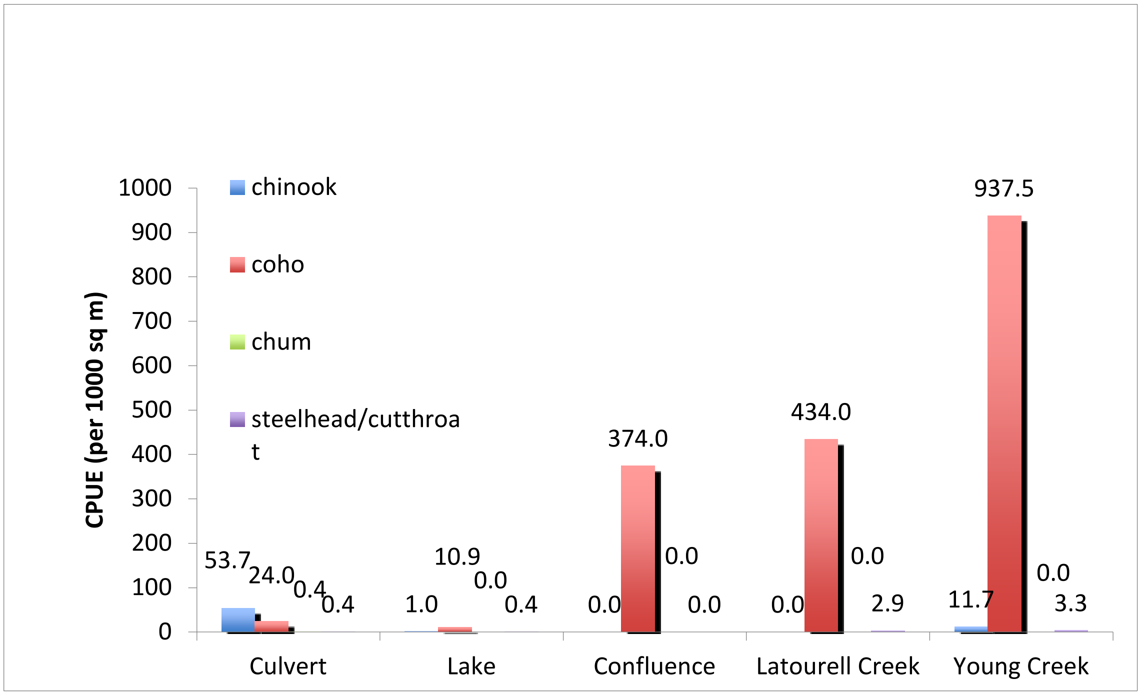


Figure 12. Density of salmonids captured in 2010 per 1000 sq meters, as determined from catch per unit effort (CPUE).

3.3.5 Salmonid Size and Condition.

The average lengths and weights of coho salmon from the Mirror Lake sites are shown in Table 8. The size range of the coho salmon collected varied greatly throughout the sampling period. At the Culver site, length and weight increased steadily from April to July, but no clear trends were observed in length and weight with time at the other sites. The condition factor of coho salmon also varied throughout the sampling period, but no definite trend was observed. However, the condition factor of coho from the Culvert was significantly lower than in coho from the Lake (Table 8, Figure 13).

The lengths and weights of Chinook salmon caught at each site are show in Table 9. Fish sampled in April had significantly lower length and weight than fish caught during other months (Tukey's HSD, $p < 0.05$). Marked Chinook were caught only at the Culvert in the month of July. The mean length and weight of the marked Chinook was not significantly different from the unmarked Chinook sampled at the same time. Additionally, the overall mean condition factors were not significantly different in Chinook salmon caught from the Lake and from the Culvert (Table 9, Figure 13).

Only one chum salmon was caught in 2010 (length 59mm, weight 1.9g).

Length, weight, and condition factor of steelhead/cutthroat trout are shown in Table 10. Due to the small sample size, statistics were not performed in these fish; however, the steelhead/trout captured at the Lake was found to be smaller, and had lower condition factor than fish captured at Young Creek and at Culvert.

Table 8. Summary table showing number of unmarked coho salmon caught at each site for each month of sampling and average length, weight, and condition factor by site and sampling time.

Site	Date	Number caught	Number measured	Fork length (mm)	Weight (g)	Condition factor
Culvert	04/06/10	13	16	45.7±16.2	1.4±2.9	0.93±0.22
	05/18/10	7	7	65.6±8.0	3.4±1.5	1.14±0.05
	06/16/10	41	23	75.8±16.6	6.0±4.2	1.17±0.20
	07/06/10	2	2	81.0±5.7	5.6±1.6	1.04±0.75
Lake	04/06/10	1	1	90.0±0.0	8.6±0.0	1.18±0.00
	05/18/10	44	39	67.8±4.6	3.8±0.7	1.23±0.18
	06/16/10	6	6	92.0±16.4	9.7±4.7	1.19±0.13
Confluence	05/18/10	109	60	65.0±12.8	3.5±2.8	1.13±0.10
	07/07/10	587	0	NA	NA	NA
Latourell Creek	07/07/10	295	60	91.9±9.8	9.8±3.3	1.22±0.11
Young Creek	04/05/10	35	35	93.8±31.9	11.8±8.0	1.08±0.13
	05/17/10	50	42	73.9±33.8	7.7±7.9	1.15±0.21
	07/07/10	693	89	84.2±15.8	8.0±4.2	1.22±0.13
	08/03/10	361	58	83.9±16.8	8.3±8.8	1.14±0.17

Table 9. Summary table showing number of Chinook salmon caught at each site for each month of sampling, and average length, weight, and condition factor by site and sampling time). L = value is significantly lower than the values observed at the same site (ANOVA and Tukey's HSD, $p < 0.05$).

		Chinook (marked)				Chinook (unmarked)			
Site	Date	Number caught	Length (mm)	Mean wt (g)	Condition Factor	Number caught	Length (mm)	Mean wt (g)	Condition Factor
Culvert	04/06/10	0	-	-		19	41.3±3.8[L]	0.6±03[L]	0.78±0.15
	05/18/10	0	-	-		10	53.9±4.72	1.61±0.4	1.01±0.42
	06/16/10	0	-	-		25	60.8±9.9	2.5±1.6	0.97±0.31
	07/06/10	27	78.8±8.8	4.66±1.4	1.07±0.09	21	73.5±10.7	4.6±1.8	1.08±0.08
	08/02/10	0	-	-		1	70.0±0.0	3.6±0.0	1.04±0.00
Lake	04/06/10	0	-	-		2	54.5±2.12	1.6±0.4	0.95±2.12
	05/18/10	0	-	-		5	55.0±2.7	1.9±0.3	1.16±0.07

Table 10. Summary table showing number of unmarked steelhead/cutthroat caught at each site for each month of sampling and average length, weight, and condition factor by site and sampling time.

Site	Date	n	Length (mm)	Weight (g)	Condition factor
Culvert	06/16/2010	1	195.0±0.0	110.0±0.0	1.48±0.0
Lake	06/16/2010	1	33.0±0.0	0.30±0.0	0.83±0.0
Young Creek	07/07/2010	4	194.3±51.0	82.8±48.8	1.06±0.18

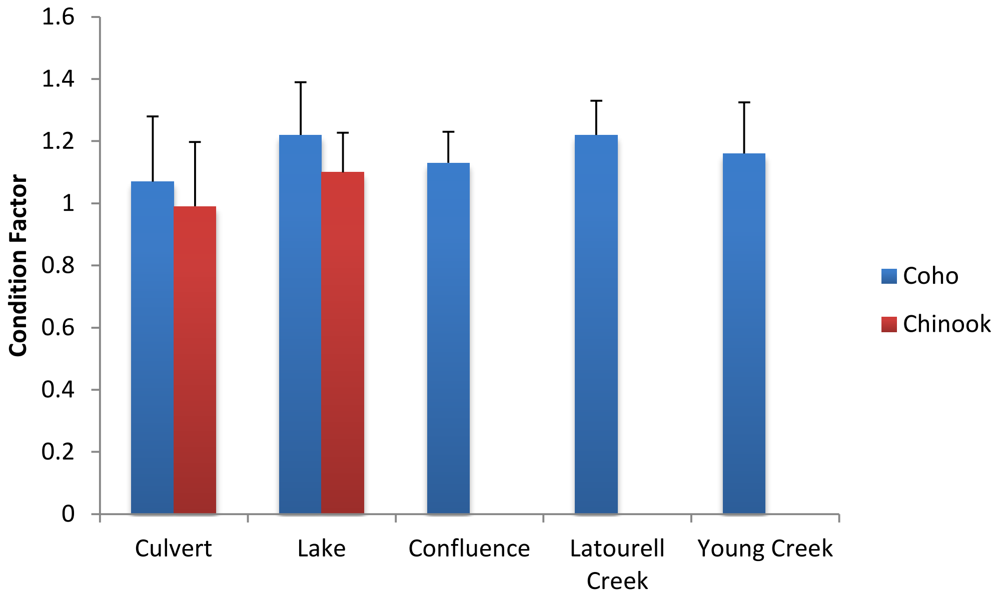


Figure 13. Mean condition factor (CF) of juvenile coho and Chinook salmon from the Culvert, the Lake, the Confluence, Latourell Creek and Young Creek. Error bars represent standard deviation from the mean. Condition factor (K) of coho from the Culvert was significantly lower than K of coho from the Lake (ANOVA and Tukey's HSD, $p < 0.05$), but no other significant differences were observed.

3.3.6 Lipid content of Mirror Lake juvenile Chinook salmon

Lipid analyses on samples collected in 2009 have been completed. The 2010 samples will be analyzed when genetics data are available, as this information is needed to form sample composites.

Overall, the mean lipid content of juvenile Chinook salmon from the Culvert and Lake sites did not differ significantly ($p=0.7376$). The average level was 1.56% at the Lake and 1.65% at the Culvert (Figure 14). Lipid content of fish sampled at the Lake site changed little between 2008 and 2009 (Figure 15), but lipid content if fish from the Culvert site was much higher in 2009 than in 2009 (0.63% vs. 1.9%). However, these values were not significantly different, likely because of the small sample size.

The lipid content of salmon from the Mirror Lake sites was also similar to the lipid content of juvenile Chinook salmon from other Reach H sites sampled as part of the Ecosystem Monitoring Project (Figure 14). No significant differences were observed in lipid levels of fish from these sites.

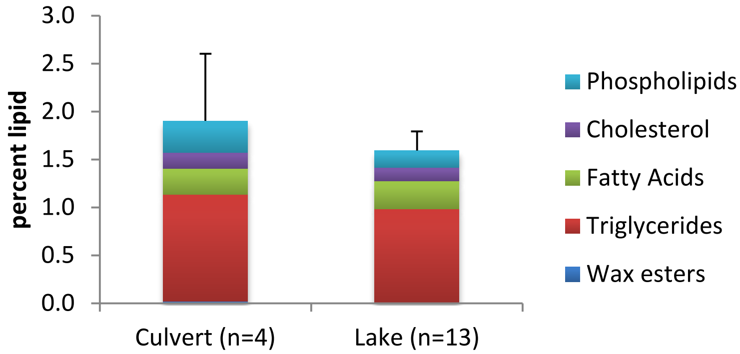


Figure 14. Lipid content and classes in juvenile Chinook salmon bodies sampled at the Mirror Lake sites in 2009.

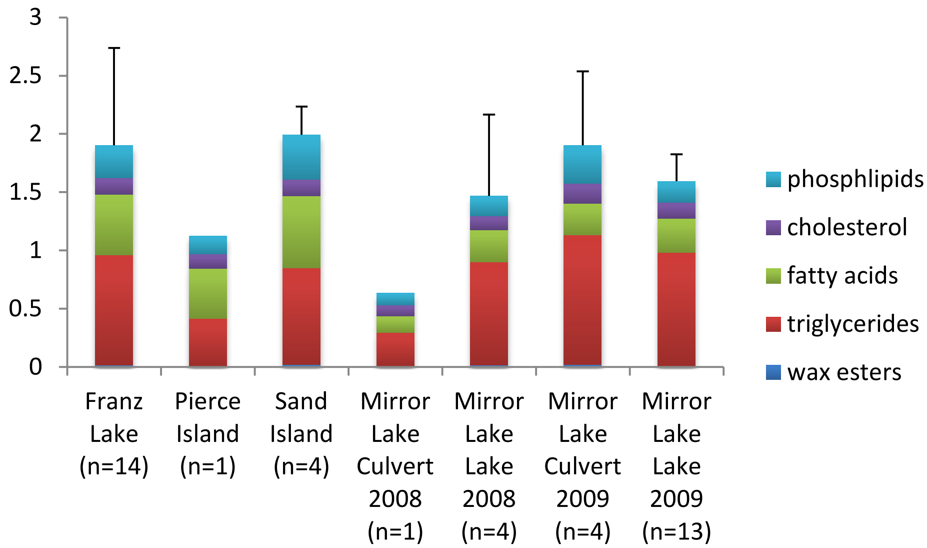


Figure 15. Lipid content and classes in juvenile Chinook salmon bodies sampled at the Mirror Lake sites in 2009 in comparison to Reach H sites samples as part of the Ecosystem Monitoring Project.

3.3.7 Growth rates of Mirror Lake Juvenile Chinook salmon as determined from otolith analysis

Growth rates were determined from otoliths collected from juvenile Chinook salmon from Mirror Lake Culvert and Lake sites between 2008 and 2010. Overall growth rates did not differ significantly between the two sites, although the mean growth rate was somewhat higher at the Lake than the Culvert (Table 11). Also, growth rates in fish from the two Mirror Lake sites did not differ significantly from growth rates determined for juvenile Chinook salmon from other sites in Reach H, sampled as part of the Ecosystem Monitoring Study (Table 11).

Table 11. Results of Bonferroni post-hoc tests showing significant p-values from the pair-wise comparisons of mean growth rates from Mirror Lake sites and other Reach H sites sample as part of the Ecosystem Monitoring Project. Results compared as those from the analysis of growth rates for the last 7 days before fish capture.

	Mirror Lake Culvert	Mirror Lake Lake	Sand Island	Franz Lake	Beacon Slough	Pierce Island
Mean growth rate	**0.55**	**0.59**	**0.56**	**0.61**	**0.48**	**0.51**
Mirror Lake Culvert						
Mirror Lake Lake						
Sand Island						
Franz Lake						
Beacon Slough						
Pierce Island						

There was some variation in growth rate from year to year at both the Culvert and Lake Sites (Figure 16). Fish from Mirror Lake #1 (Lake) showed significantly slower growth in 2010 compared to 2009 (but not 2008; and differences were only detected for the last 14 days and 21 days of growth). Fish from Mirror Lake #4 had significantly slower growth in 2008 relative to 2009 and 2010 (for the last 7 and 14 days, but the last 21 days showed significant differences between 2008 and 2009).

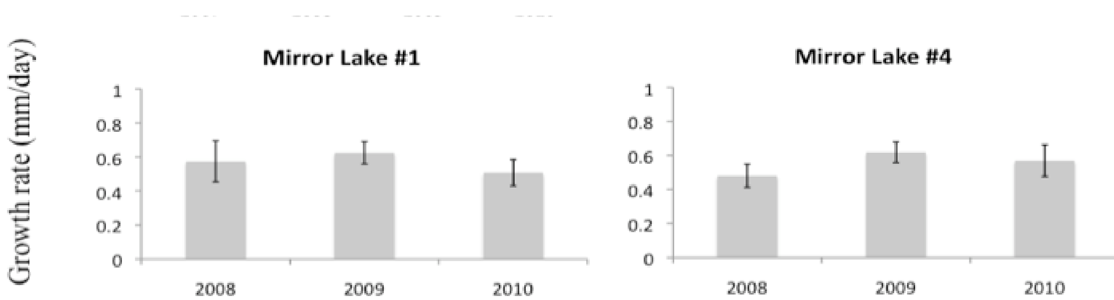


Figure 16. Daily growth rate as estimated from otolith examination at Mirror Lake Culvert (Mirror Lake #4) and Lake sites (Mirror Lake #1) from 2008 through 2010.

3.3.8 Contaminant concentrations in Mirror Lake juvenile Chinook salmon

In 2010 we collected 66 Chinook salmon body samples (five from the Lake and 61 from the Culvert) for chemical analyses. These samples will be analyzed when genetics data are available, as this information is needed to form sample composites. Due to the small volume of bile produced by juvenile Chinook salmon, it was not possible to collect sufficient bile for analysis in 2010.

Analyses have been completed for samples collected in 2009, and the data are shown in Figure 17. Contaminant concentrations tended to be higher in samples from the Mirror Lake sites than in Reach H samples, especially in comparison to Franz Lake, although differences were not always statistically significant. At the culvert, concentrations were lower in the samples collected in 2009 than in the one composite sample collected in 2008, whereas at the lake site, contaminant concentrations were similar in 2008 and 2009.

3.3.9 Prey Availability

In 2010, prey availability surveys were conducted at the Mirror Lake sites by sampling with Neuston tows in open water and emergent vegetation. Sixty-two invertebrate prey samples were collected from Mirror Lake complex in 2010 (Table 12). These samples are now being analyzed and results will be presented in a subsequent report.

Table 12. Summary table showing number of prey samples collected in 2010 at each site for each month of sampling.

Sites	April	May	June	July	August	Total
Culvert	4	6	4	4	4	22
Lake	6	6	4	6	6	28
Young Creek	3	3	0	3	3	12
Total	9	14	8	10	9	62

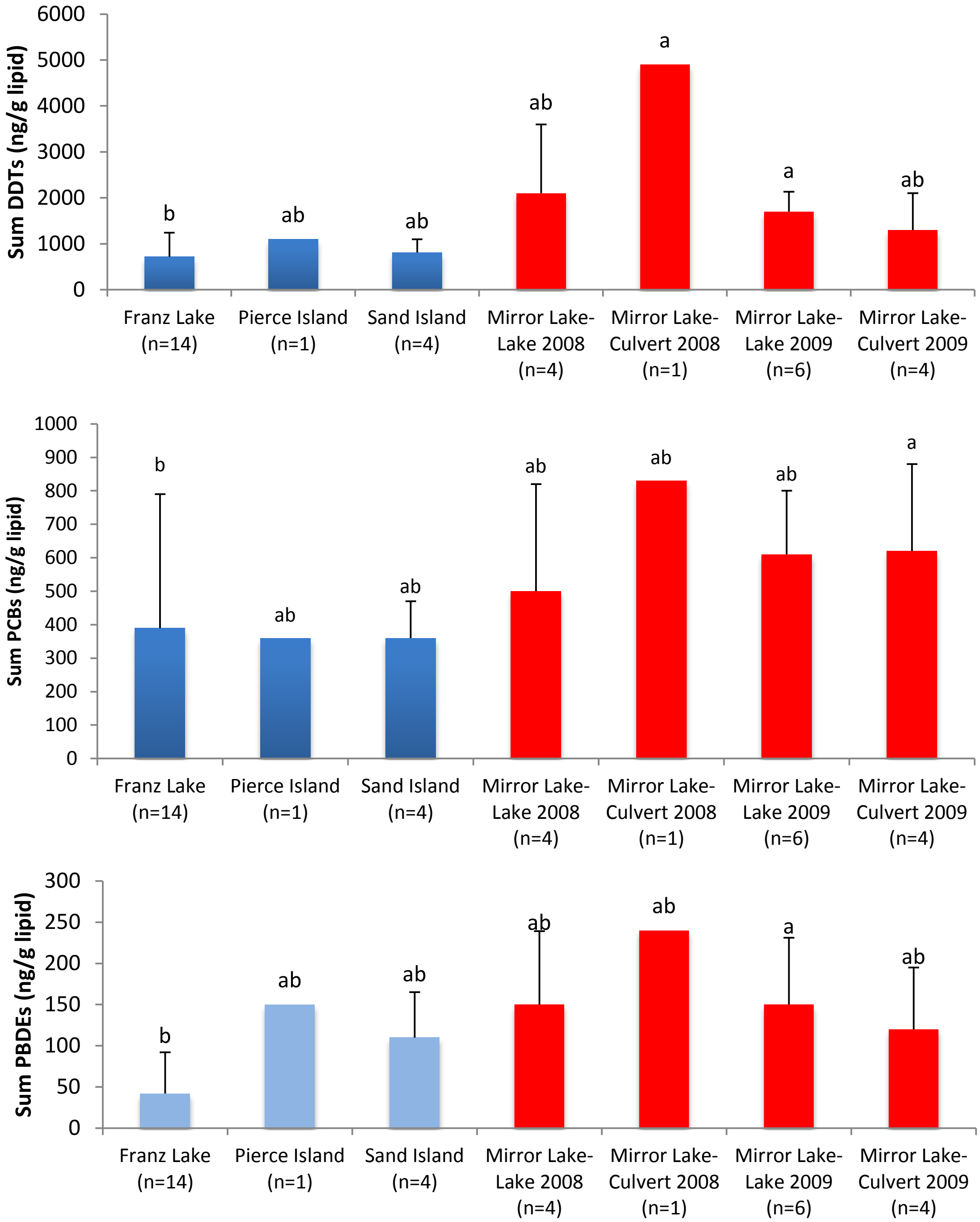


Figure 17. Concentrations of DDTs, PCBs, and PBDEs (ng/g lipid) in juvenile Chinook salmon from Mirror Lake in comparison to Ecosystem Monitoring Reach H sites.

3.4 Discussion

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 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. Because restoration activities are beginning at additional locations in the Mirror Lake Complex, two new sites were added in 2010 to collect baseline data for this work: the Confluence site, at the confluence of Latourell Creek and Young Creek; and the Latourell Creek site, 100 meters downstream of Latourell Lake. In late August of 2010, after fish sampling had been completed, large woody debris was added to Latourell Creek.

This report summarizes our monitoring results for 2008 and 2009, and compares them with the new data we have collected in 2010. Genetic stock composition, prey availability and salmon diets, salmon lipid content, growth rates, and chemical contaminant concentrations are not discussed because the 2010 data are not yet available.

3.4.1 Summary of 2008 and 2009 Findings

Our sampling in 2008 and 2009 has revealed clear distinctions among our sampling sites. Two sites, the Lake and the Culvert, are of a habitat type comparable to the emergent marsh habitats sampled as part of the Ecosystem Monitoring Project (e.g. Jones et al. 2008), although with higher levels of disturbance or alteration. Fish communities at the Lake and Culvert had relatively high species richness and diversity, with 13-17 species present. Stickleback were the generally the dominant non-salmonid species in catches, but other species, including carp, chiselmouth, killifish, and pumpkinseed were also common, with an approximately 50:50 ratio of native to non-native species. These sites supported both Chinook and coho salmon, and occasionally steelhead, cutthroat, or rainbow trout. Chum salmon were also present at the Culvert. However, the proportion of salmonids in catches at these sites was typically low in comparison to non-salmonid species, and catch per unit effort for salmonids was relatively low (< 5 -20 fish per 1000 m^2). Chum salmon were found at these sites only early in the sampling season (e.g., in April), but other species were typically present through June. Water temperatures at both sites were quite high in the summer months (up to 25-30^{o}C), likely creating an unfavorable habitat for juvenile salmon. Salmon health indicators (e.g., lipid content, condition factor, and growth rates) were comparable to values found at the Ecosystem Monitoring sites in Reach H in salmon from the Lake. However, condition factor tended to be low in both Chinook and coho salmon from the Culvert. The lipid content of Chinook salmon sampled from the Lake site was about the same in 2008 and 2009 (1.5% vs. 1.6%), but at the Culvert site, the lipid content of Chinook sampled in 2009 was much higher than in 2008 (0.63% vs. 1.9%). The reason for the increase in lipid content in not clear, but could be related to the fact that of the four samples analyzed in 2009 were from fish of hatchery origin while the 2008 sample included only wild fish. Our data on lipid content of wild and hatchery Chinook salmon in Reach H from the Ecosystem Monitoring Project suggests that lipid content tends to be higher in fish of hatchery origin (Johnson et al. 2010). The genetics data on Chinook salmon from these sites suggested that they were supporting Lower Columbia wild and hatchery fish from populations in the Columbia Gorge area, as well as Chinook migrating through the area from the Snake and Upper Columbia Rivers. These fish appeared to be entering the sites from the mainstem of the Columbia, as no juvenile Chinook were observed at upstream sites in Young Creek.

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 and 2009 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 in 2008 and 11-20^{o}C in 2009. 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 in 2008 and 68% of the catch in 2009 and stickleback made up most of the rest of the catch in both years, along with a few other native non-salmonid species. Typically the total number of species captured at this site was only 5-6. Coho salmon were present at Young Creek from April through the end of the sampling period in September, and were found in large numbers with CPUE values of 1000-1700 fish per 1000 m^2. Condition of the coho salmon from the Young Creek site seemed good, with average K values consistently above 1.0 and similar to or higher than the values observed for coho from the Reach H Ecosystem Monitoring sites.

3.4.2 Fish Monitoring Findings for 2010

Culvert and Lake. In general, fish community characteristics, and patterns of occurrence of salmon species at the Lake and the Culvert in 2010 were consistent with our observations in previous sampling in 2008 and 2009. The numbers and type of species present were almost the same (15 total species at the Lake and Culvert, as compared to 13-17 species in other years). As in 2009, stickleback dominated the catches at the Lake site while a wider range of species was present at the Culvert. The proportions of salmonids in the total catches at the Lake and Culvert sites were also similar to previous years (3% in 2010 vs. 3-4% in 2008 and 2009 for the Lake site, and 21% in 2010 vs. 20-29% in 2008 and 2009 at the Culvert site).

There were some differences between 2010 and previous years. The time period when salmon were present at the Culvert site was longer in 2010 (April through August vs. April through June). At both sites, the dominant salmonid species varied from year to year. At the Culvert, Chinook were the dominant salmon species in 2010 and 2009, but coho were more abundant in 2008. At the Lake site, in contrast, Chinook were the most abundant salmon species in 2008 and 2009, but coho were dominant for the first time in 2010.

From 2008 to 2010, CPUE at the Lake and Culvert varied but showed no clear trends. CPUE for Chinook salmon at Lake and Culvert for 2010 (1- 53 fish per 1000 m^2) was lower than 2009 (45 - 145 fish per 1000 m^2) but higher than in 2008 (2 - 9 fish per 1000 m^2). In contrast, for coho salmon, CPUE for 2010 at the Lake and Culvert ranged from 10 – 24 fish per 1000 m^2, higher than in 2009 (2-15 per 1000 m^2) but lower than in 2008 (3-89 fish per 1000 m^2). For chum, the CPUE value observed for 2010 was 3.3 fish per 1000 m^2, slightly lower than the value for 2009 (5.0 fish per 1000 m^2).

The relatively low condition factor observed in Chinook and coho salmon from the Culvert, observed in 2008 and 2009, was also seen in 2010. In 2010, as in previous years, K was significantly lower in juvenile coho from the Culvert than in coho from the Lake. However, for Chinook salmon the difference was not significant in 2010, perhaps in part because of the small number of Chinook collected at the Lake in 2010. The condition of Chinook salmon also varied from year to year, but showed no clear trends at either the

Lake or Culvert. Values of K in 2010 (0.99-1.10) were higher than 2009 (0.75- 1.02), but not as high as those observed in our first year of sampling in 2008 (1.06-1.24). The K values for coho salmon sampled in 2010 (1.07-1.22) were similar those from 2008 (0.98-1.24) and 2009 (0.90-1.20).

Like several other indicators, mean daily growth rates, as determined from otoliths, showed no clear increasing or decreasing trends at the Mirror Lake sites. Growth rates were significantly lower in fish from the Lake site in 2010 than in 2009, whereas at the Culvert site, growth rates were higher in 2009 and 2010 than in 2008. The low growth rate in 2008 at the Culvert site is consistent with the low lipid level in the sample analyzed at the same time.

A number of factors could contribute to variation in lipid levels and growth rates in fish from the Mirror Lake sites, including the proportions of hatchery fish and fish from different genetic stocks in the samples, as well as variations in water temperature and other environmental conditions. So far we have not observed consistent changes in any of these parameters that would suggest improvements in fish function (Simenstad and Cordell 2000) attributable to restoration actions, but on the other hand, values are generally within what would be considered the normal range and comparable to those observed at relatively undisturbed sites in Reach H sampled as part of the Ecosystem Monitoring project.

Contaminant concentrations in Chinook salmon from Mirror Lake were generally comparable to those found in Chinook from the other Reach H sites, and would be within the typical range for relatively undisturbed sites. An exception was one composite samples from the culvert site collected in 2008, in which DDT concentrations were fairly high (4900 ng/g lipid).

Based on the consistently high summer water temperatures observed at the Lake and the Culvert in 2008 and 2009, we hypothesized that temperature may have been a limiting factor for salmon at the Lake and Culvert sites. In 2008 and 2009, water temperatures increased substantially from May to August, reaching a maximum of 30°C and remaining above 20°C in September. In 2010, water temperatures were more moderate; the maximum temperature was 24°C, and temperatures remained below 20°C through July. Salmon appeared to respond to these more moderate temperatures, as they were present at one of the other of these sites for a longer period, from April through August for Chinook, and from April through July for coho salmon.

Young Creek. At Young Creek, fish community and salmon occurrence patterns in 2010 generally confirmed our findings in 2008 and 2009. Water temperatures at this site were substantially cooler in 2010 than 2009 or 2008, from 8.5°C to a maximum of 13°C in August. Again, catches were dominated by juvenile coho salmon (88% of the total catch in 2010), and the fish community was characterized by low species richness and low species diversity. As in 2008 and 2009, stickleback was the primary non-salmonid species, accounting for 12% of the total catch. Also, as in previous years, neither Chinook nor chum salmon were found at the site, although a small number of steelhead/trout were collected.

As in 2008 and 2009, juvenile coho were present at Young Creek throughout the sampling season, suggesting that this site provides favorable habitat, with low temperatures even during the summer months. Based on catch per unit effort data, estimating coho density at 940 per 1000 m^2, coho salmon were more abundant at Young Creek in 2010 than in the 2009, when coho density was approximately 270 per 1000 m^2. However, the 2010 CPUE was not as high as that reported for 2008 (1700 fish per 1000 m^2; Sol et al. 2009). Previously we hypothesized that placement of large woody debris at the Young Creek site prior to the 2009 sampling might have reduced efficiency of fishing with the modified block net at the site, leading to low CPUE in 2009. However, since site conditions and fishing methods were the same in 2010 as in 2009, the increased density of coho in 2010 suggests that factors other than sampling efficiency are contributing to the variation in coho CPUE. Perhaps the fish were affected by the unusually warm temperatures in 2009, which influenced water temperature even at the Young Creek site. Also, return rates for adult coho salmon at Bonneville Dam were substantially higher in 2009 than in 2008 (data from the Columbia River Fish Passage Center, www.fpc.org), suggesting that a higher number of spawners in the areas may have contributed to a higher density of juveniles in 2010.

Coho condition factor at Young Creek was higher in 2009 and 2010 than in 2008, with mean values of 1.20 and 1.16 in 2009 and 2010 as compared to 1.09 in 2008, but whether this reflects improvements in habitat conditions associated with restoration activities is unclear.

Confluence and Latourell Creek. The two new sampling sites, the Confluence and Latourell Creek, were very similar to Young Creek in physical habitat characteristics and in water temperature, based on the limited data collected in 2010. Species richness (i.e., the number of species present) at the two new sites was also similar to Young Creek, with five species at the Confluence and four species at Latourell Creek. However, species diversity and fish community composition were intermediate between the Lake site and Young Creek. At the Confluence site, stickleback dominated the catch, as at the Lake site, but fewer other species were encountered and coho salmon were present in higher proportions. At Latourell Creek, the proportion of coho salmon was still higher (52%), with stickleback making up 47% of the catch.

Patterns of salmon occurrence at the Confluence and Latourell Creek were very similar to those observed at Young Creek. Coho were the dominant salmonid species; a small number of steelhead and/or rainbow trout were also captured at the Latourell Creek site. Neither of the sites were being utilized by Chinook or chum salmon at the times they were sampled; however, neither of these sites was sampled for the entire sampling season Coho CPUE for these sites (374 fish per 1000 m^2 at the Confluence and 434 fish per 1000 m^2 at Latourtell Creek) was lower than the CPUE observed for Young Creek (938 per 1000 m^2), but significantly higher than at the Culvert or Lake (10-24 per 1000 m^2). Coho condition factor values at these two sites (1.13 ± 0.10 at the Confluence and 1.22 ± 0.11 at Latourell Creek) were similar to those in coho from Young Creek.

3.5 Summary and Conclusions

In summary, our results for 2010 confirm our earlier observations that the Young Creek site appears to be an important rearing area for juvenile coho salmon. Coho salmon were also present in large numbers at the two new sampling sites, Latourell Creek and the Confluence of Latourell and Young Creeks. However, with the exception of a small number of steelhead, cutthroat, and rainbow trout, these sites did not support any other salmon species. In 2010, as in previous years, coho salmon were also found at the Lake and Culvert sites, but generally in low numbers. However, Chinook salmon were present at both the Lake and Culvert sites, with the greatest number at the Culvert where they were found from April through August. The Chinook salmon appeared to be entering the site from the main stem Columbia River and did not migrate up to Young and Latourell Creeks. As in past years, species diversity and richness were higher at the Lake and Culvert sites closest to the mainstem Columbia River, and non-native species were more predominant at these sites. Species diversity and richness at the two new sites were similar to patterns seen at Young Creek, except that they tended to have higher proportions of stickleback and lower proportions of coho salmon in catches than the Young Creek site.

Between 2008 and 2010, there was some variability in fish community composition and salmon catch, although the general patterns of occurrence at the sampling sites were similar. As yet we have seen no clear trends in salmon catch per unit effort, condition factor, lipid content, or growth rate that can be attributed to the habitat improvements made during the past years. However, the data collected so far suggest that the health and condition of the salmon using the sites is favorable, and the Mirror Lake complex is a valuable rearing area, especially for coho salmon.

4.0 Planting Success AEM at Mirror Lake and Sandy River Delta

For the third consecutive year, Ash Creek Forest Management LLC (ACFM) staff sampled vegetation monitoring plots across 259 acres at five restoration projects at the Sandy River Delta and at Rooster Rock State Park (Mirror Lake) in Multnomah County, Oregon (Table 13). A total of 185 plots were sampled using the rapid monitoring protocol in *Protocols for Monitoring Habitat Projects in the Lower Columbia River and Estuary*, Roegner, et al. 2009.

Since 2002, several projects at the Delta and Mirror Lake have re-established native plants and managed 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.

Data analysis yielded estimates of current stocking levels of natural and planted native plants, weed competition, and native plant suppression and vigor. Additionally, field observations provided essential information for adaptive management of these dynamic systems.

Figure 18. Planting rows at 155-acre Sundial Island North restoration site, 2010.

4.1 Survey Sites

In August 2010 Ash Creek Forest Management staff returned to five restoration project sites that were first monitored in 2008. Trained staff surveyed five sites totaling 259 acres: Estuary Partnership's 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 US Army Corps of Engineers' 155-acre "Sundial Island North"- located at the Sandy River Delta - and the 29-acre "Mirror Lake" site at Rooster Rock State Park.

Table 13. Restoration sites at Sandy River Delta and Mirror Lake

Site Name	Number of Acres
Sundial Island North	155
Southwest Quad	40
South Bank/North Slough	20
North Bank Sandy Channel	15
Mirror Lake	29

Table 14. Woody species installed at Sandy River Delta and Mirror Lake

TREES	
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
Prunus emarginata	Bitter cherry
*Pseudotsuga menziesii**	Douglas-fir
Quercus garryana	Oregon oak
Rhamnus purshiana	Cascara
Thuja plicata	Western redcedar

*Planted at Mirror Lake only

SHRUBS	
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 generally followed Roegner et al, *Protocols for Monitoring Habitat Projects in the Lower Columbia River and Estuary*. First-year monitoring initiated on all sites in 2008 followed the comprehensive monitoring protocol described in Roegner et al, 2008. Permanent 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 habitat. 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 the cardinal directions that to capture visual change over time. In 2009 and 2010, according to the Roegner, 2009 rapid monitoring protocol, permanent plots were re-located, marked and sampled. All other plots along each transect were installed systematically at intervals pre-determined for each survey unit based on unit size.

At each plot, the surveyor recorded woody vegetation by species and noted whether live or dead, natural or planted; plant vigor, average height and suppression by weedy vegetation were recorded. Herbaceous species were listed. Where a plot center landed on or near a boundary, the plot was transformed into a 5.66 radius semicircle (noted in data). Where the middle of the woody plant (stem or stem cluster) was not within the plot radius, 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 permanent photo point locations.

For all sites, the number of plants installed per hectare was calculated by dividing the total number of plants installed by number of hectares planted. Stocking and percent survival were calculated as: total number of live, installed plants (T) divided by number of plots sampled (n) to yield average of live, installed plants per plot (Tp); total per plot was 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 was 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 = % survival

Natural regeneration is a critical process in the restoration of self-sustaining, fully-stocked natural stands. For all sites except North Bank Sandy Channel, we estimated natural regeneration by calculating the average number of naturals per plot multiplied by the reciprocal of plot area. On the North Bank Sandy Channel, where natural plants are no longer distinguishable from installed plants, we calculated natural regeneration as the difference between current total stocking and the number of surviving installed plants in 2008.

4.3 Results

At all planted restoration sites, we found a range of 2,400 to 3,200 live, woody plantings per hectare, corresponding to survival rates of 74% to 119%. Trees comprised 30% to 78% of live, woody plantings (Table 15). When naturally occurring (non-planted) trees and shrubs were included, the total of live, woody native plants on all restoration sites ranged from 2,500 to 4,300 per hectare. In Table 15 below, 2008, 2009 and 2010 figures are presented for comparison.

Table 15. Plant survival and stocking by site

Site		**Sundial Island North**	**Southwest Quad**	**South Bank/North Slough**	**North Bank Sandy Channel**	**Mirror Lake**
Original number of plants installed per hectare		2010	3840	2150	4610	3444
Plots per site						
	2008	50	30	20	50	38
	2009	50	37	22	50	33
	2010	49	30	20	50	36
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

2010	2,400	3,246	2,450	N/A*	2,538
Percent Stocking relative to initial planting density					
2008	61%	84%	72%	56%	90%
2009	75%	68%	97%	N/A*	98%
2010	119%	86%	114%	N/A*	74%
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
2010	2,514	3,453	2,630	4,312	2,591
Natural Recruitment					
2008	556	127	120	272	0
2009	887	168	110	1205	34
2010	114	207	180	1724	53
Proportion trees of total woody plants					
2008	75%	37%	75%	64%	51%
2009	60%	33%	88%	33%	40%
2010	78%	30%	71%	51%	49%

*Planted and natural vegetation no longer reliably distinguishable**.**

Table 16, below, shows vigor of native plants averaged across all sites and the potential impact of competing vegetation on vigor of installed plants. 'Low vigor' describes a plant that is severely suppressed or damaged; 'Medium vigor' indicates normal stress expected in recent plantings (discoloration of leaves, herbivory, etc); and '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/or overtopped by competing weedy vegetation. While 'suppressed' plants may eventually grow through competing weeds, and weed cover may provide some protection from browse, weeds still significantly affect growth and survival.

Table 16. Plant vigor and suppression

VIGOR	**LOW**	**MEDIUM**	**HIGH**
total live, installed trees and shrubs on surveyed plots	45	2,375	272
2008 ratio per rating	6%	87%	7%
2009 ratio per rating	2%	87%	11%
2010 ratio per rating	2%	88%	10%
SUPPRESSED	**Yes**	**No**	
total live, installed trees and shrubs on surveyed plots	709	1983	
2008 ratio per rating	25%	75%	
2009 ratio per rating	19%	81%	
2010 ratio per rating	26%	74%	

The most dominant weed species found 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 and Himalayan blackberry were shown to have greatest impact on plant survival, vigor and suppression. 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.

4.4 Discussion

Overall density of native woody plants (stocking) increased at all sites, except Mirror Lake. Plant vigor also appeared to improve from 2008, but suppression from weeds increased from 2009 levels. Ratio of trees to total woody plants trended downward, possibly indicating succession of restoration sites toward target, reference site conditions.

Natural regeneration increased at all sites over 2008 and 2009 numbers, except at Sundial Island North. Because natural regeneration is a critical process in the restoration of self-sustaining, fully stocked natural stands, percent natural (non-planted) plants were analyzed as an indicator of restoration success. Natural regeneration was measured as difference in number of live, planted woody plants and total live woody plants.

Sundial Island North (155 acres)

At the largest restoration site among those monitored, stocking increased to 119% of initial, 2007 restoration planting density. Total live, installed plants per ha doubled from years 2008 to 2010 – from 1200 to 2400 plants. Total natural and planted live woody plants per hectare increased – from 1,780 to 2,500 – with natural regeneration contributing approx 100 stems. The high level of stocking is likely related to interplanting in February 2010, when 12,200 trees and shrubs were installed. High tree count relative to total woody plants (78%), however, suggested that plantings are still dominant, and natural regeneration of native shrubs is occurring at a slower rate than on more mature restoration sites.

Natural regeneration figures at the Sundial Island North site, however, do not appear to reflect a clear trend, showing a high and increasing level of natural stocking between 2008 and 2009, falling to a much lower level in 2010. Two factors may have contributed to the observed figures: First, random sampling in 2008 and 2009 included small numbers of plots with extremely high numbers of natural plants, as can happen in remnant patches of native hardwoods and scrub. These plots may have skewed the data relative to 2010, when randomly selected plots did not land in areas of heavy natural stocking. Second, the site was mowed immediately prior to data collection, which may have removed evidence of some amount of natural regeneration. When 2008 and 2009 data are recalculated without the outlying natural stocking plots, the natural recruitment trend appears relatively flat, which is the expected trend at this point in stand development.

Southwest Quad (40 acres)
Originally restored in 2005 and interplanted before monitoring in 2008, the Southwest Quad showed high stocking rate relative to original planting (86%). The prevalence of shrubs, which comprise 70% of overall stocking at this site, reflected original project design, where shrubs were installed to accommodate BPA powerline corridors on the site. A modest increase in natural regeneration (>200 stems per ha), reflected decreases in weedy competition as the canopy closes on site and as plantings reproduce through natural seeding and vegetative growth.

South Bank/North Slough (20 acres)
Like Sundial Island North, the South Bank/North Slough showed a greater than 100% woody plant stocking (114%) as compared to original restoration planting density. Increases were attributable to interplanting in February 2010, where approx 400 plants per hectare were installed to improve plant densities in understocked portions of the site. High percent tree cover reflected both site conditions and plantings installed during restoration in 2005, as well as slower progress toward reference site conditions. Increase in natural plant occurrence (to 180 stems per ha), however, indicated that natural regeneration is occurring on site, attributable to decreases in weedy competition as canopy closes on site and as plantings reproduce through natural seeding and vegetative growth.

North Bank Sandy Channel (15 acres)
Originally installed in 2006, the North Bank Sandy Channel restoration project showed succession toward target, self-sustaining conditions in 2009, as indicated by a doubling of original planting densities through natural regeneration. This marked increase in naturals was attributable to continued decline in weedy competition and increased volumes of native seed production. Development of multi-stem clones and rhizomatous spread of native trees and shrubs also increased native plant density and made indistinguishable natural and planted species in places. High shrub to tree ratio (51%) indicated trends toward recovery of healthy riparian conditions and succession of site toward reference site targets.

Mirror Lake (29 acres)
The lowest stocking rates compared to original planting density (74%) and natural regeneration (less than 50 stems/ha) were found at the Mirror Lake site, originally restored in 2008. Animal damage – browse and antler rubs by the large, resident elk herd – appeared to be the most important factor contributing to increasing mortality. Vigor measurements reflected this stress, with elevated low-vigor ratings (13%) compared to average for all sites (2%). While suppression occurred on 18% of woody plants sampled, impact from weeds was lower at Mirror Lake than the average for all sites (26%). Natural recruitment remained a small component of overall woody plant stocking, possibly due to delayed canopy closure associated with animal damage.

4.5 Recommendations

Continued maintenance at all sites is needed to achieve the goal of restoring naturally reproductive Columbia River floodplain forest and scrub. Additional vegetation management treatments are indicated for all of the sites, shown in Table 17, below.

Table 17. Recommended 2010 maintenance treatments for Sandy River Delta and Mirror Lake

Site	**Treatment Date**	**Sundial Island N**	**SW Quad**	**S Bank N Slough**	**N Bank Sandy Channel**	**Mirror Lake**
Interplanting	2/1/2011		**X**			**X**
RCG and blackberry spot spray	5/1/2011		**X**			**X**
Mow	8/1/2011	**X**				**X**
Blackberry spot spray	9/1/2011	**X**	**X**	**X**	**X**	**X**

4.6 Conclusions

2010 monitoring indicates that site preparation, planting, and maintenance treatments are resulting in establishment of significant areas of functional 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 and frequency of treatments are declining. The advent on maturing sites of natural native plant establishment is highly encouraging for the long-term, sustainable restoration of these sites.

5.0 Salmon, Salmon Prey, and Habitat AEM at Scappoose Bottomlands and Fort Clatsop

5.1 Sample Site Descriptions

Hogan's Ranch Conservation and Enhancement

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 (Figure 19). 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.

Despite the ecological benefits these tidally influenced bottomlands have to offer, human impacts to the ecosystem might hinder salmonid survival. Water control structures, previously installed by Ducks Unlimited (DU), artificially regulate flow to the lower ponds on the property (Figure 1). Though water fowl had a prolonged presence, the structures introduced 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 understory and trampled the riparian zones, and their fecal run-off degrades water quality.

In 2007, the Lower Columbia River Estuary Partnership (LCREP) collaborated with Scappoose Bay Watershed Council (SBWC) to improve environmental conditions at Hogan's Ranch. No suitable reference site has been selected in the vicinity, leaving little guidance for rehabilitation implementation. Still, habitat was conserved on 173 ac 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. Water quality improvement was a goal to enhance wildlife habitat for salmon, steelhead, beaver, river otter, waterfowl, bald eagles and many others.

From 2008 through 2010, the Columbia River Estuary Study Taskforce (CREST) was contracted to monitor the fish community including prey availability and utilization, primarily to establish the presence or absence of salmonids. Water levels vary widely, subject to seasonal extremes, dam spill and to some degree the tide. Initial fish community monitoring was experimental as we adjusted our efforts to suit the set of conditions.

Figure 19. 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 (Teal Slough) through 6.

Ft. Clatsop South Slough

For the first half of the twentieth century, dairy farming drove deforestation, flood plain 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 Ft. Clatsop South Slough when they replaced a failing tide-gate with a bridge (Figure 20). 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.

Since 2008, ecological benefits have been quantified by monitoring biological, chemical and physical responses to restoration, like fish community structure, water quality and channel morphology at Ft. Clatsop South Slough. This annual report summarizes the 2010 monitor metric results from inside the new bridge at Ft Clatsop South Slough and discusses them as compared to those recorded inside the failing tide gate before restoration.

Ft. Clatsop Reference Slough

The 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 (Figure 20). Side channels yield space, surrounding spruce trees provide shade, and 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, we began to collect water quality data as well. These data will be directly compared to results from the restoration site.

Figure 20. South Slough tidegate removal/bridge installation site, located on the Lewis and Clark River mainstem, including the nearby reference slough (Alder Creek) and current dike breach site, Otter Point.

5.2 Monitoring Methods

In 2010, CREST monitored habitat, salmon and salmon prey for the Estuary Partnership, at Ft Clatsop South Slough, in conjunction with the Effectiveness Monitoring Program. All sample gear and fishing techniques were consistent with the methods described in “Monitoring Protocols for Salmon Habitat Restoration Projects in Lower Columbia River and Estuary” (Roegner et al., 2009).

5.2.1 Sample Sites

Hogan’s Ranch Teal Slough

In 2009 and 2010, Teal Slough (Figure 19, site 1) was the only trap net site at Hogan’s Ranch. Seining in 2008 and 2009 occurred at sites 3 and 4, in an effort to explore potential salmon stranding after high-flow sheeting events. Such efforts to determine salmonid presence or absence associated with sheeting events that could strand salmon in ranch ponds were thwarted by vegetation that entangled fishing seines and boat motors. Given the inaccessibility of our gear to the pond sample sites, SBWC decided to cease monitoring services at Hogan’s Ranch, in 2010.

Ft. Clatsop South Slough

From 2007 through 2010, a trap-net was employed at Ft Clatsop South Slough. Where before wing nets were used to funnel fish into a sanctuary bag, in 2010, ¼ in mesh net stretched over 3-ft-wide by 10-ft-deep pvc frames that corralled fish into a 20-ft-long, $^{3}/_{16}$ in mesh sock net and finally, a 2 ft by 3 ft by 1 ft live box. The sock and live box are designed to continually disperse water flow minimizing stress to fish while they wait to be processed. Typically trap-nets are checked every 45 min, however, the live-box was designed to handle up to 400 fish in order to be left unattended for longer periods of time. Sampling from high tide to low tide we capture upriver salmon stocks, marine and freshwater fishes as well as resident juvenile salmon that use the off-channel habitat during the flood tide and return to the mainstem Lewis and Clark River on the ebb.

Ft. Clatsop Reference Slough

Extremely low water velocity on the reference slough inhibited initial attempts to trap-net at Ft Clatsop Reference Slough in 2007. Without a swift current, the sanctuary bag collapsed 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 crew members walked to set the net. In 2009, the aforementioned live-box was successfully employed whereby 10 ft deep by 50 ft long ¼ in mesh net wings corralled the fish into the sock net and live-box. Given the low flow and narrow channel at the reference site, panels were not necessary to minimize the bag that forms with high flow on 50-ft-long wing nets at the restoration site.

5.2.2 Sample Period

Hogan’s Ranch Teal Slough

In 2010, Hogan’s Ranch water levels varied according to the season, tides and the hydropower system. . The sample season began in February coincident with the start date on our scientific collection permits and the spring salmon migration period. When the water level was too high in early spring for sampling in March and April, monthly events continued between May and July. Summer water levels were too low to sample. The fall event for November has been cancelled as Hogan's Ranch will no longer be one of four effectiveness monitoring restoration properties for LCREP (Janelle St. Pierre, Scappoose Bay Watershed Council, pers. comm., September, 2010). Property damage independent of CREST fish monitoring activities also prompted the decision to discontinue restoration monitoring there (StPierre, SBWC, Pers. Comm., 2010).

Ft Clatsop South Slough

Monthly sampling events occurred between February and July at the South Slough restoration site, coincident with the aforementioned sampling permits and spring migration period. Extra sampling event in March and April at Ft. Clatsop South Slough would allow for wing net alterations meant to reduce stress on the net during high flows and facilitate their deployment.

Ft Clatsop Reference Slough

Monthly sampling events occurred between February and July at the reference site as well. Extra sampling event in March and April coincided with the restoration net design development.

5.2.3 Sample Processing

Aerated black buckets of clean water kept the catch cool and comfortable while handling fish one dip-net full at a time. After separation for priority processing, we anesthetized the salmon individually with a buffered tricaine methanesulfonate (MS222) solution. We identified all fish to species, measured and counted them, and weighed the salmon. Salmon caudel fin clips were obtained and preserved for future genetic analysis of stock source information, pending funding. Salmon were allowed to fully recover from anesthesia in aerated buckets of clean cool water before being released.

5.2.4 Prey Availability

Insect fall-out traps made of 30 qt rectangular plastic tubs and filled with an inch of soapy water, captured bugs that land by disrupting flight ability. Five trap sites were selected near each trap site concurrent with fishing events. We collected the samples after 48 hours of exposure in the marsh and preserved for later lab analysis in house. Results will qualify and to some degree quantify prey taxa, demonstrating what the marsh offers salmon to eat. Sediment cores samples were also collected and analyzed in accordance with the fall out trap sets, to determine the benthic component of prey availability to compare to the riparian/terrestrial contribution.

5.2.5 Prey Consumption

Anesthetizing the salmonids that measured more than 60 mm also provided us with an opportunity to sample their diet using a non-lethal gastric lavage method. The tip of a sprayer containing filtered water is inserted down the salmon's throat and minimal pressure is applied to evacuate their stomach contents into a clean sieve. After rinsing the macro-invertebrates into a jar, we preserved them with 95% ethanol for future in house analysis and comparison to prey availability. After subsequent laboratory analysis, we were able to compare the prey utilization patterns to those for prey availability over space and time.

5.2.6 Sediment Accretion

Two level stakes were placed one meter apart and the distance measured incrementally from there to the ground twice during the sample season to accumulatively reveal temporal and spatial shifts in sedimentation. Both the restoration and reference sites have been documented as such, though we anticipate minimal if any erosion or accretion associated with the historic Alder Creek reference channel, given the lack of human disturbance.

5.2.7 Channel Morphology

Ft Clatsop South Slough

Channel cross section surveys were from north to south using the differential leveling method (Engineering Field Handbook, 2006). A stadia rod measured depth in meters at 0.5 m increments along an out-stretched measuring tape between channel banks. Immobile stakes planted at the vegetation line on each stream bank served as end-points to measure bathymetry at Ft. Clatsop South Slough, in addition to the Global Position System (GPS) coordinates recorded.

GPS coordinates were recorded for channel cross sections 1, N46°7’44.6” W123°52’46.7”, N46°7’43.8” W123°52’47.6”, 2, N46°7’43.7” W123°52’43.6”, N46°7’44.0” W123°52’43.0”, 3, (N46°7’44.7” W123°52’50.2”, N46°7’43.7” W123°52’50.7”, 4, N46°7’44.3” W123°52’52.0”, N46°7’43.9” W123°52’51.0”, and 5, N46°7’43.1” W123°52’52.2”, N46°7’43.1” W123°52’52.2”, labeled downstream to upstream.

Ft Clatsop Reference Slough

Channel cross section surveys were from East to West using the differential leveling method (Engineering Field Handbook, 2006). A stadia rod measured depth in meters at 0.5 m increments along an out-stretched measuring tape between channel banks. Immobile stakes planted at the vegetation line on each stream bank served as end-points to measure bathymetry at Ft. Clatsop reference slough, in addition to the GPS coordinates.

GPS coordinates were recorded for the East side of the channel cross sections; 1, N46° 7' 53.472" W123° 52' 44.544", 2, N46° 7' 53.7594" W123° 52' 44.4354", 3, N46° 7' 54.264" 123° 52' 44.7594", 4, N46° 7' 55.0554" W123° 52' 44.6514", 5, N46° 7' 56.5674" W123° 52' 44.58", labeled downstream to upstream.

5.2.8 Landscape Change

Subtle changes in landscape can be measured using rudimentary time-lapse photography, where consistency is crucial. After using GPS coordinates combined with compass readings to establish the location and ensure photo-point replication ability, we recorded each site on film in the spring and again in the fall of 2010.

Ft Clatsop South Slough

Photo-point GPS locations and compass bearings at Ft Clatsop South Slough were N 46° 7’43.4” and W 123° 52’44.8” at 360°, ; N 46° 7’44.7”and W 123° 52’47.7” at 180°, and ; 46° 7’43.7” and W 123° 52’44.3” at 250°.

Ft Clatsop Reference Slough

The photo-points at Ft Clatsop Reference Slough were all taken from one GPS location and three different compass bearings; N 46° 7’53.5”, W 123° 52’44.8”, 250°, 70° and 10°.

5.2.9 Water Quality

Ft Clatsop South Slough

A multi-parameter series 9500 water quality meter manufactured by In-Situ Inc. continually measured temperature, pressure (depth), dissolved oxygen and conductivity (salinity) inside South Slough and the reference Channel in 2010. A rugged dissolved oxygen (RDO) probe was retro-fitted for the meter for increased accuracy and decreased maintenance.

The original water quality meter was deployed at N46°7’43.4” W123°52’42.9”, N46°7’43.7” W123°52’43.2” but when the unit was stolen in 2009, a new one was deployed at a different location further upstream; N45°51’53.2” W122°44’43.2.

Ft Clatsop Reference Slough

The same series of water quality meter was used with an RDO probe to continuously record temperature, pressure, dissolved oxygen and conductivity at the reference site concurrently with the restoration site data. When the housing for the apparatus cracked after initial deployment, we obtained a new unit from the manufacturer.

5.3 Results

5.3.1 Fish Community

Hogan's Ranch

Four wild subyearling Coho and 2 wild subyearling Chinook salmon were trapped on Teal Slough between May and July of 2010 (Figure 21). We did not encounter many invasive species in 2010, for example Dojo Loach and Goby, and native by catch numbers were low in Teal Slough for 2010 (Table 18). The Coho recorded in the Spring of 2010 averaged 18 mm in length while the Chinook salmon seen there in the Summer were 43 mm on the average (Table 19).

Data from May of 2009 have been recovered and are presented here. Scientific collection permits were authorized in February, but March and April sample dates were cancelled due to high water events. Monthly sampling ensued in May and continued through July. November sampling was cancelled as effectiveness monitoring will no longer take place at Teal Slough or the Hogan Ranch property (2010).

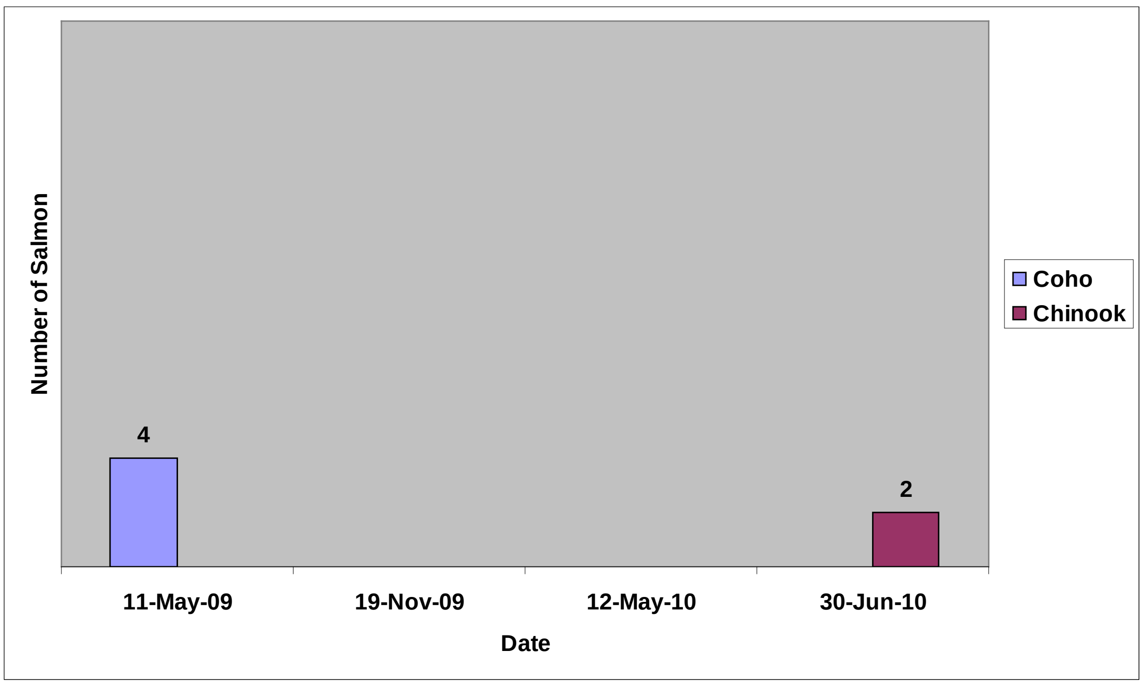


Figure 21. Total number, species composition and temporal distribution of salmonids observed at Hogan's Ranch Teal Slough, 2010.

Table 18. Total number, species composition and temporal distribution of bycatch observed at Hogan's Ranch Teal Slough, 2010.

Date	Gold-fish	Stickle-back	Banded Killifish	Sunfish	Black Crappie	Bull-head Cat-fish	Dojo Loach	Pea-mouth Chub	Large-scale Sucker	Dace	Mosquito-fish	Cottid	Goby
11-May-09	**21***	**1,061***	**49***	**0***	**17***	**0***	**0***	**2,105***	**39***	**0***	**0***	**0***	**2***
19-Nov-09	**19**	**3,457**	**79**	**3**	**126**	**0**	**0**	**207**	**27**	**5**	**3**	**0**	**0**
13-Feb-09	**	**	**	**	**	**	**	**	**	**	**	**	**
13-Mar-09	**	**	**	**	**	**	**	**	**	**	**	**	**
13-Apr-10	**	**	**	**	**	**	**	**	**	**	**	**	**
12-May-10	**0**	**2,775**	**2**	**1**	**16**	**6**	**0**	**13**	**1**	**7**	**0**	**0**	**5**
30-Jun-10	**0**	**67**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**1**	**0**
29-Jul-10	**0**	**14**	**6**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
15-Nov-10	***	***	***	***	***	***	***	***	***	***	***	***	***
2010 Total	**40**	**7,374**	**136**	**5**	**159**	**6**	**0**	**2,325**	**67**	**16**	**3**	**1**	**7**

*** 2009 data not reported**
**** 2010 event cancelled due to high water**
***** 2010 event cancelled (SBWC)**

Table 19. Salmonid mean length distribution, Teal Slough, 2010.

Date	Chinook	Coho
11-May-09	*	*
19-Nov-09	--	--
13-Feb-09	**	**
13-Mar-09	**	**
13-Apr-10	**	**
12-May-10	--	43
30-Jun-10	83	--
29-Jul-10	**	**
15-Nov-10	***	***

*** 2009 data not reported**

**** 2010 event cancelled due to high water**

***** 2010 event cancelled (SBWC)**

Ft. Clatsop South Slough

Chinook salmon and coho were sampled in 2010 while Chum, steelhead and Cutthroat trout were not observed at South Slough (Figure 22). In 2010, 47 wild salmon were observed. Coho were observed throughout the entire sample season, while Chinook salmon came in a little later in the spring and were absent from the system in July.

By catch species abundance was low in 2010 (Table 20). The Three-Spine Stickleback (*Gasterosteus aculeatus*) dominated in terms of number of individuals. Other native species observed include Peamouth Chub (*Mylocheilus caurinus*), Sculpin (*Cottus* sp.) and Banded Killifish (*Fundulus rathbuni*); Lamprey were absent from the system. Invasives included Sunfish (*Lepomis gibbosus*) and Black Crappies (*Poxmoxis nigromaculatus*).

In 2010, wild Coho were observed throughout the entire sample season, and they were all subyearling sized; no hatchery individuals were found (Table 21). All 43 of the coho were wild subyearlings, less than 120 mm in fork length. Two Chinook were yearlings, measuring more than 120 mm, without adipose fin clips, we presumed they were wild; two Chinook were wild subyearlings.

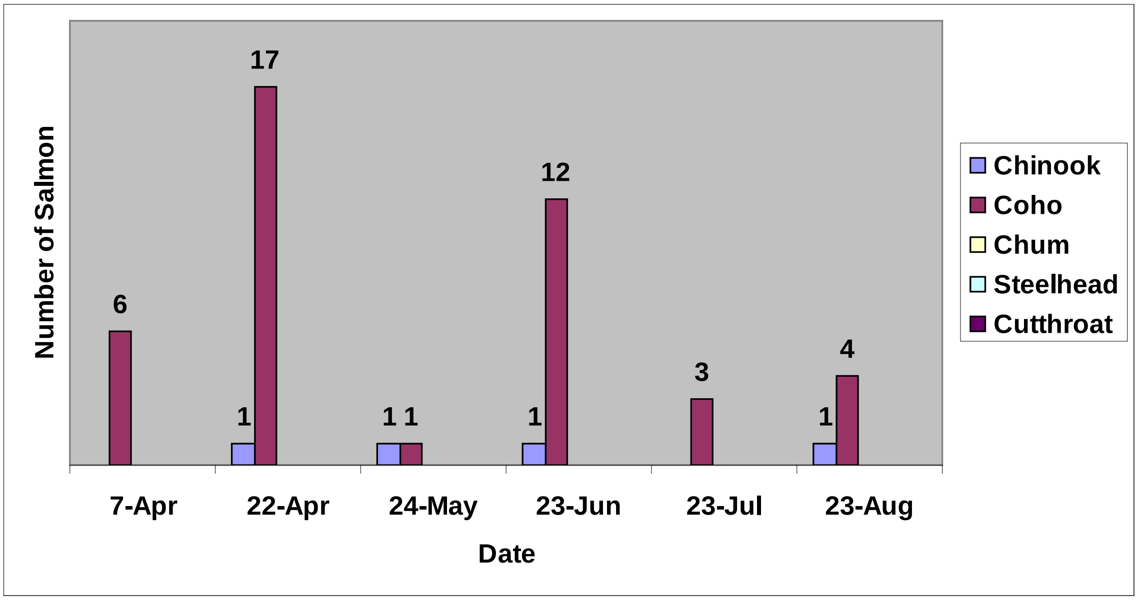


Figure 22. Total number, species composition and temporal distribution of salmonids observed at Ft. Clatsop South Slough, 2010.

Table 20. Total number, species composition and temporal distribution of bycatch observed at Ft. Clatsop South Slough, 2010.

Date	Stickle-back	Banded Killifish	Cottid	Peamouth Chub	Shiner Perch	Large-scale Sucker	Pumpkin-seed Sunfish	Smelt	Black Crappie	Lam-prey
7-Apr	264	0	2	0	0	0	0	0	0	1
22-Apr	140	0	1	1	0	0	0	0	0	0
24-May	190	0	0	0	0	0	0	0	0	0
23-Jun	1,745	7	3	1	0	0	0	0	0	0
23-Jul	908	3	0	1	0	0	0	0	0	0
23-Aug	732	5	0	5	0	0	0	0	2	0
Totals	**3,979**	**15**	**6**	**8**	**0**	**0**	**0**	**0**	**2**	**1**

Table 21**.** Salmonid mean length distribution, post-restoration, Ft. Clatsop South Slough, 2010. Lengths representing a single fish are noted with an asterisk.

Date	Chinook	Coho	Chum	Steelhead	Cutthroat
7-Apr	--	38	--	--	--
22-Apr	116*	44	--	--	--
24-May	42*	47*	--	--	--
23-Jun	104*	58	--	--	--
23-Jul	--	61	--	--	--
23-Aug	94*	81	--	--	--

Ft. Clatsop Reference Slough

Four salmon were observed at the reference site in 2010; two Coho and two Chinook salmon (Figure 23). All of the salmon sampled at the reference slough in 2010 were of wild descent. All of the Coho and Chinook adipose fin clips were intact and they were all too small to be from a hatchery release group.

By catch species were similar in composition and abundance to the restoration site (Table 22). The Three-Spine Stickleback (*Gasterosteus aculeatus*) dominated in terms of number of individuals. Other native species observed include the Peamouth Chub (*Mylocheilus caurinus*), Sculpin (*Cottus* sp.) and Banded Killifish (*Fundulus rathbuni*). Largescale suckers and Smelt were also found, along with some invasive species like Sunfish.

No yearlings were observed at the reference site in 2010 (Table 23). All four of the salmon were subyearling size; less than 120 mm. Both of the Coho were in the 40 mm range while the two Chinook were larger; 87 mm and 53 mm.

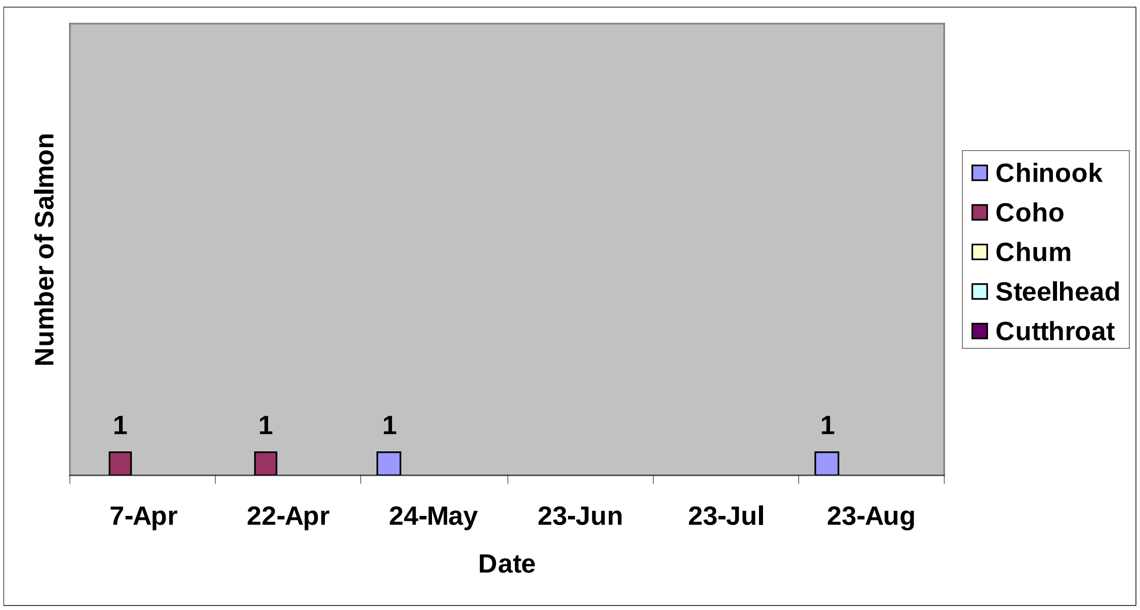


Figure 23. Total number, species composition and temporal distribution of salmonids observed at Ft. Clatsop Reference Slough, 2010.

Table 22. Total number, species composition and temporal distribution of bycatch observed at Ft. Clatsop Reference Slough, 2010.

Date	Stickle-back	Banded Killifish	Cottid	Peamouth Chub	Shiner Perch	Large-scale Sucker	Pumpin-seed Sunfish	Smelt	Black Crappie
7-Apr	35	0	0	0	0	0	0	0	0
17-Apr	45	0	0	1	0	0	0	0	0
24-May	360	4	0	4	0	0	0	1	0
23-Jun	680	17	1	5	0	0	2	0	0
23-Jul	34	0	1	41	0	3	1	0	0

23-Aug	40	0	1	33	12	0	0	0	0
Totals	**1,194**	**21**	**3**	**84**	**12**	**3**	**3**	**1**	**0**

Table 23. Salmonid mean length distribution, post-restoration, Ft. Clatsop Reference Slough, 2010. Lengths representing a single fish are noted with an asterisk.

Date	Chinook	Coho	Chum	Steelhead	Cutthroat
7-Apr	--	44*	--	--	--
22-Apr	--	41*	--	--	--
24-May	87*	--	--	--	--
23-Jun	--	--	--	--	--
23-Jul	--	--	--	--	--
23-Aug	53*	--	--	--	--

5.3.2 Prey Availability

Hogan's Ranch

We obtained fall-out trap and benthic core samples from the Teal Slough trap net site on the Hogan's Ranch property during May and July of 2010. We sampled five prey locations, numbered consecutively from downstream to upstream, 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 would typically be analyzed. However, high water conditions prevented SBWC staff from setting fall out trap bins for retrieval by CREST biologists during the June 30 fishing event; the only month when salmon sampled were large enough for the gastric-lavage procedure.

Ft. Clatsop South Slough

Between April and August of 2010, we collected prey from five fall-out trap and benthic core sample locations at South Slough (Figures 24 -27). With the exception of May, all of the prey availability and salmon diet sample dates at South Slough coincide. Traps one and three were more productive than the others in terms of abundance, while trap two was more productive in terms of species richness. Traps four and five were least diverse.
Temporal and spatial patterns revealed adult insects were more prevalent than were other life history stages. Species readily available for consumption were primarily representative of the Homopteran and Dipteran orders of insects. Chironomids (order Diptera) were more numerous than were other insect prey taxa.

In 2010, we simultaneously collected benthic core samples at each fall out trap location (Figures 28-31). In April of 2010, annelids were most abundant, for example, Oligocheates and Nematodes. Prey availability results for May of 2010 are not respresented as we did not catch any salmon at South Slough during that sampling event. During the month of June, annelids including Oligocheates, Polycheates and Nematodes were most diverse given they were present throughout all of the traps at one or more life history stages. Ceratopogonidae adults and larva were also found, along with ostracod cyprids. During

July, Gastropods and Ostracod availability remained the same while aphids were a new prey taxa that month. Fewer annelids were found overall but Oligocheates were most abundant in space and time. In August, Corophium and Isopods also came into play while the Ostracods did not. The spatial distribution for gastropods increased and Annelids were available once again.

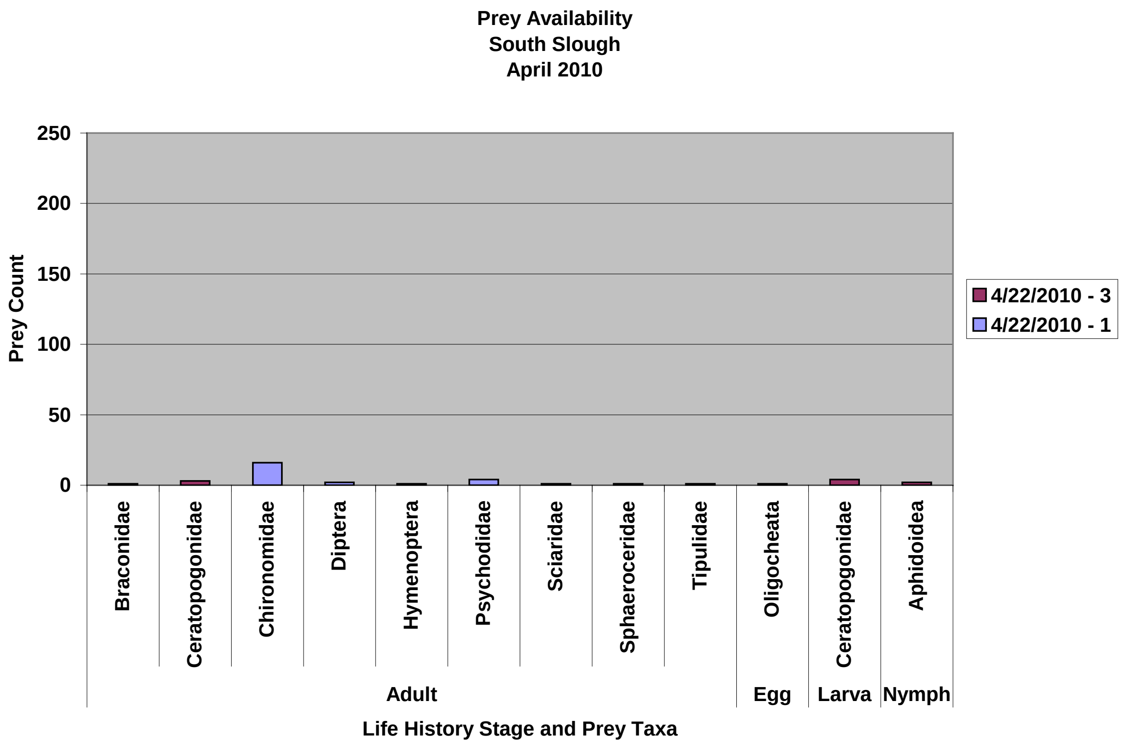


Figure 24. Salmonid Prey Availability, South Slough Fall Out Traps, April, 2010

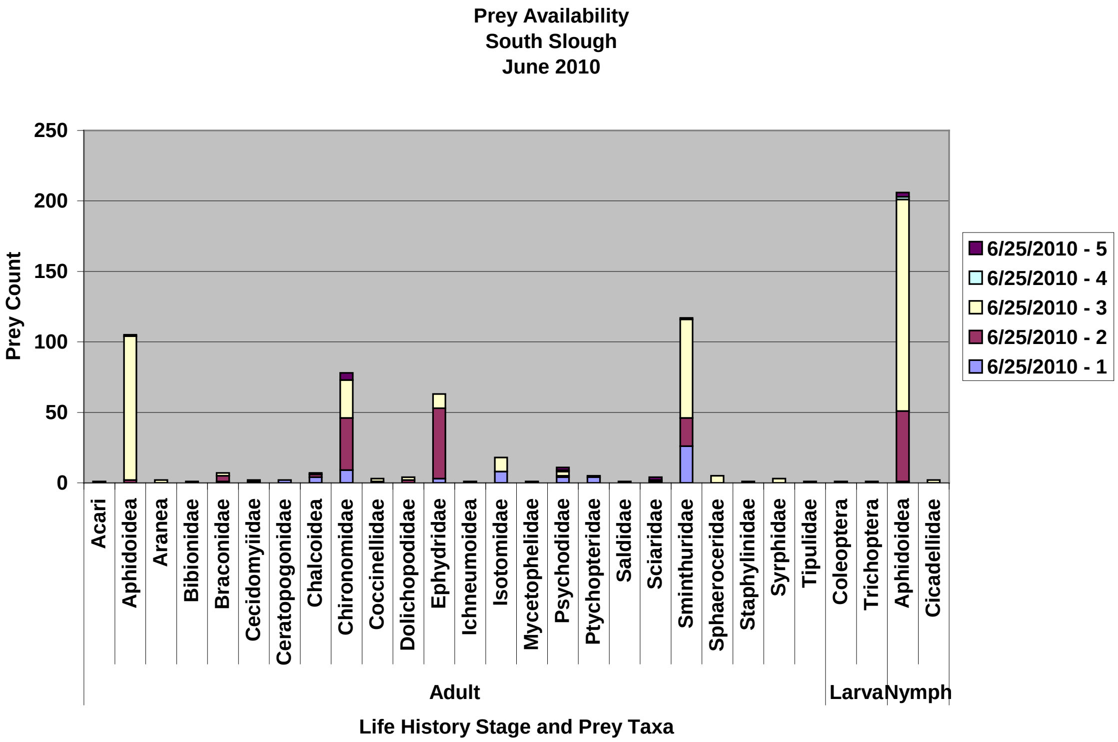


Figure 25. Salmonid Prey Availability, South Slough Fall Out Traps, June, 2010

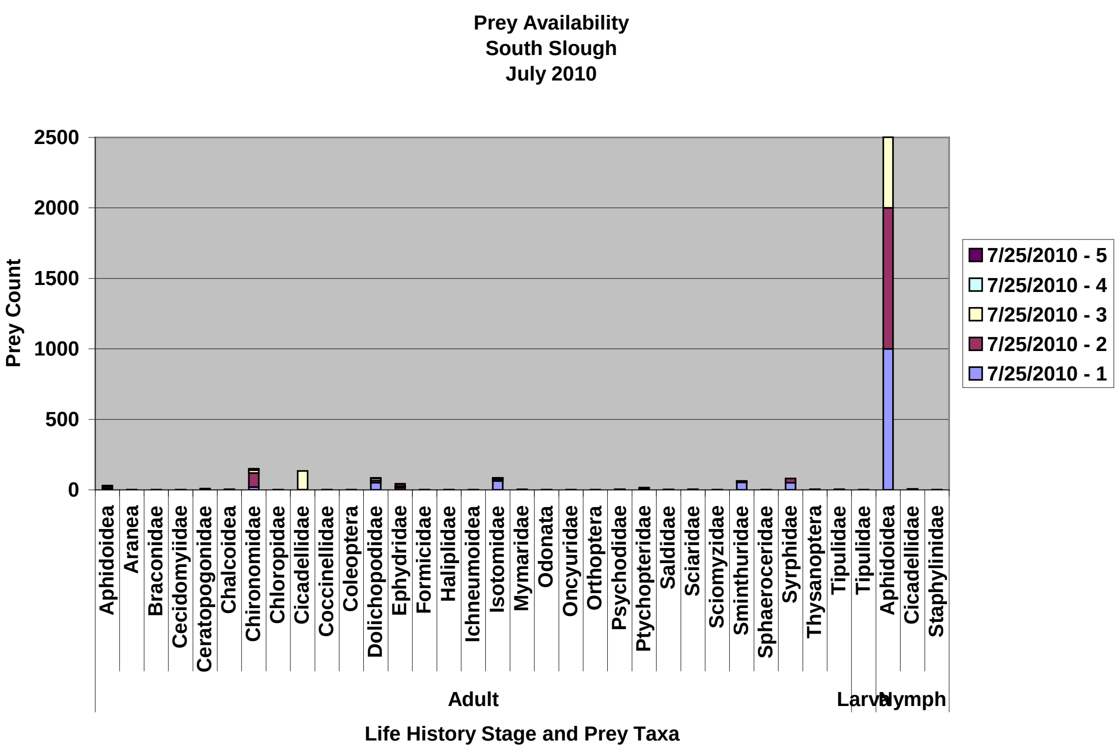


Figure 26. Salmonid Prey Availability, South Slough Fall Out Traps, July, 2010

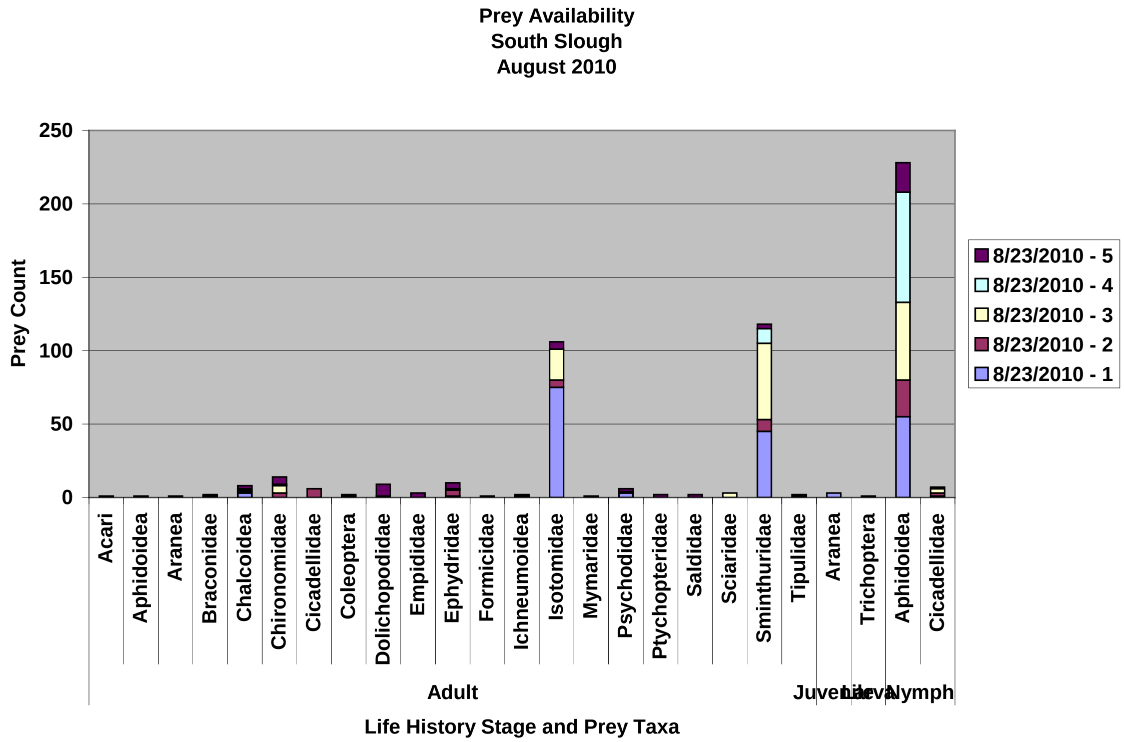


Figure 27. Salmonid Prey Availability, South Slough Fall Out Traps, August, 2010

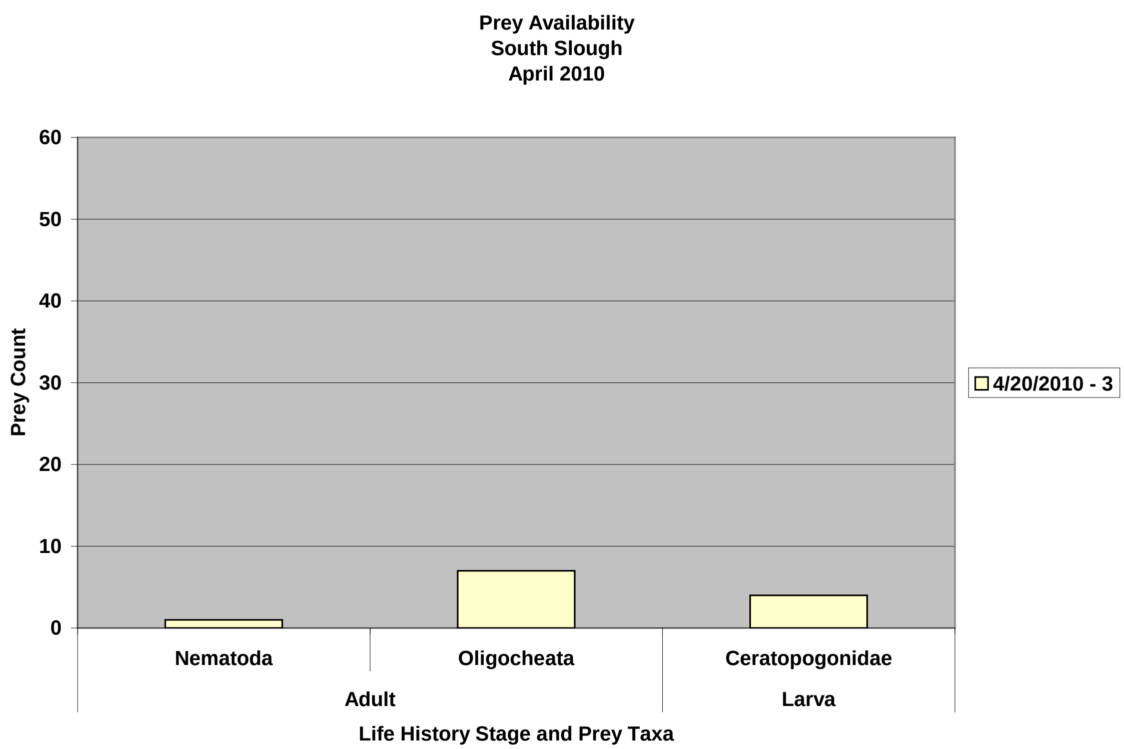


Figure 28. Salmonid Prey Availability, South Slough Sediment Cores, April, 2010

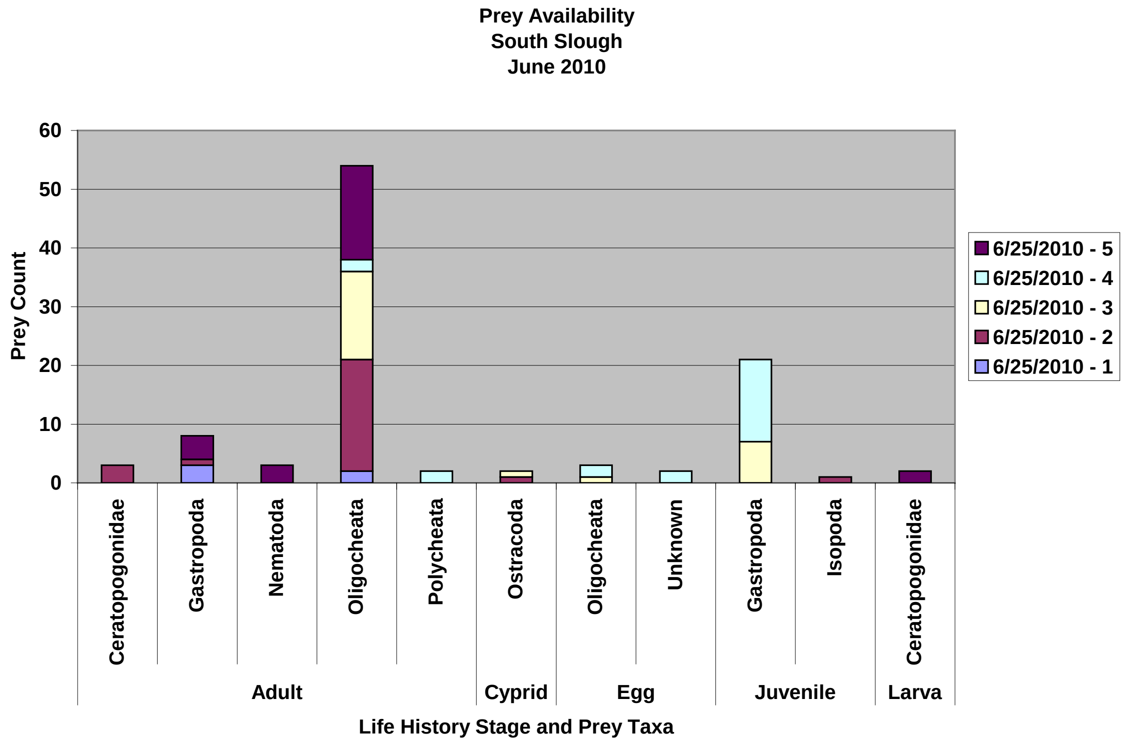


Figure 29. Salmonid Prey Availability, South Slough Sediment Cores, June, 2010

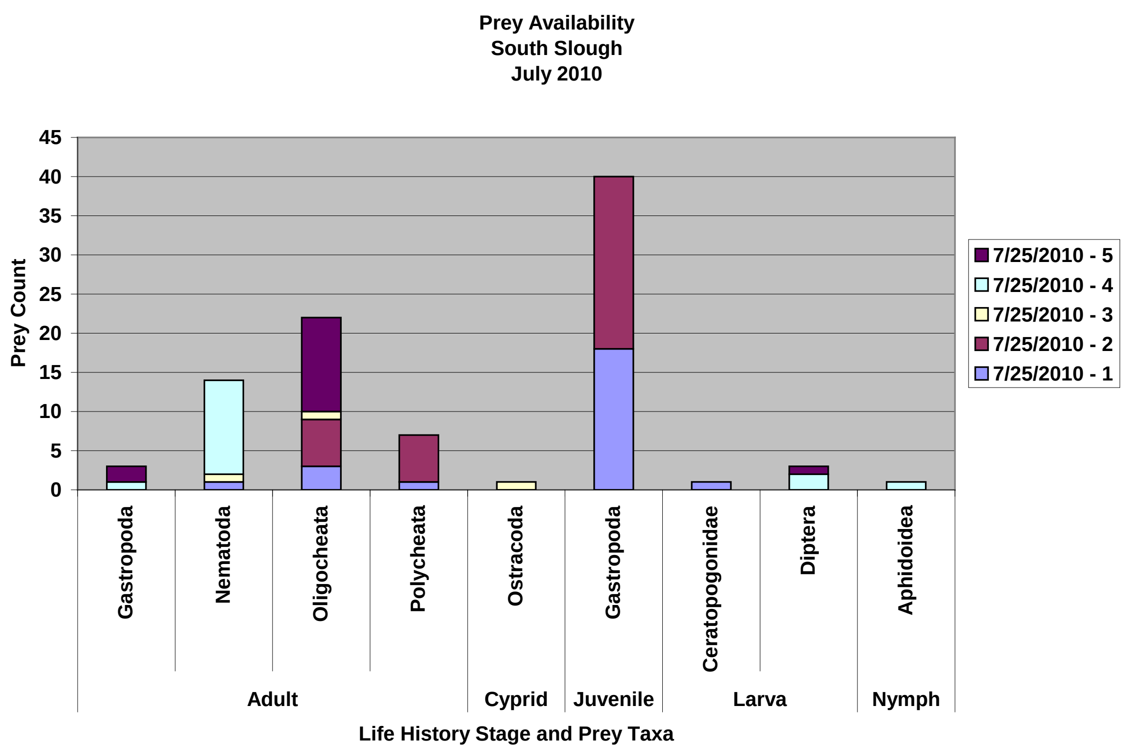


Figure 30. Salmonid Prey Availability, South Slough Sediment Cores, July, 2010

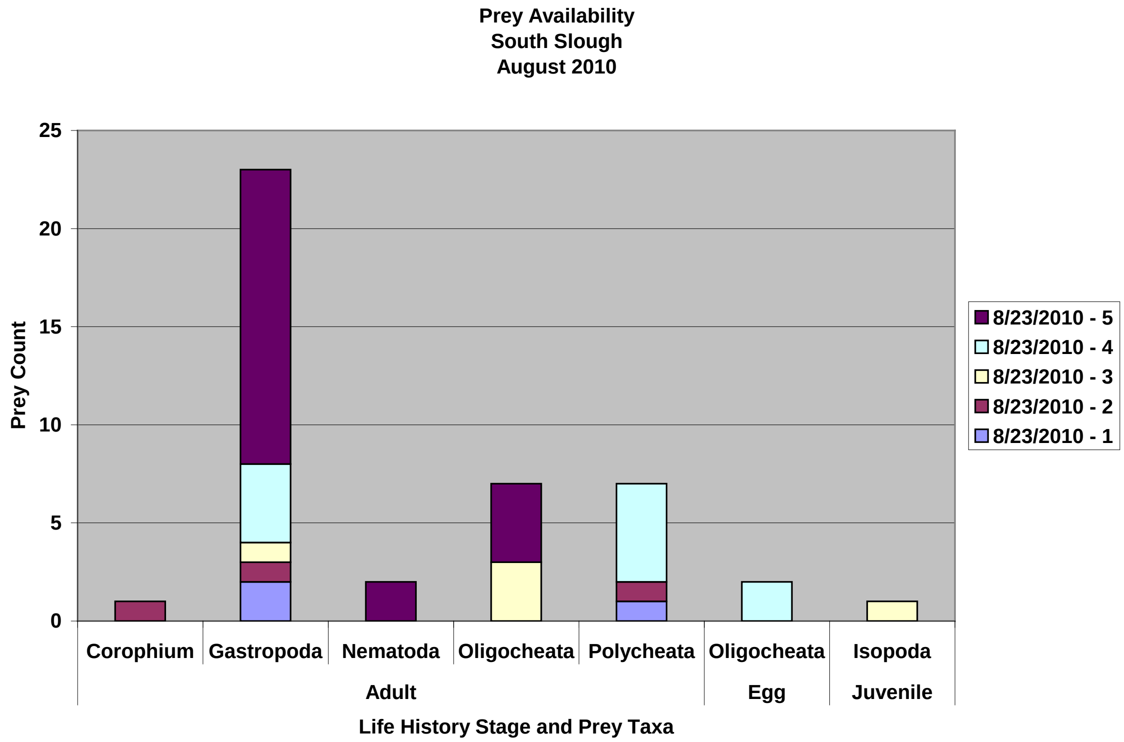


Figure 31. Salmonid Prey Availability, South Slough Sediment Cores, August, 2010

Ft. Clatsop Reference Slough

Five prey availability sites were also sampled for all five South Slough fishing events at the reference slough in 2010 (Figures 32– 33). Priority processing went to those fall out trap and benthic core samples that corresponded to dates when salmon diets were also collected, i.e., May of 2010. Trap 2 was most productive in terms of species diversity, regardless of life history stage. Only adult life history stage prey were found in trap one whereas no adults were observed in trap three. Traps four and five were flooded out.

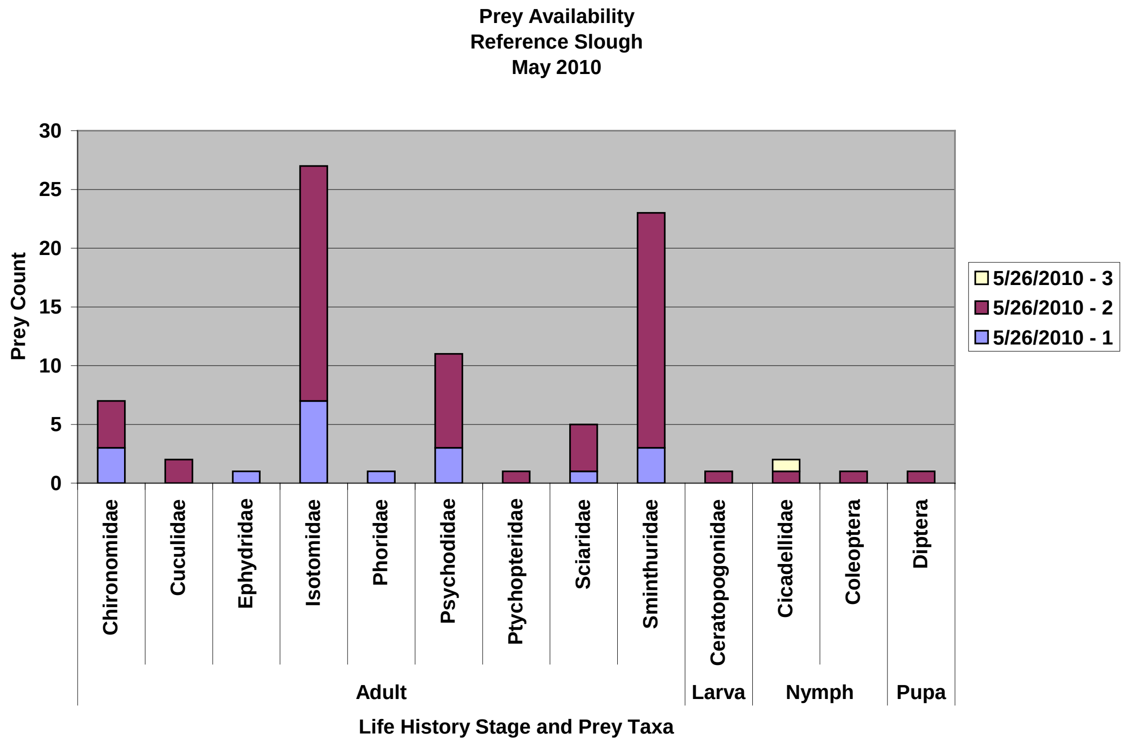


Figure 32. Salmonid Prey Availability, Reference Slough Fall Out Traps, May, 2010

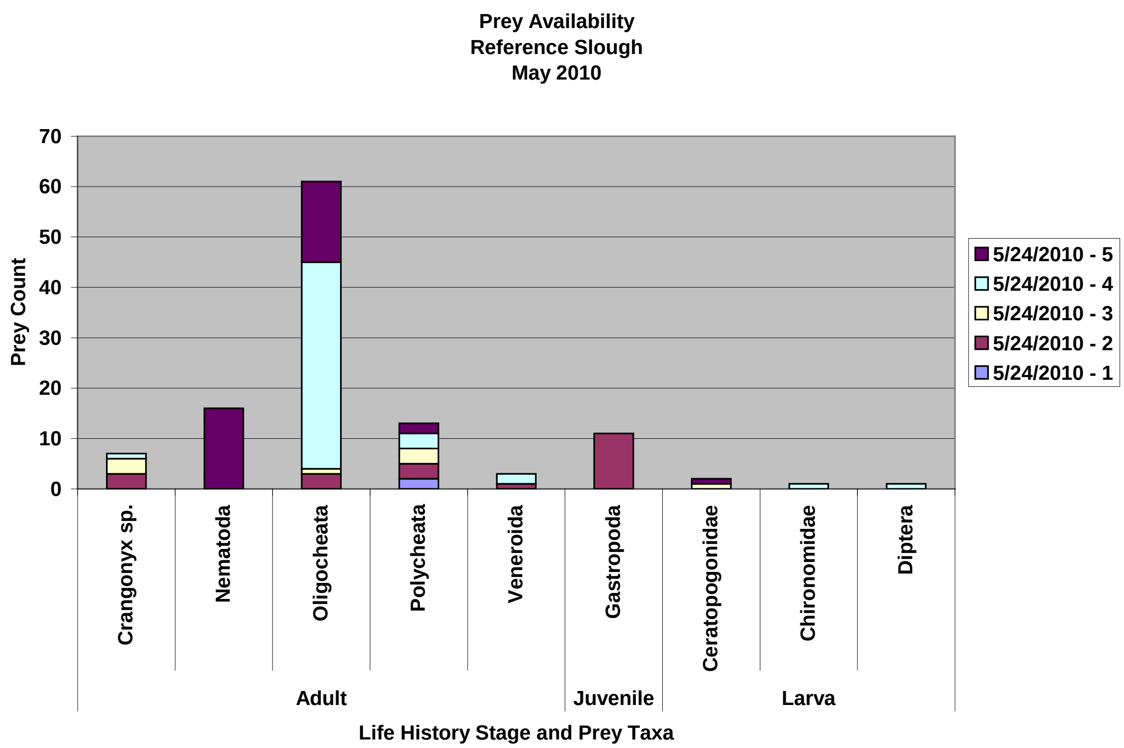


Figure 33. Salmonid Prey Availability, Reference Slough Benthic Cores, May, 2010

5.3.3 Prey Utilization

Hogan's Ranch

Two wild Chinook salmon observed at Teal Slough in June of 2010 were large enough to undergo the gastric lavage procedure (Figure 34). Corixids were a preferred prey item amongst salmon. No comparable prey availability samples were obtained that were coincident with gut content samples.

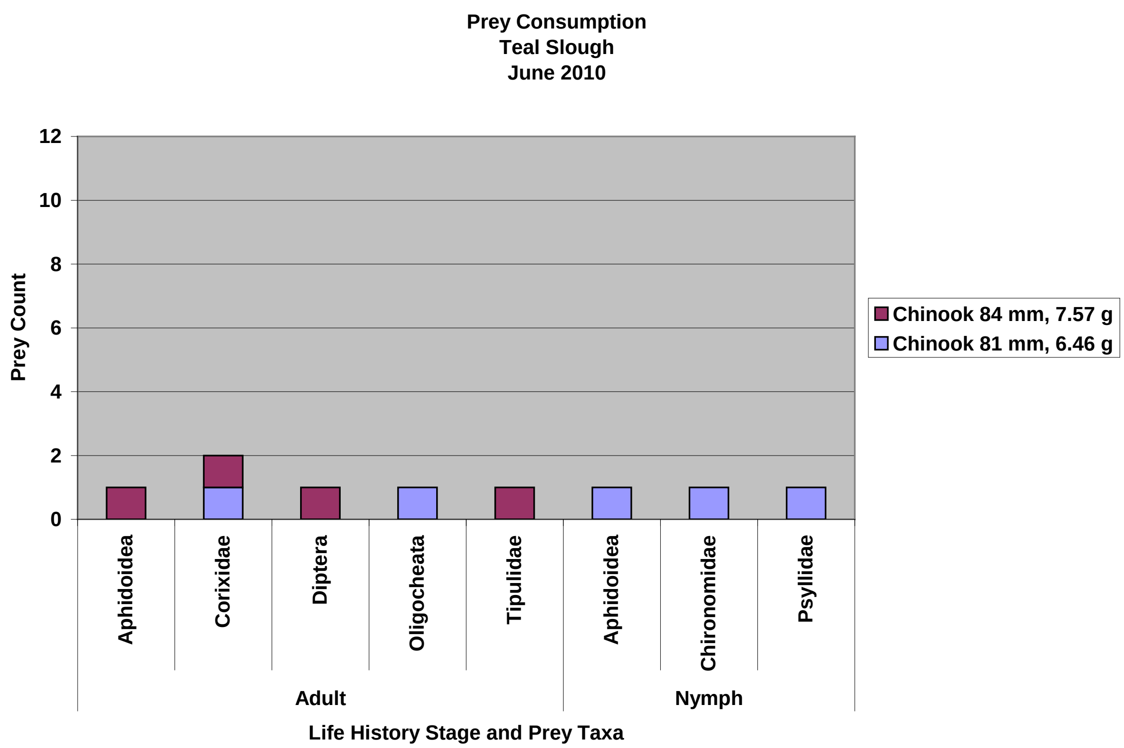


Figure 34. Salmonid Diet Composition, Teal Slough, June, 2010

Ft. Clatsop South Slough

Three wild subyearling Chinook salmon and four wild subyearling Coho were sampled for diet contents between April, June, July and August of 2010 at South Slough restoration site (Figure 35 – 38). June was the most productive month in terms of number of salmon diets sampled, life history stages and prey taxa represented, and species diversity. Adult isopods were the most popular prey item sampled.

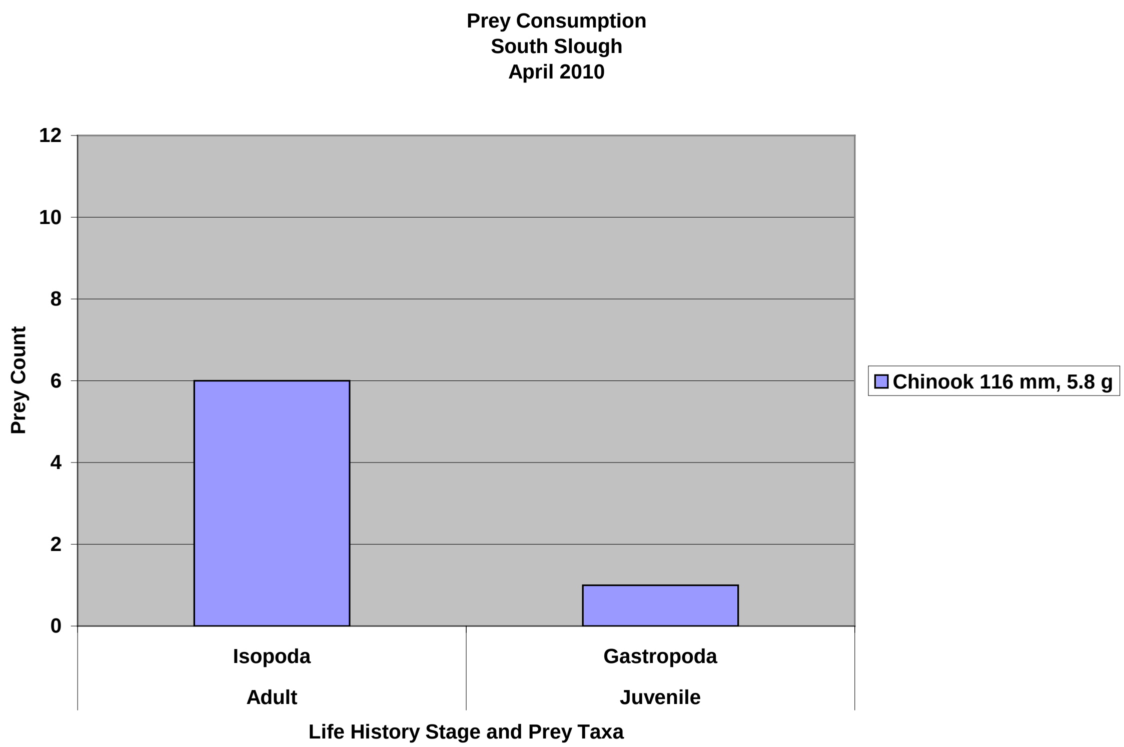


Figure 35. Salmonid Diet Composition, South Slough, April, 2010

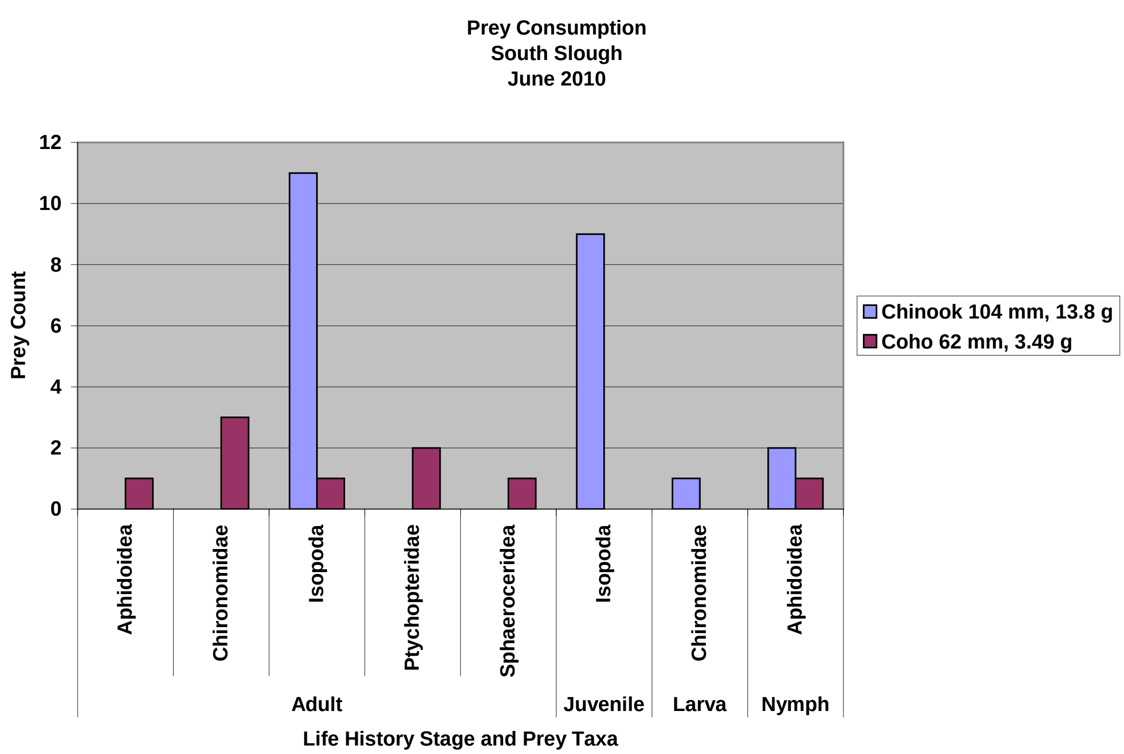


Figure 36. Salmonid Diet Composition, South Slough, June, 2010

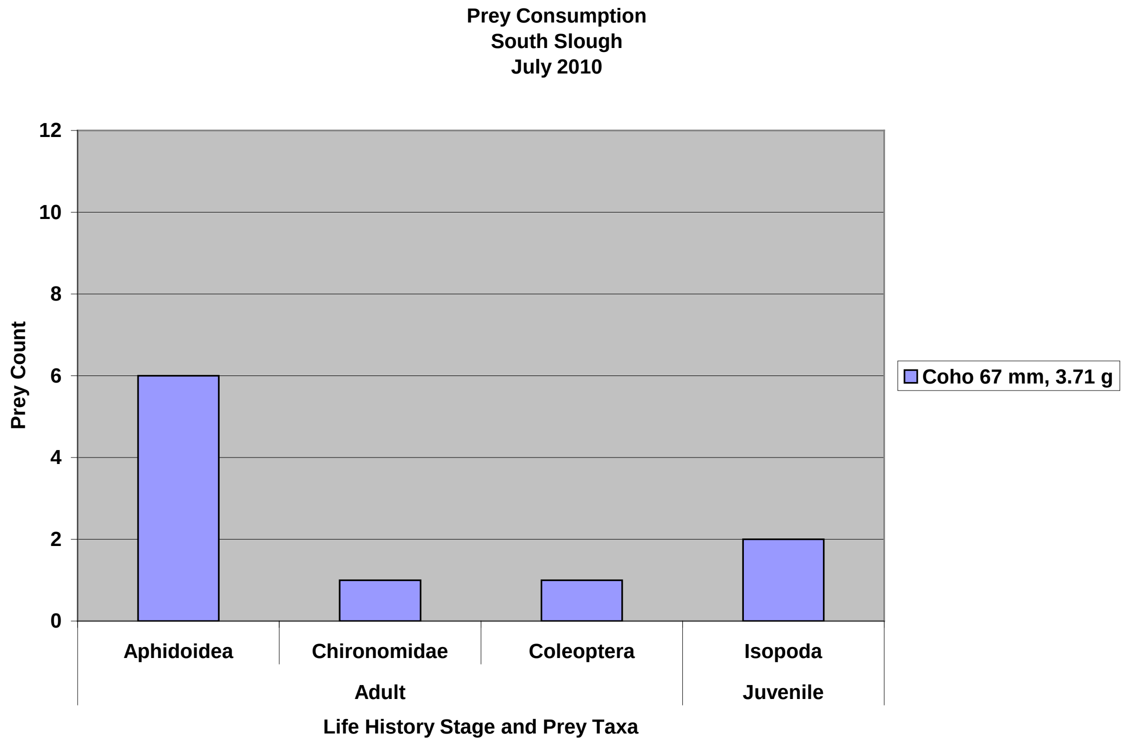


Figure 37. Salmonid Diet Composition, South Slough, July, 2010

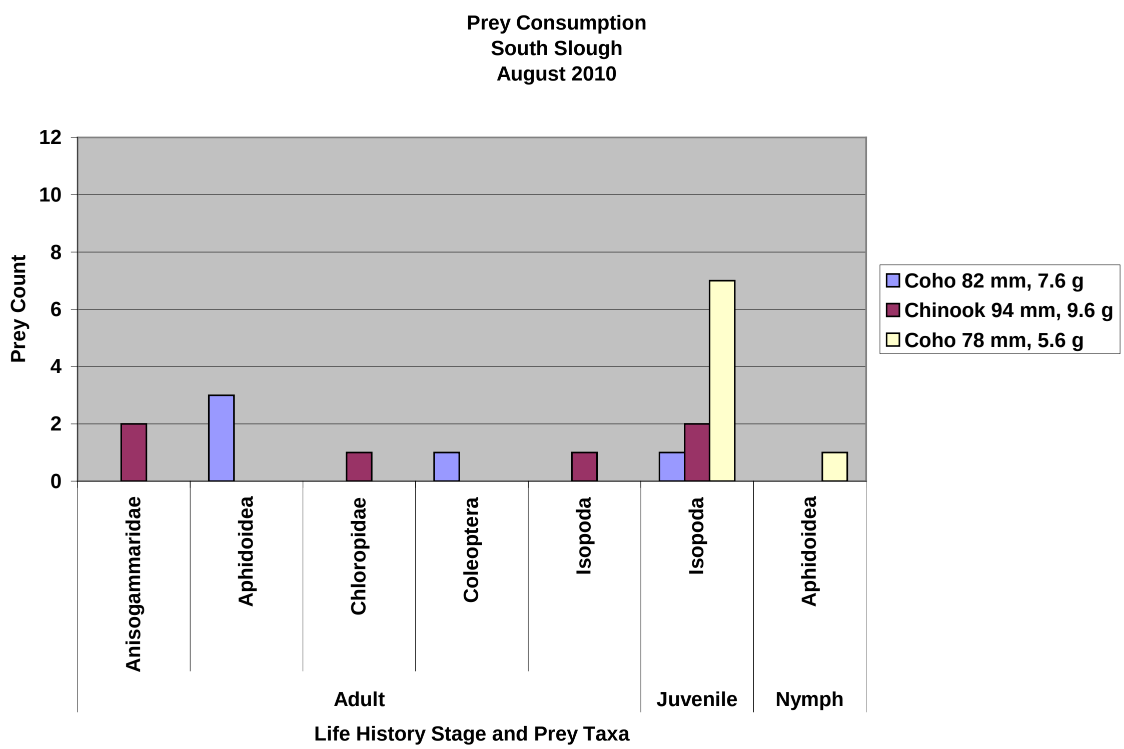


Figure 38. Salmonid Diet Composition, South Slough, August, 2010

Ft. Clatsop Reference Slough

In 2010, a single wild subyearling Chinook salmon sampled at the reference slough was large enough to handle the gastric-lavage procedure used to obtain gut contents for diet composition analysis (Figure 39).

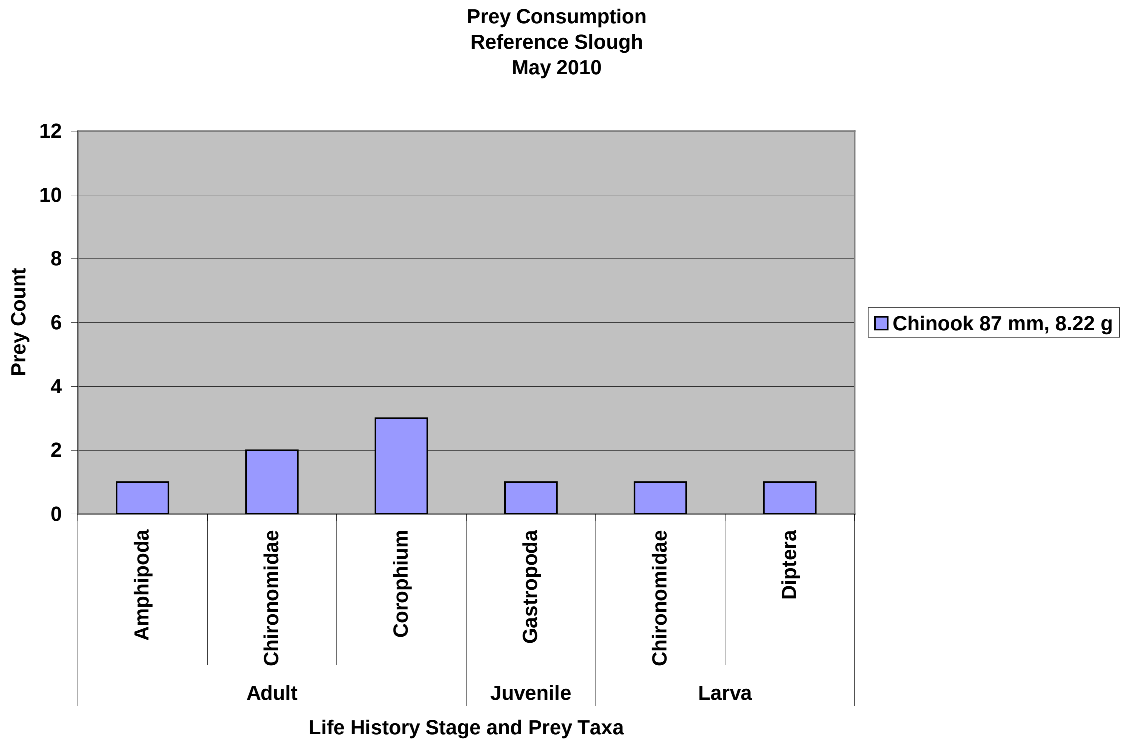


Figure 39. Salmonid Diet Composition, Reference Slough, 2010

5.3.4 Habitat

5.3.4.1 Sediment Accretion

Ft. Clatsop South Slough

In 2010, there was more sediment on the downstream end of the plot, closest to the restoration location, and less on the upstream end (Figure 40).

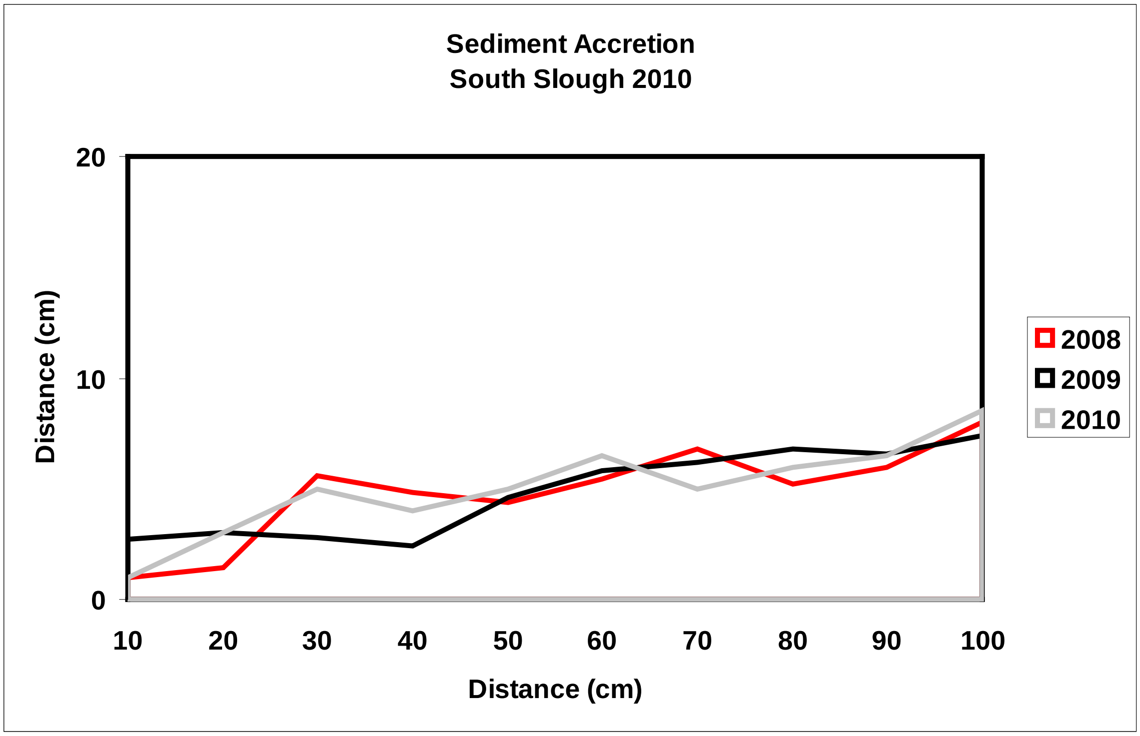


Figure 40. Sediment Accretion Measurements, 10 cm (upstream) to 100 cm (downstream), Fort Clatsop South Slough, 2008 - 2010.

Ft. Clatsop Reference Slough

In 2010, the reference slough revealed accretion on the upstream and downstream end of the plot stakes, closest to the fish community sample site (Figure 41)**.**

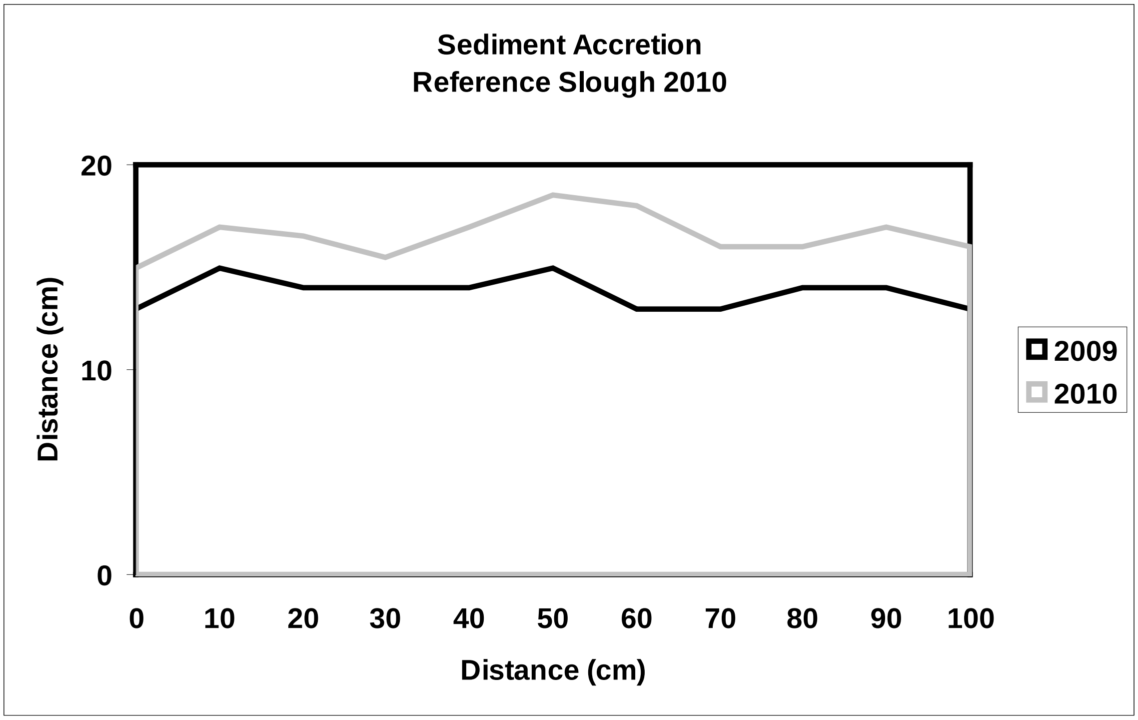


Figure 41. Sediment Accretion Measurements, 10 cm (upstream) to 100 cm (downstream), Fort Clatsop Reference Slough, 2009 - 2010.

5.3.4.2 Channel Profile

Ft. Clatsop South Slough

In 2010, the channel bank had sloughed off at the north end of cross section point 1, and there was considerable woody debris displaced at the south end-point. The channel morphology reflects accretion nearest the restoration site, point 1 and channel deepening at subsequent upstream locations, points 2 through 5 (Figure 42).

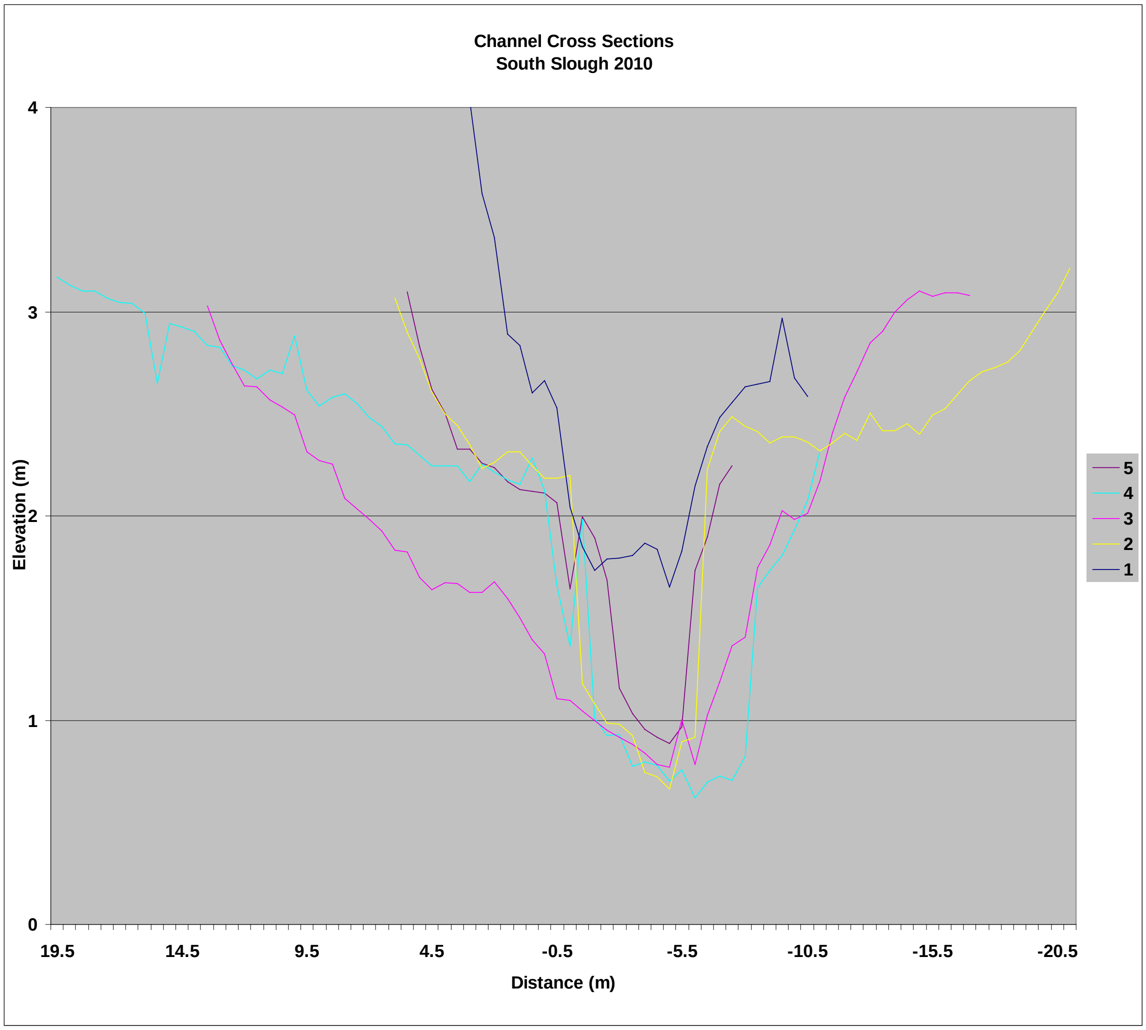


Figure 42. Channel Profile, Cross Section Transects 1 (downstream) through 5 (upstream), Fort Clatsop South Slough, 2010

Ft. Clatsop Reference Slough

In 2010 bathymetry revealed the thalwag to be proportionally lower in elevation at downstream points, nearest the mouth of the reference slough, points 1 and 2, and higher at upstream locations, points 3 through 5 (Figure 43). The survey benchmark, for known elevation is to date an estimate, pending confirmation from the National Parks System.

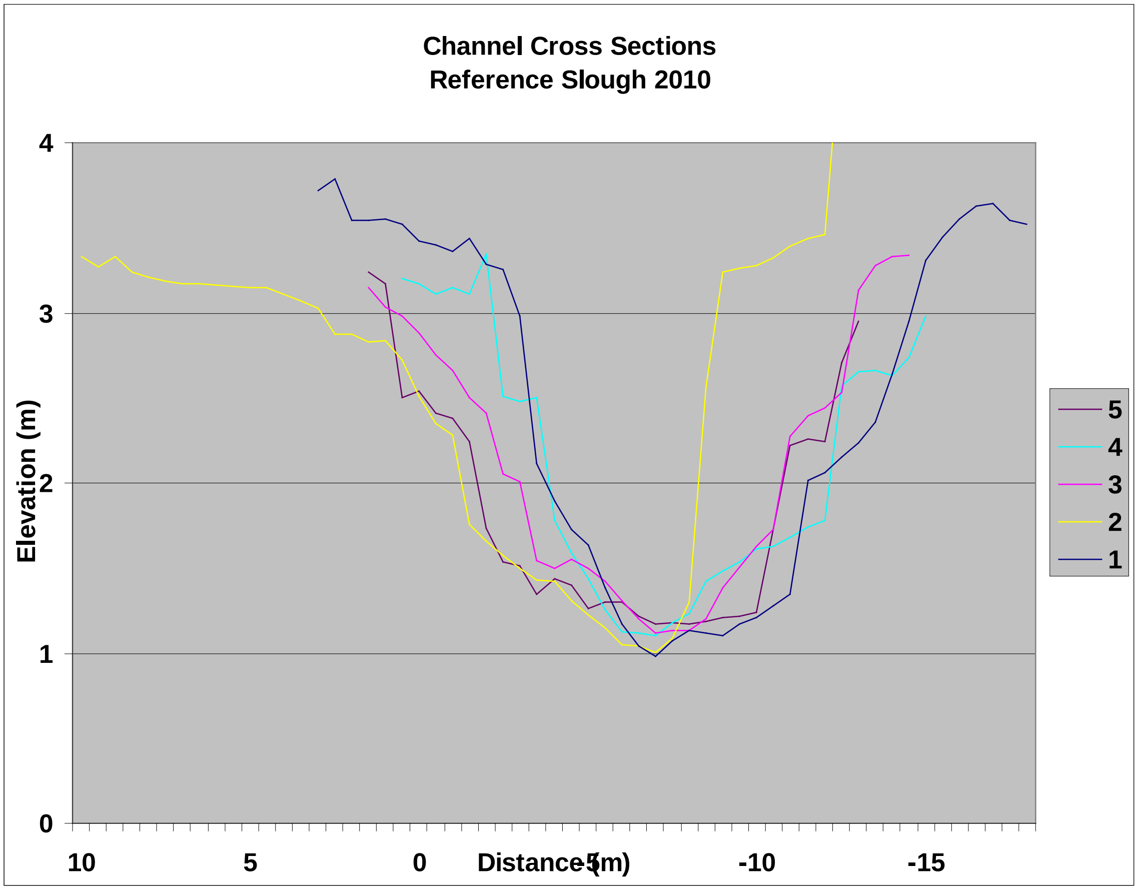


Figure 43. Channel Profile, Cross Section Transects 1 (downstream) through 5 (upstream), Fort Clatsop Reference Slough, 2010.

5.3.4.3 Landscape Change

Ft. Clatsop South Slough

Pre-restoration photo points are not available for comparison, but subtle landscape changes at South Slough appear in post-restoration photos taken during the spring and summer of 2008 and the summer and fall of 2009 and 2010. The Northward shots reveal invasive, decaying Reed Canary grass in the foreground by fall, while the native Bull Rush remains prevalent in the background along the riparian zone (Figures 44 – 49). The Southward shots show the Bull Rush thriving on the near bank, and the Reed Canary grass in the foreground getting taller by fall. The shots facing up the restoration stream by comparison show the vegetation has been visibly reduced by the beginning of fall.

Ft. Clatsop Reference Slough

Despite the designation of the reference slough as healthy habitat, riparian vegetation is still dominated by reed canary grass at this site as well (Figures 50 – 55). Photo points were taken from the same location at three different compass bearings.


Figure 44. Ft. Clatsop South Slough, photo-point, Spring, 2010

Figure 45. Ft. Clatsop South Slough photo-point, Fall, 2010


Figure 46. Ft. Clatsop South Slough photo-point, Spring, 2010

Figure 47 Ft. Clatsop South Slough photo-point, Fall, 2010.


Figure 48. Ft. Clatsop South Slough photo-point, Spring, 2010

Figure 49. Ft. Clatsop South Slough photo-point, Fall, 2010


Figure 50. Ft. Clatsop Reference Slough photo-point Spring, 2010

Figure 51. Ft. Clatsop Reference Slough photo-point Fall, 2010


Figure 52. Ft. Clatsop Reference Slough photo-point Spring, 2010

Figure 53. Ft. Clatsop Reference Slough photo-point Fall, 2010


Figure 54. Ft. Clatsop Reference Slough photo-point Spring, 2010

Figure 55. Ft. Clatsop Reference Slough photo-point Fall, 2010

5.3.4.4 Water Quality

Ft. Clatsop South Slough

During the winter of 2010, specific conductivity, an indicator of salinity, hovered between 0 µS cm^{-1} and 5000 µS cm^{-1}, with peaks of up to 12000 µS cm^{-} (Figure 56). Temperatures dipped to below freezing early in the winter but remained between 5°C and 10°C the rest of that season. Dissolved oxygen consistently measured between 5 mg L^{-1} and 12 mg L^{-1}, with small decreases associated with higher temperature and lower tide. In general, water column depth was between 5 m and 10 m, with low water conditions in early January and infrequent outliers that entire season, most likely indicating the unit was exposed to air.

Spring conductivity measurements were similar to the winter early on, with salinity dropping to around 3000 µS cm^{-1} by late spring of 2010 (Figure 57). Water temperature was similar to winter conditions between 5 °C and 10°C early in the spring, but increased to between 10 °C and 15 °C by late spring with peaks of 20 °C. Dissolved oxygen was similar to winter results; between 5 mg L^{-1} and 12 mg L^{-1}, with small decreases associated with higher temperature and lower tide. Depth too was similar to winter readings, however, by late spring, the water column was shallower; between 0 and 5 m in depth.

During the early summer of 2010, conductivity remained low during early summer; between 1000 µS cm^{-1} and 2000 µS cm^{-1} (Figure 58). By late summer, conductivity had increased to between 3000 µS cm^{-1} and 6000 µS cm^{-1}, to 9000 µS cm^{-1}.

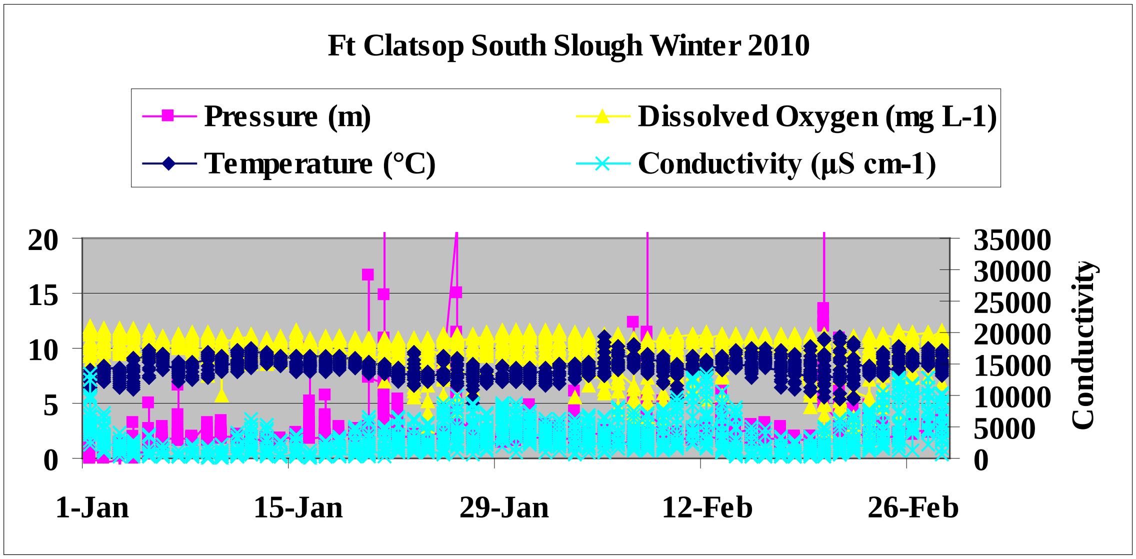


Figure 56. Winter water quality results for Fort Clatsop South Slough, 2010

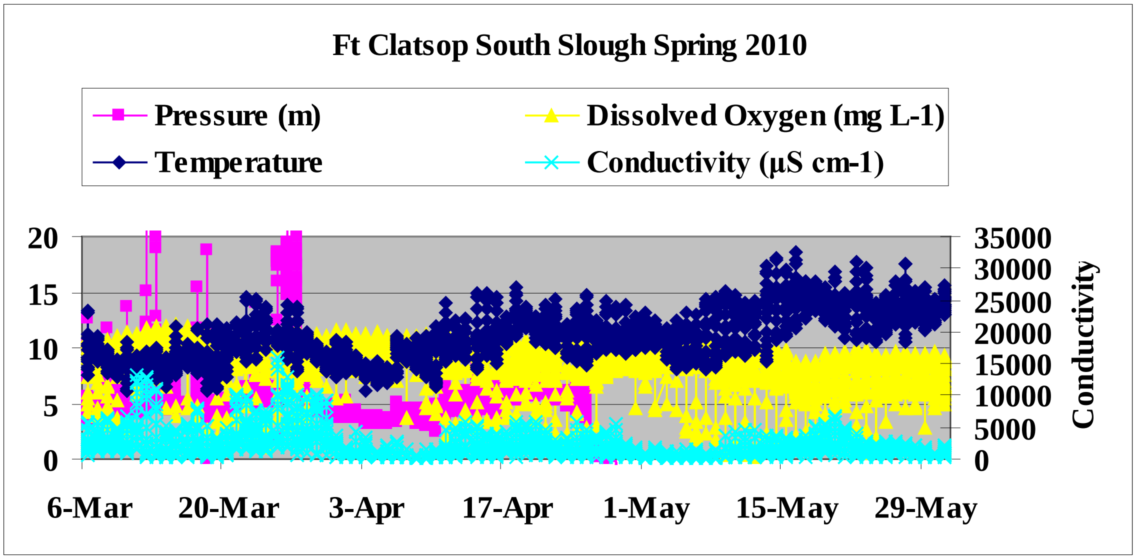


Figure 57. Spring water quality results for Fort Clatsop South Slough, 2010

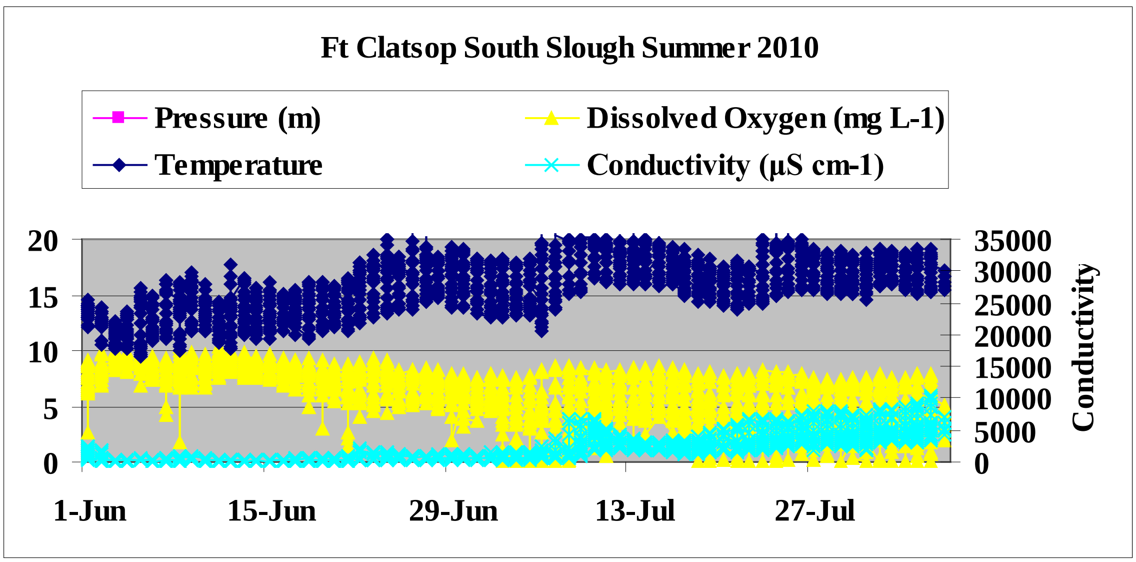


Figure 58. Summer water quality results for Fort Clatsop South Slough, 2010

Ft. Clatsop Reference Slough

The new reference site water quality unit came with a factory default, rendering winter and spring 2010 water quality data irretrievable. The unit was returned to the research funder and then the manufacturer during summer of 2010. A restored water quality unit complete with a RDO probe was redeployed in the fall of 2010.

5.3.5 Discussion

5.3.5.1 Fish Community
Hogan's Ranch Teal Slough

In 2008, one Chinook salmon was observed in Teal Slough on the Hogan's Ranch Property (CREST, 2009). Continued sampling in 2009, primarily on Teal Slough, produced one Coho and similar bycatch species diversity. Salmon totals for 2010 were higher than years' previous while bycatch numbers were down. Fish species composition was similar to years' previous, for salmon and bycatch alike. Documenting salmon stranding on the properties ponds after annual sheeting events had been a secondary goal for SBWC, but after attempts to seine proved impossible in 2008 and 2009, electro-shocking was deemed the only means possible.

Ft Clatsop South Slough

Temporal patterns of salmonid distribution at the restoration site reflect documented life history strategies (Dawley et al. 1986). However, in 2010, Chinook salmon were observed later in April than were Coho where typically we catch Chinook before Coho. Coho used the South Slough system all season, which was to be expected, given their increased temperature resilience as compared to Chinook. This community structure is typical of estuarine and some warmer, fresh-water environments. The restoration and reference sites differ in terms of temporal and size distributions of salmonids, while the salmon and bycatch species compositions are similar.

Cutthroat trout were absent from the South Slough system in 2010, whereas a single Cutthroat trout was recorded in April of 2009 (CREST, 2009). Steelhead were also absent from the system; observed in April and July of 2008. Coho and Chinook stayed in the system longer in 2010 than 2009, similar to sightings in 2008. We did not find any Chum at South Slough in 2010, unlike all other sample seasons.

Monthly sampling in 2009 and 2010 as oppose to bimonthly sampling in 2008, has proved less productive at South Slough (CREST, 2009). Pre-restoration fish community results in 2007 revealed only 10 salmon in the system. The highest species diversity recorded at South Slough since the restoration in 2007, was in 2008. Since restoration, salmonids have been more abundant and diverse, especially in 2008 following restoration when 122 were recorded. Since then, salmon species richness and abundance decreased in 2009, with only 11 salmon total, and 2010 produced even lower richness but higher abundance. Bycatch species diversity in 2010 was similar to previous years although species abundance was down in 2010 compared to 2008 and 2009.

Ft Clatsop Reference Slough

In 2010, the reference slough was less productive than 2009; the most productive year on record (CREST, 2009). Salmon species richness has remained the same since before restoration at South Slough with Chinook salmon and Coho the only inhabitants. Species composition was similar between years at the reference slough, though fish were more abundant in 2009 than any other year; an artifact of gear efficiency. Where before, yearling sized salmonids had been observed more often at the reference site than the restoration site, the opposite was true for 2010.

5.3.5.2 Prey Availability

Hogan's Ranch Teal Slough

Prey availability fall out trap samples were not obtained coincident with salmon gut content samples, neither during the 2008 nor the 2010 sampling events at Teal Slough (CREST, 2009). However in 2009, trap 1 was the most productive in terms of species diversity for the month of March when salmon gut contents were collected. Dipteran insects like Chironomids and Ephydrids were dominant as were members of the Collembolan family; Isotomids and Sminthurids.

Prey availability benthic core samples were not obtained coincident with salmon gut content samples neither during the 2008 nor the 2010 sampling events at Teal Slough (CREST, 2009). However in 2009, core 1 was the most productive in terms of species diversity for the month of March when salmon gut contents were collected. Annelids and in particular Oligocheates were the only prey taxa available for consumption.

Ft Clatsop South Slough

In April of 2010, trap 1 was more productive than trap 3 in terms of species diversity at South Slough; traps 2, 4 and 5 were flooded out. During April of 2009, traps 1 and 5 produced the highest species diversity during two respective events (CREST, 2009). In April of 2008, trap 1 was the most diverse. Traps were not analyzed for May of neither 2010 nor 2009, given there weren't any coincidental salmon gut contents for comparison. Trap 5 was most diverse in May of 2008. In June of 2010, trap 3 was most diverse, unlike June of 2008 when trap 5 was most diverse. June trap samples were not analyzed for 2009 without salmon prey consumption samples for comparison. During July of 2010, trap 1 was most diverse whereas trap 5 was most diverse in July of 2009, and trap 1 in July of 2008. August prey availability samples were only analyzed in 2010, when salmon gut contents were simultaneously sampled. Trap 3 had the highest species abundance and trap 5 had the highest species richness. Prey availability was not sampled neither in Augusto of 2009 nor 2008.

In April of 2010, benthic core 4 results were similar to other cores and years; other cores were not taken as fall out traps had flooded out or the cores have yet to be located. In April of 2009, benthic cores 4 and 1 were most productive in the spring and summer, respectively, in terms of species diversity (CREST, 2009). No benthic core samples were processed for April of 2008, given budget constraints. With no gut contents for comparison, benthic core samples were not analyzed for May of 2010. In June of 2010, benthic core 5 was most productive in terms of species abundance and trap 4 was most productive in terms of species richness. June prey availability samples for 2009 weren't analyzed given the lack of corresponding salmon gut content samples for comparison. No benthic core samples were analyzed for June of 2008. In July of both 2010 and 2009, trap 1 had the highest species diversity. No benthic core samples were analyzed for July of 2008. During August of 2010, trap 3 had the highest species richness and trap 5 the highest species abundance. Benthic core samples were not analyzed for August of 2009 or 2008.

Ft Clatsop Reference Slough

During May of 2010, fall out trap 2 was most productive in terms of species diversity. While traps 4 and 5 were flooded out in 2010, they had the highest species diversity in 2009 (CREST, 2009). Given that no salmon were sampled for gut contents in 2008 at the reference slough, coincidental fall out trap samples were not analyzed for comparison.

Benthic core results were obtained from the reference slough in May of 2010 and to those from April of 2009; the only sample dates from either year when salmon gut contents were simultaneously sampled (CREST, 2009). Benthic core samples were not processed from 2008 due to budget and time constraints. Instead, archived such archived samples will be analyzed and results represented in the 2011 annual report.

5.3.5.3 Prey Utilization

Hogan's Ranch Teal Slough

In 2010, Teal Slough gut contents were analyzed and compared to previous year's data from 2009 and 2008 (CREST, 2009). Salmon diets were similar between years for Teal Slough, for example, Corixids were present in salmon diets for all three years. All Chinook salmon and Coho diets compared between years shared Aphids and Isopods as common prey items as well. In 2010, the Chinook diet was more diverse than the Coho in terms of both species richness and abundance. In 2010, the Chinook salmon sampled at Teal Slough ate a variety of prey taxa from different life history stages, including representative fall out prey and benthic prey items. In 2009, Coho fed on fall out and benthic prey alike, while in 2008, the Chinook salmon did not feed on benthic prey.

Ft Clatsop South Slough

During 2010, Chinook salmon and Coho consumed Aphids and Isopods during most months, similar to results from Teal Slough. Chironomids and other dipteran insects were also popular prey items. Adults and nymphs were represented more often than other life history stages at South Slough. By comparison, salmon diets from 2009 showed adult Chironomids and Isopods were the prey items utilized most often. Similarly, in 2008, Chironomids and Isopods were the most popular prey items. Coho diets were more diverse than those of Chinook in 2008 and Corophium were also consumed readily that year.

Ft Clatsop Reference Slough

Corophium, Chironomids and Amphipods were popular prey items at the reference slough in 2010, especially for fish in the adult life history stage. In 2008 and 2009, respectively, a wild yearling Chinook salmon and a wild subyearling Coho were sampled for diet composition (CREST, 2009). The results have been similar regardless of species, size, rear-type, sample season or site; prey consumption reflects prey availability. Although salmon are opportunistic predators, feeding primarily on the most abundant prey types, feeding behavior might suggest selection for specific prey taxa. For example, Corophium are not often available to eat, but they often show up in salmon diet samples. This might also indicate that fish sampled are eating outside the marsh, or that we are not sufficiently sampling the trap-net site in space or time or both.

5.3.5.4 Sediment Accretion

Ft Clatsop South Slough

In the spring of 2010, additional sediment accretion data points were comparatively more similar to 2008 than 2009. Sediment accretion measurements from South Slough revealed subtle shifts in sedimentation between 2008 and 2009 and from 2009 to 2010.

Ft Clatsop Reference Slough

Sediment accretion measurements from 2010 showed a couple centimeters of silt had accumulated since 2009. Visual observations made during high tide events documented the water surface submerging the sediment accretion stake area, unlike years past (Jason Smith, NPS, pers. comm., 2010). It's likely that suspended particles deposited during submersion contributed to the increase in material. Fall 2010 versus spring 2009 comparisons meant downed, decayed vegetative matter may have contributed to 2010 results as well.

5.3.5.5 Channel Profile

Ft Clatsop South Slough

In 2010, there was sediment accretion downstream, near to the restoration site, and scouring further upstream, above the trap-net site. In 2009, the opposite was true; the thalwag was lowest in elevation nearest the restoration site, points 1 and 2 (CREST, 2009). In 2008, bathymetry at South Slough revealed the thalwag to be proportionally higher in elevation near the site of restoration, points 1 and 2, compared to the upstream cross-sections, points 3 through 5.

Ft Clatsop Reference Slough

The 2010 channel morphology findings for the reference slough are supported by similar measurements from the same reference slough locations in 2009 (CREST, 2009). Furthermore, a reference site study documented similar channel profile measurements in 2008 (PNNL, 2009).

5.3.5.6 Landscape Change

Ft Clatsop South Slough

Photos from 2010 are similar to previous pictures from 2009 and 2008 in terms of plants. However, westward, upstream shots show the north bank sloughed off since then and some large woody debris has shifted, scraping down the south bank.

Ft Clatsop Reference Slough

Pictures taken in 2010 at the reference site reveal similar vegetation community structure to 2009 and 2008 (CREST, 2009) (CREST, 2008). The channel bed has not changed in the last three years, though, east bank sloughing, in part due to sample staging, seems to have progressed considerably.

5.3.5.7 Water Quality

Ft Clatsop South Slough

In 2010 as in 2009 and 2008, chemical water quality parameters recorded at South Slough since restoration, e.g. salinity and dissolved oxygen, fluctuate primarily according to the tide (Figure 59 – 61) (CREST, 2009). Water quality results that have not been presented to date for 2008 are reported here for comparison. Depth data for the restoration site has not been adjusted for atmospheric pressure or probe elevation.

Tidal reconnection of the brackish influence of the Pacific Ocean to the South Slough resulted in fluctuation in salinity directly correlated with the diurnal tidal cycle. Dissolved oxygen increased and decreased similarly, in tandem with the seasons and the tide. Physical water quality parameters included temperature as well as depth. Dissolved oxygen has an inverse relationship with temperature so as the slough warmed up, oxygen levels dropped. Warmer water was also directly linked to depth, and thus with season and tide as well.

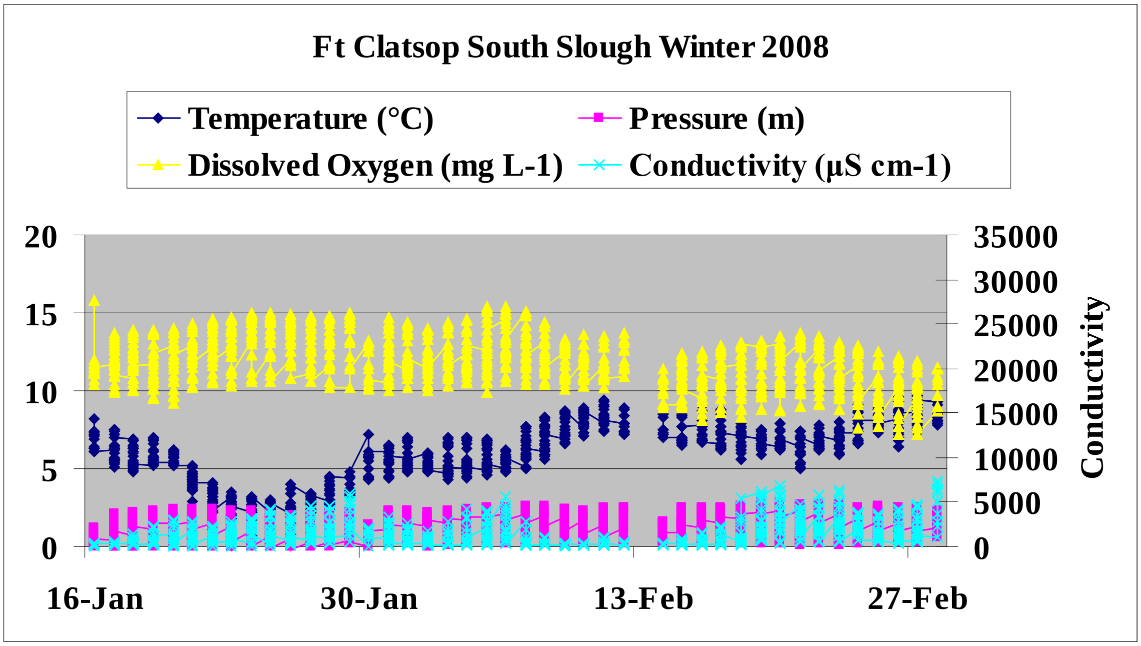


Figure 59. Winter water quality results for Fort Clatsop South Slough, 2008

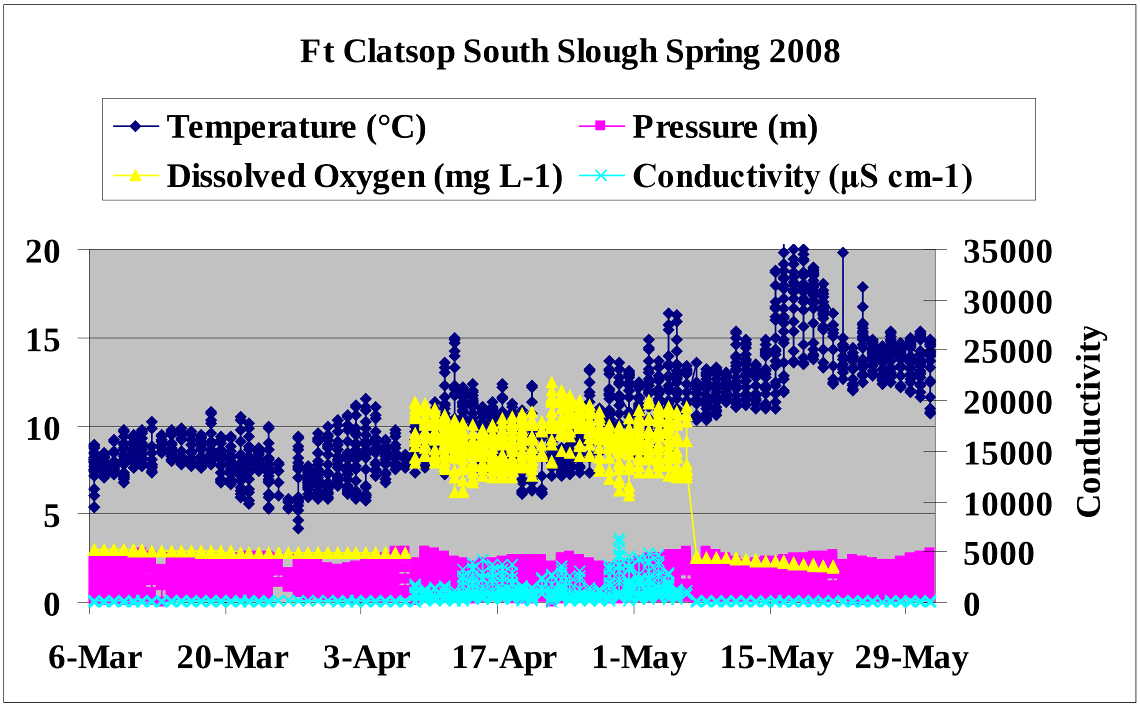


Figure 60. Spring water quality results for Fort Clatsop South Slough, 2008

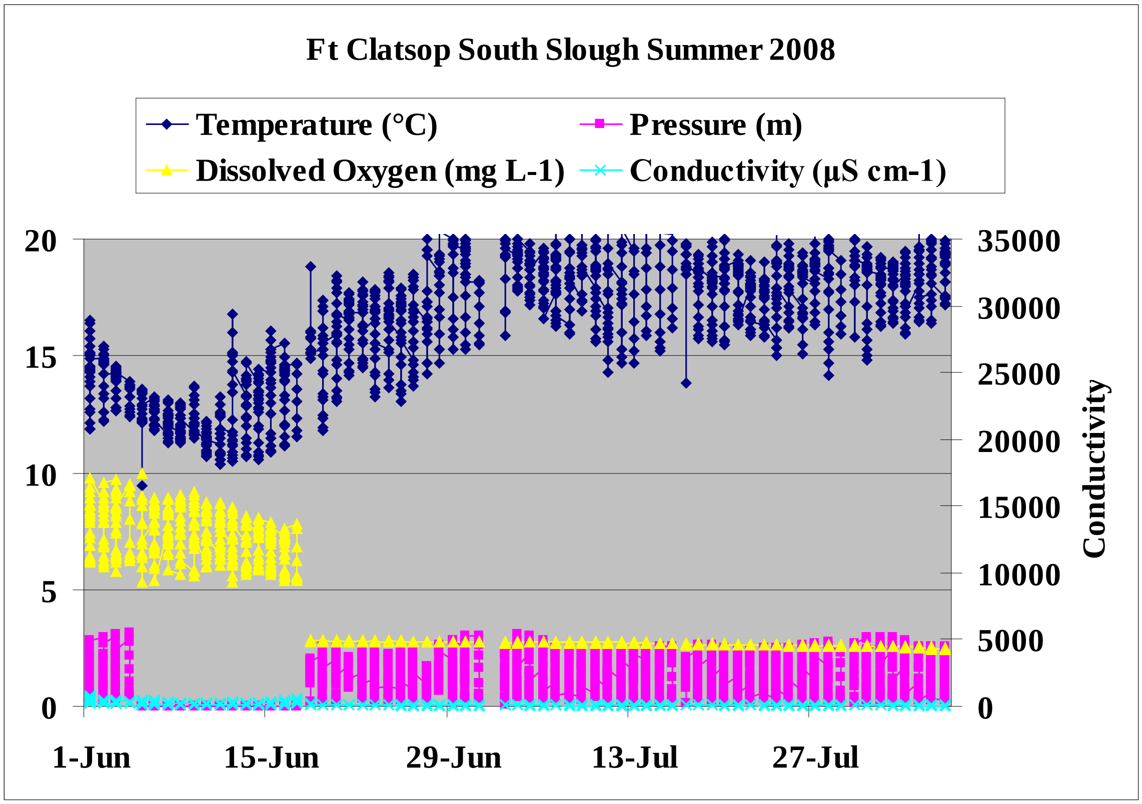


Figure 61. Summer water quality results for Fort Clatsop South Slough, 2008

Ft Clatsop Reference Slough

In 2010, reference site water quality data was compromised when retrieval of the new unit revealed a factory malfunction. The unit has since been repaired and redeployed. In 2009, reference site temperature and dissolved oxygen levels showed similar seasonal and tidal trends to the restoration site, but conductivity was much higher in the summer than spring at the restoration site (CREST, 2009). Depth data for the reference site has not been adjusted for atmospheric pressure or probe elevation. We did not deploy a water quality instrument at the reference slough in 2008.

6.0 Vegetation and Habitat AEM at Scappoose Bottomlands

6.1 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 re-vegetation 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.

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 qualty 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. This water quality monitoring was conducted to characterize basic water quality conditions important to salmonids and identify changes in these conditions as an indicator of changing salmonid habitat quality due to livestock exclusion. Monitoring water quality early in the restoration process allows baseline parameter levels to be established and changes to be identified as the restoration sites change over time.

In 2008 through 2010, 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.

6.2 Site and Restoration Description

Scappoose Bay Bottomlands

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.

Hogan Ranch

Hogan Ranch lies north of the city of Scappoose, between Scappoose Creek (to the east) and Multnomah Channel (to the west; Figure 62). This area has low alluvial rolling plains with numerous ponds, creeks and sloughs (DEA 2000). Restoration of these wetland Ponds has been conducted in partnership with Lower Columbia River Estuary Partnership (LCREP), Oregon Watershed Enhancement Board (OWEB), Natural Resources Conservation Service (NRCS), the Wetlands Conservancy, Ducks Unlimited, Bureau of Land Management (BLM), Hogan Ranch and the Scappoose Bay Watershed Council. In 2004 the NRCS acquired a conservation easement for the property through the Wetlands Reserve Program on Hogan Ranch. LCREP provided funding for the establishment of monitoring sites within the easement and pre-restoration site monitoring in 2004. In 2005 fencing was installed around the easement, partially excluding livestock. In 2007 additional fencing was installed and livestock were fully excluded from the restoration area. In 2007 Ducks Unlimited replaced the failed water control structures on Ponds 1 and 2, removed a dike on the south end of Pond 2 and excavated the west side of Pond 2 to create additional wetlands (Pond 3 has maintained natural hydrology throughout the restoration process). The excavated areas were seeded with native wetland plants. In 2007, 2008 and 2009 native trees and shrubs were planted around the Ponds. In 2007, 2008, 2009 and 2010 native plantings were maintained by mowing and weed suppression. LCREP, Ducks Unlimited, NRCS, Wetlands Conservancy and BLM assisted in the project development stage of the restoration. LCREP and OWEB provided funding for restoration of the plant communities, additional fencing and maintenance. LCREP funded the restoration site monitoring.

For this action effectiveness monitoring effort, all 3 major ponds (referred to as Ponds #1, #2, and # 3) are being evaluated. This area consists of seasonal and perennial wetlands and ash forests. The water levels of Ponds 1 and 2 are controlled by two water control structures (Figure 62). However, both ponds are subject to sheet flows and tidal influence during high water events. Pond 3 lies on the eastern edge of the property and has natural tidal hydrology year round (Figure 62). According to the Cowardin estuarine wetland classification system, Pond 1 is classified as seasonally flooded forested and emergent wetland (Cowardin et al. 1979). Pond 2 is considered a partial seasonal and partial permanently flooded wetland (Cowardin et al. 1979). Pond 3 is classified as a sub-tidal, semi-permanently flooded emergent wetland (Cowardin et al. 1979). Pond 1and 2's water levels are controlled during the dry season by the water control structures located at the northwest corner of Pond 1 and northern end of Pond 2 (Figure 62). The immediately surrounding fields (meadows) of all three Ponds are irregularly flooded during high water events (Cowardin et al. 1979). Before the water control structures were replaced, Pond 1 tended to dry up by late summer and Pond 2 (which is deeper than Pond 1) tended to hold water throughout the year.

Scappoose Creek (Wilson/LaCombe Properties)

The Scappoose Creek riparian vegetation restoration project is located on two adjacent private properties (Wilson and LaCombe) which compose a total of 18.5 acres (Figure 63). Scappoose Creek runs along these properties' northern border for approximately 560 meters (Figure 63). The restoration area can be described as part of the low alluvial rolling plains forming Scappoose Creek's flood plains (DEA 2000). This section of Scappoose Creek has a very low gradient, a deep fine sediment base and is tidally influenced year round. The surrounding area is subject to sheet flows several times each year during winter high water events. According to the Cowardin wetland classification system this site is classified as a riverine landscape with persistent emergent vegetation and the adjacent fields are irregularly flooded (Cowardin et al. 1979).

Riparian vegetation restoration was conducted along the stream's south edge (8-10 meters wide) for a total of approximately 1 acre of riparian plantings (Figure 63). Prior to restoration this area was used for pasture and agriculture (hay crops). The pasture and hay planting areas are now backset from the stream's edge and restoration vegetation is fenced to protect it from grazing. Through a partnership between the landowners, Scappoose Bay Watershed Council (SBWC), Oregon Watershed Enhancement Board (OWEB), and the Lower Columbia River Estuary Partnership (LCREP) the restoration area was fenced (to exclude livestock) in 2006, and then planted with native riparian vegetation in 2007 and the spring of 2008. Before restoration there was only one tree providing canopy cover (within the restoration area) along this section of stream and non-native species such as reed canarygrass (*Phalaris arundinacea*), oxeye daisy (*Leucanthemum vulgare*), curly dock (*Rumex crispus*), Canada thistle (*Cirsium arvense*), and Himalayan blackberry (*Rubus armeniacus*) dominated the site (Figure 63) (SBWC Planting Survival Report 2010). As the restoration plantings mature it is expected that the riparian area will become fully shaded and non-native species will be suppressed. The nature of riparian restoration work makes it difficult to observe significant habitat and water quality changes over a short period of time (Dosskey et al. 2010). Monitoring water quality conditions and documenting changes on the site with photo points will help determine the long-term impacts of these restoration efforts.

6.3 Methods

6.3.1 Water Quality Monitoring

Water quality monitoring was conducted following the methods and protocols laid out by the Oregon Department of Environmental Quality (ODEQ) and the Oregon Watershed Enhancement Board (OWEB) for measuring water temperature, specific conductance, pH, dissolved oxygen, bacteria, depth and turbidity (OWEB 2001). See Table 24 for specifics on equipment used and accuracy ranges of each parameter measured. Monthly (approximately every 4 weeks) water chemistry monitoring was conducted and continuous water temperature and depth data (from data loggers) was obtained year round. This was done to characterize water-quality conditions while juvenile salmonids were present, extending through migration and thereafter. Monthly water quality tests were conducted on samples of water taken from the same sample location of all three Ponds throughout the study period (Figure 62). Continuous data loggers were placed in Teal Creek and Crooked Creek (Figure 62). Monthly water quality tests were conducted on samples of water taken from Scappoose Creek at the downstream corner of the Wilson property (GIS # SSCA01) and the upstream corner of the LaCombe property (GIS # SSCA05) (Figure 63). Continuous data loggers were placed near the Wilson property monthly water quality testing site (Figure 63).Water quality data was summarized and compared to standard parameter ranges for ideal salmonid habitat as defined by the ODEQ, OWEB and Environmental Protection Agency (EPA) (EPA 2001, OWEB 2001, ODEQ 2003).

Water Quality Parameter	**Equipment**	**Accuracy**
Water Temperature	HOBO Data Logger and YSI 30 Conductivity Meter	(+/-) 0.5 °C
Air Temperature	NIST Digital Thermometer	(+/-) 0.5 °C
Dissolved Oxygen	Hach Dissolved Oxygen Titration Kit	(+/-) 0.3mg/l (ppm)
pH	Orion pH meter	(+/-) 0.2 pH
Turbidity	Hach Turbidity Meter	(+/-) 5% of standard value (NTU)
Specific Conductance (Conductivity)	YSI 30 Conductivity Meter	(+/-) 7% of standard value (µS/cm)
Depth	HOBO Data Logger	(+/-) 0.5 cm water

Bacteria and E. Coli Counts	IDEXX Quanti-Tray 2000® MPN	(+/-) 0.5 log

Table 24. Water quality parameters measured, equipment used and accuracy standards (ODEQ A level data quality standards) (OWEB 2001).

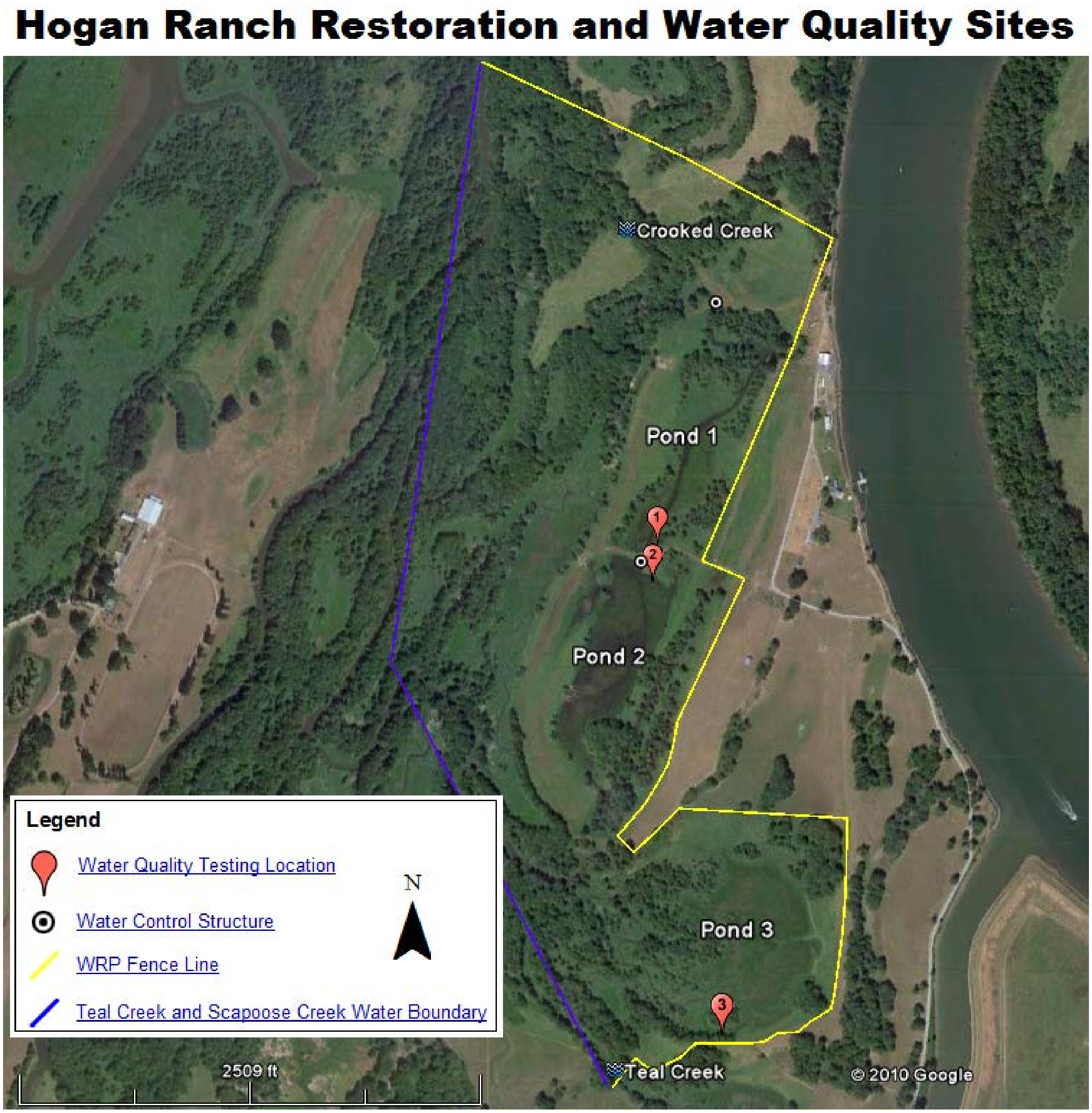


Figure 62. Location of restoration wetland Ponds 1-3, as well as location of water control structures, water quality grab sample sites, and data logger sites along Teal and Crooked Creek.

Scappoose Creek Riparian Restoration and Water Quality Sites

Figure 63. Map of Scappoose Creek Riparian Restoration Area and Water Quality Testing Sites

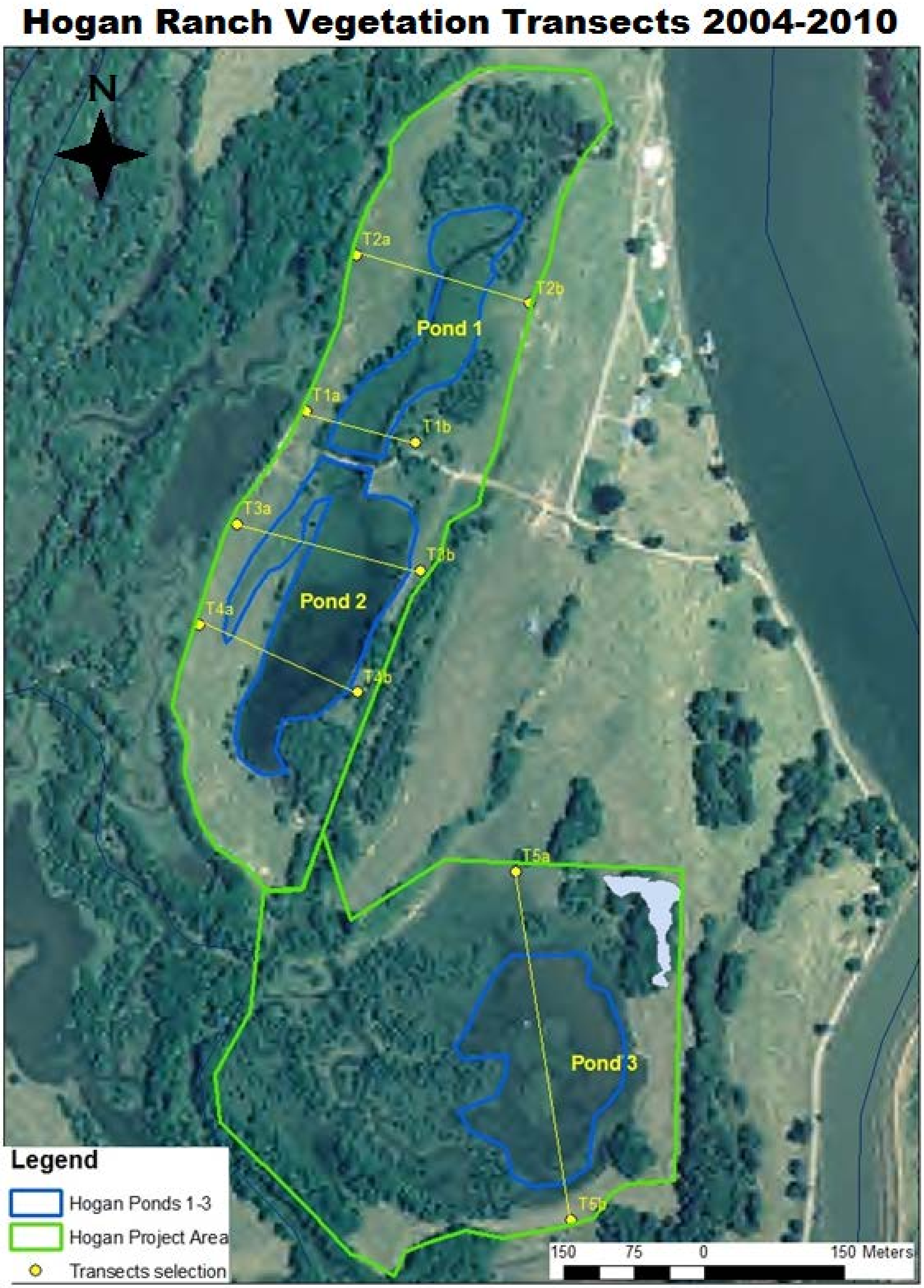


Figure 64. Location of vegetation community transects in the three Ponds on Hogan Ranch

6.3.2 Vegetation Community Monitoring Methods

The Scappoose Bay Watershed Council has conducted late summer vegetation monitoring of these sites from 2004-2005 and 2008-2010. Five transects were established in 2004, three years before restoration, and permanently marked. Subsequent monitoring in 2005 (two years before restoration efforts began), 2008 (one year after construction phase), 2009 (two years after construction) and 2010 (three years after construction) used the same transects (Figure 64).

In 2004, three years prior to restoration, transects were permanently established through each Pond (Figure 64). Pond 1 and Pond 2 have 2 transects and Pond 3 has 1 transect. The number and location of transects were determined through field surveying of each Pond to identify the best location for each transect to represent the larger Pond area. These transects were situated across each Pond to capture the wetland plant communities on either side and through the middle of each Pond (Figure 64). The simple basin topography of each Pond leads to clear bands of dominant vegetation ringing the central Pond depression. The vegetation communities change abruptly along this hydrologic gradient. The vegetation varies from a mix of upland and facultative upland pasture grasses, to a band of facultative wetland grass with a sparse willow overstory, to an obligate wetland marsh edge community, to the submerged and floating vegetation in the wetted area of the Pond. This pattern is reflected on both sides of the Pond. The transects run across each Pond and intersect each of the upper rings of vegetation twice. Vegetation composition and wetland plant community width were monitored along the transects in 2004 and from 2008 through 2010. In 2005 vegetation composition data was collected but no community widths were reported.

Vegetation surveys were conducted in August during the driest part of the year allowing for the best access to the Pond wetland areas. A vegetation survey was conducted along each transect by first identifying the vegetation communities found along each transect and then collecting vegetation composition data for each community. Vegetation communities were identified as facultative upland (FACU): grasses and forbs, facultative wetland (FACW): grasses and forested, facultative wetland (FACW)/obligate wetland (OBL): marshy shore, or obligate wetland (OBL): floating and submerged (wetted area). These vegetation communities were identified visually based on changes in dominant vegetation wetland indicator status (WI) and soil moisture along each transect. A plant’s WI status is commonly used to determine the likeliness of the plant to grow in different wetland conditions (saturated, anoxic soil), based on the species tolerance to flooding (Table 25, Tiner 1991, Welch et al. 2006).

Table 25. Wetland Indicator Categories (Tiner 1991)

Wetland indicator category	Estimated probability of occurrence in wetlands	Estimated probability of occurrence in nonwetlands
Obligate wetland (OBL)	>99%	<1%
Facultative wetland (FACW)	67–99%	1–33%
Facultative (FAC)	34–66%	34–66%
Facultative upland (FACU)	1–33%	67–99%
(Upland (UPL)	<1%	>99%)

The width of each community along the transect was recorded in 2004 and from 2008 through 2010 (no community widths were recorded in 2005).

Within each identified community, 50cm x 100cm quadrant plots were randomly established within a 2 meter band extending on both sides of the transect. The random location of the plots was determined by tossing the plot frame along the transect with closed eyes. The number of plots in each community varied by the width of each community sampled along the transect. Wider communities were sampled more times than narrow communities, with plots being distributed in a random systematic fashion along the transect through each community. In 2010 vegetation plots were randomly tossed every 5 meters along each transect and plot (meter) locations along the transect were recorded. This change in methodology for locating vegetation plots was done to increase the resolution of vegetation data collected and enable GIS mapping of the data. Plot locations differ between years because they were placed with random tosses at each sampling time. The number of plots in each community also varied between years as community widths changed in response to changes in hydrology (Table 26) and plant community width. The 2010 change in plot location methodology increased the number of plots measured in each community (Table 26).

Plant cover (species of all heights, up to 2 meters) of every plant species rooted in the quadrant was recorded for every plot, and when possible plants were identified to species. Taxonomic guides to regional flora were consulted; Hitchcock and Cronquist (1973), Pojar and MacKinnon (1994), and Guard (1995), to help with species identification and to determine native or non-native (introduced) status of each plant species. Native, non-native and invasive status determination, in addition to the wetland indicator status of each plant species was also identified using the online NRCS PLANTS database (http://plants.usda.gov). Water depth and canopy cover of plots were also recorded when applicable. When deep water and/or mud made it impossible to access the central areas of the Ponds, community composition was estimated visually from the edge of the Pond and the width of the inaccessible area was estimated by subtraction from the total transect length, determined with a rangefinder.

Pond	**Community**	**No. plots 2010**	**No. plots 2009**	**No. plots 2008**	**No. plots 2005**	**No. plots 2004**
1	FACU grasses and forbs (I and C)	15	12	8	5	5
	FACW grasses/ forested fringe (H and D)	29	6	6	4	4
	Marshy shore (G and E)	9	9	4	5	7
	Wetted area (F)	35	8	6	1	0
2	FACU grasses and forbs (I and C)	7	10	7	5	6
	FACW grasses/ forested fringe (H and D)	19	0*	1	2	2
	Marshy shore (G and E)	6	8	5	2	3
	Wetted area (F)	31	9	7	1	5
3	FACU grasses and forbs (I and C)	0^+	4	1	3	0
	FACW grasses/ forested fringe (H and D)	9	0*	3	1	3
	Marshy shore (G and E)	9	4	2	1	4
	Wetted area (F)	0^+	4	1	0	2

Table 26. Sampling effort associated with each vegetation community in three Ponds on Hogan Ranch, * In 2009 the FACW and Marshy shore plant communities were not distinguishable in Ponds 2 & 3. $^+$In 2010 the FACU community was not distinguishable in Pond 3and vegetation within the wetted area was not accessible.

6.3.3 Vegetation Cover Methods

Plot vegetation cover was summed and averaged by plant community to determine the overall % cover represented by each plant in the vegetation communities for each Pond. When the estimated cover was less than 1%, it was recorded as 0.5%, which allowed more ease of calculation than classifying it as "trace". Species with total cover less than 1% were recorded as "trace (T)" in the final data table after all calculations were complete.

Diversity

Native and non-native (introduced) plant species richness and relative cover were calculated for each Pond. Plant community diversity was determined by calculating the species richness along each transect. Species richness is defined as the total number of species in a given area and weights all species equally (Ludwig and Renolds 1988, Chaneton and Facelli 1991). Percent relative cover was calculated for all plant species along each transect to determine species dominance. Percent relative cover was calculated by dividing the total percent cover of an individual plant species within each plant community by the total percent cover of all plant species found within that plant community. Plant species with the highest relative percent cover on a transect were considered dominant.

Data were analyzed by comparing plant species cover and diversity in each community at each Pond. This allowed us to look for changes in native richness and wetland status between monitoring years. Additionally, we 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. Since the transects intersect each of the outer rings of vegetation twice, plant communities were recorded separately in the field. Recurrent communities were combined for the purposes of data analysis when no significant differences emerged between sides of the Pond.

6.3.4 Photo Point Monitoring Methods

Photo point monitoring protocols have been adapted from those outlined in the Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program (PNNL-17300, 2008, p18, Table 2). These locations have been established with GPS locations. Photos are taken at 90˚ intervals (4 pictures) at each site once each season for a total of 4 times per year. The photo points were established to track long term changes to the environment along the stream channel. While out in the field wildlife observations were also recorded (a note of the species and number of wildlife observed was taken).

6.3.5 Plantings Survival Monitoring Methods

Survival monitoring was conducted in mid-late August of 2010, 2009 and 2008 after summer mowing. Sites are mowed once or twice a year to control the non-native reed canarygrass (*Phalaris arundinacea)* herbaceous layer. Without mowing reed canarygrass can overgrow and suppress the plantings, causing poor planting vigor and mortality (Lavergne and Molofsky 2004, WRMWG 2009).

At each site, we followed the current protocols recommended by LCREP (Roegner et al. 2008) as closely as possible. The riparian planting site, Wilson/LaCombe, has plantings in a very narrow strip (4-5m) running along Scappoose Creek (Figure 65). The Wilson/LaCombe riparian plantings consisted of a dense mixture of riparian under and overstory plants. It was not possible to implement the monitoring protocol calling for a baseline and perpendicular transects at this site because of the size and shape of the planted area. We instead chose to place plots systematically from a random start in a path parallel to the creek. Property fence lines mark the starting and ending points of the planted area at this site. Plots were located every 50m along the length of the planted area (Figure 65), starting at the property line. The initial plot starting point was determined by choosing a number from a random number table. We assessed planting survival and vigor at a total of twelve 8m diameter plots (total area of 50 m^2 per plot) on this site; the number of plots was chosen based on the guidelines in Roegner et al. 2008 for this 0.4 ha project site.

At the second site, Hogan Ranch Pond 3, the planted area was wider, but irregularly shaped. We were able to use the baseline and transect sampling design for this area, but had to modify transect widths and locations along the baseline to conform to the planted area. On Hogan Ranch, plantings are composed of ash forest, willow, and shrub communities. We 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, we assessed planting survival and vigor at 62 plots (compared to 62 in 2009 and 54 in 2008) on this site

(Figure 66); this met the recommendations in Roegner (2008) for this 6.75 ha planting area. The locations of the survival monitoring baselines were changed slightly from 2008 to 2009 which accounts for the additional 8 plots assessed in 2009 and 2010. This slight adjustment in baseline location was done to establish a better representation of the larger planted area. In 2010 baselines on Hogan Ranch were permanently marked with fence stakes for easier long term identification and monitoring.

Total surveyed planting survival was calculated as the total number of living plants surveyed divided by the total number of plants (dead and living) surveyed. High, medium and low vigor was assessed qualitatively in the field. An estimate of plants per acre (plants/acre) was calculated by dividing the total number of plants surveyed by the total plot area (acres) surveyed on the site. Average planting density (APD) was calculated as the average of the density of plantings in each plot (plants/m^2). An increase in APD year to year can result from adding new plantings to the survey area, while a decrease in APD can result from plants missed in the survey due to mortality. APD can also vary from year to year due to the random placement of survey plots. Plantings are clustered in some places at Hogan Ranch and these planting clusters may or may not be captured from year to year depending on the plot placement. In addition to monitoring survival and vigor of plantings at each site dominant herbaceous vegetation and overstory canopy cover was visually estimated at each plot.

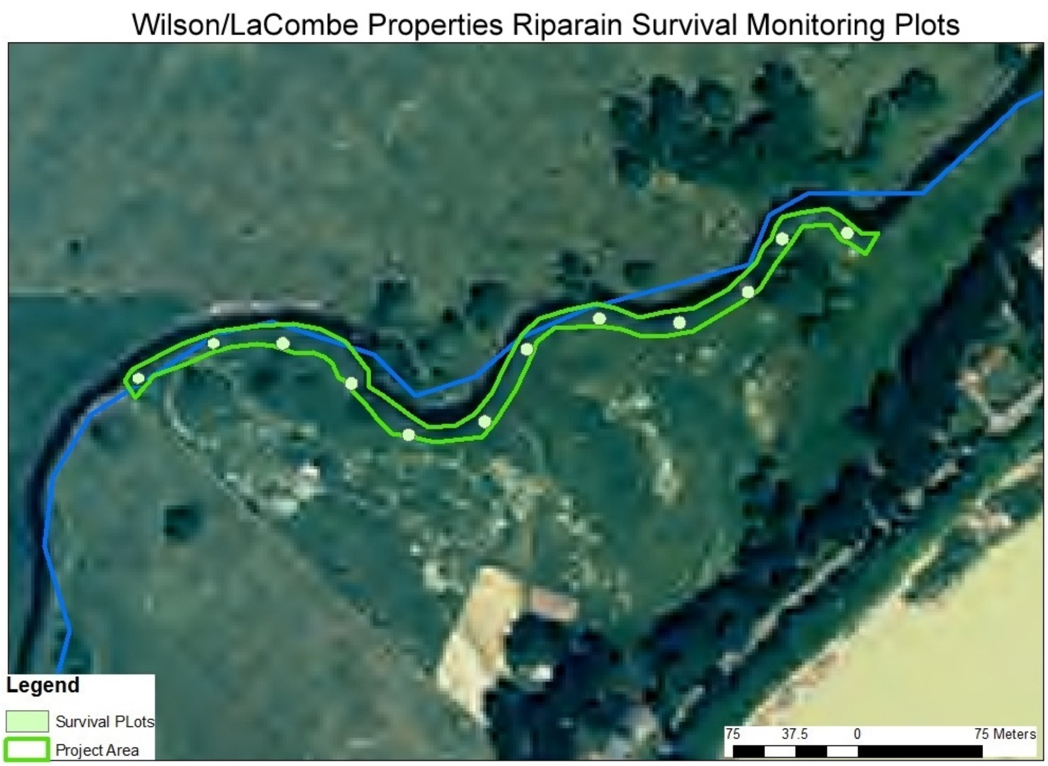


Figure 65. Planted area and approximate location of survival monitoring plots 2008-2010 Wilson/LaCombe property, Scappoose Creek.

Figure 66. Approximate location of plots for monitoring vegetation survival on Hogan Ranch Pond 3 for 2009 and 2010.

6.4 Water Quality Results

6.4.1 Monthly Water Quality Data

Hogan Ranch

Water temperature varied seasonally at both sites and was closely related to average air temperature (Figure 67). Air temperature was taken at all sites and then averaged to represent the overall approximate air temperature of the larger restoration area (Figure 67). Between June 2007 and August 2010 the average air temperature ranged from 29.8°C in July 2007 to 3.4°C in January 2009 (Figure 67). The water temperature in Pond 1 ranged from 27°C in July 2007 to 5.3°C in January 2008 (Figure 67). The water temperature at Pond 2 ranged from 24.2°C in August 2008 to 5.9°C in January 2009 & 2010 (Figure 67). The water temperature at Pond 3 ranged from 24.7°C in July 2007 to 5°C in January 2009 (Figure 67). Over the study period the warmest temperatures (>18°C) were observed from May through September. During July through September 2007, July and August 2008, May through September 2009 and June through August 2010 the water temperature was (close to or) greater than 18°C, which is not optimal for salmonids (Figure 67, ODEQ 2003). No major differences in water temperature were observed between sites and/or across years (Figure 67).

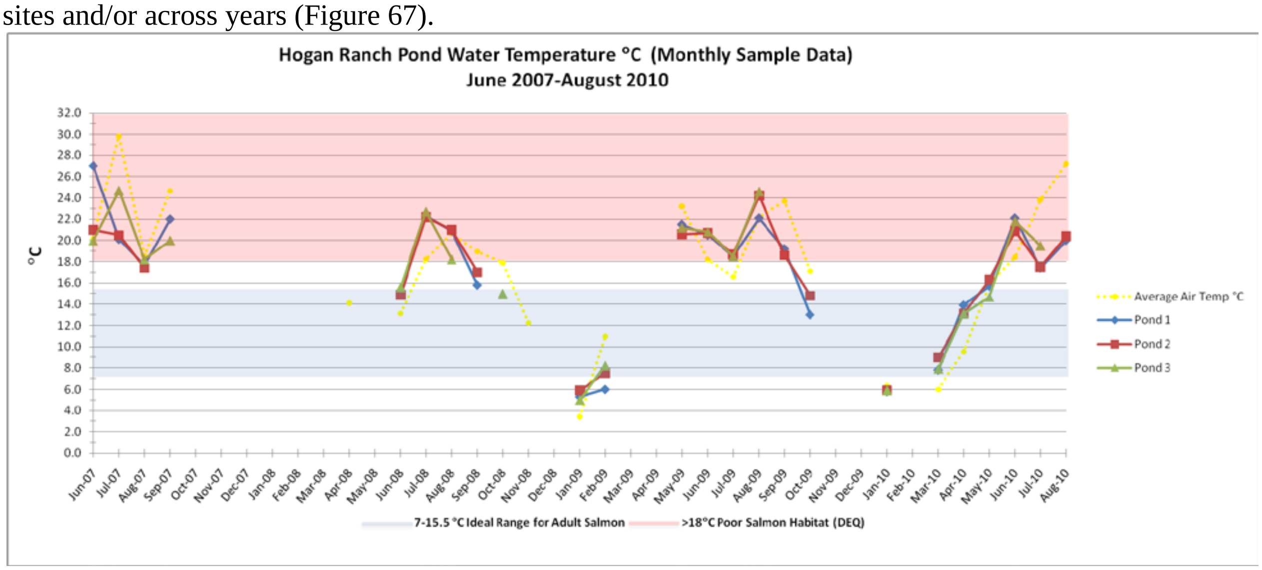


Figure 67. Hogan Ranch Ponds monthly water temperature and average air temperature data for June 2007-August 2010. Gaps in graph indicate no data was collected for those months. Water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

The concentration of dissolved oxygen (DO) in the water varied seasonally at both sites, with higher DO concentrations in the cooler winter months and lower DO concentrations in the warmer summer months (Figures 67 and 68). Diel fluctuations in DO were observed in all of the Ponds which is typical in these environments (Egna and Boyd 1997). Between June 2007 and August 2010 the DO concentration in Pond 1 ranged from 14.65 ppm in September 2009 to 1.5 ppm in July 2010 (Figure 68). The DO concentration in Pond 2 ranged from 2.67 ppm in July 2009 to 11.04 ppm in February 2009 (Figure 68). The DO concentration in Pond 3 ranged from 2.57 ppm in June 2010 to 17.76 ppm in July 2009 (Figure 68). Pond 3 had a higher average DO concentration (7.9 ppm) than both Pond 1 (6.2 ppm) and Pond 2 (6.5 ppm) which had similar DO concentrations throughout the study period. In 2009 and 2010 larger fluctuations in

DO were observed in all Ponds (Figure 68). No other major changes in DO concentrations were observed between sites and/or across years (Figure 68).

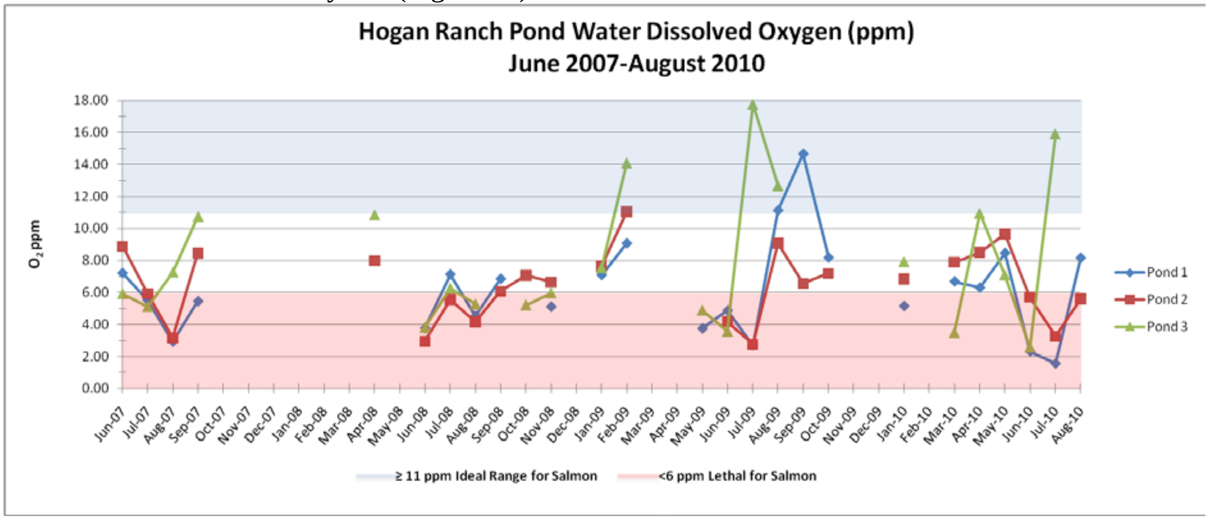


Figure 68. Hogan Ranch Ponds monthly dissolved oxygen (ppm) data for July 2008-August 2010. Gaps in graph indicate no data was collected for those months. Water dissolved oxygen concentrations ≥11ppm are considered ideal for salmonids (ODEQ 2003) and dissolved oxygen concentrations <6 ppm are considered lethal for salmonids (OWEB 2001).

Pond water pH levels were similar between sites and stayed within the salmon tolerance range between 8.5 and 6.5 pH for the majority of the study period (Figure 69). Between June 2007 and August 2010 Pond 1 had an average pH level of 6.9 and ranged from 7.73 in September 2009 to 6.02 in January 2009 (Figure 69). Pond 2 had an average pH of 7 and the pH ranged from 7.99 in September 2007 to 6.25 in July 2007 (Figure 69). Pond 3 also had an average pH of 7. In 2009 and 2010 Pond 3 had the largest pH fluctuations of all the ponds ranging from 9.3 in July 2009 to 5.99 in March 2010 (Figure 69). No other major changes in pH levels were observed between sites and/or across years (Figure 69).

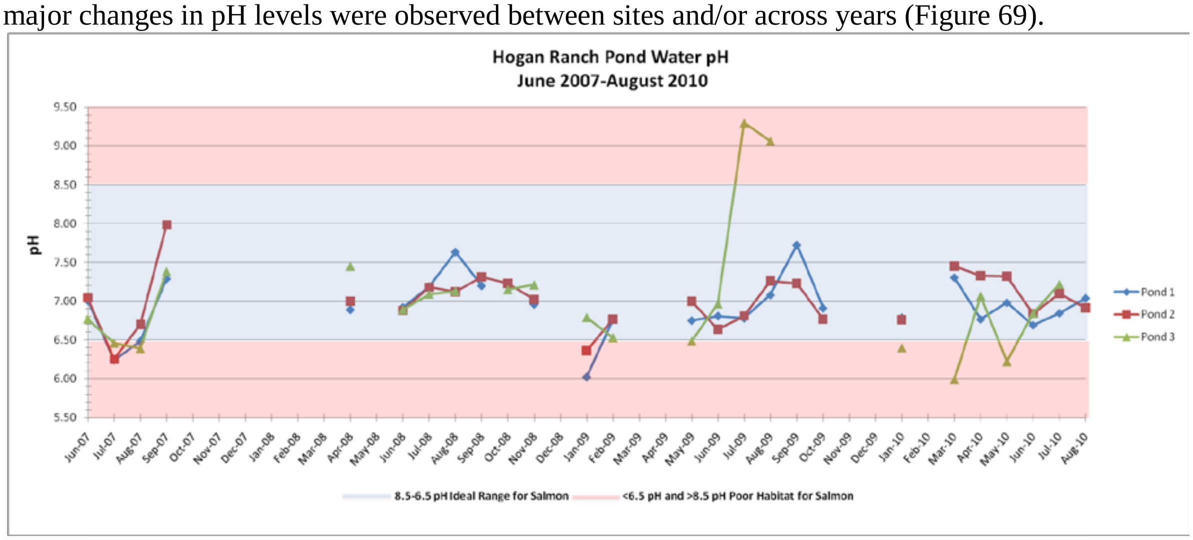


Figure 69. Hogan Ranch Ponds monthly pH data for July 2008-August 2010. Gaps in graph indicate no data was collected for those months. Water pH levels between 8.5-6.5 are considered ideal for salmonids and water pH <6.5 or >8.5 are considered poor for salmonids (OWEB 2001, ODEQ 2003).

Pond water turbidity (NTU) levels were similar between sites, with high NTU levels during the summer months corresponding with high summer algal levels (Figure 70). Between June 2007 and August 2010 the turbidity levels in Pond 1 ranged from 51.9 in August 2008 to 2.85 in October 2009 with an average turbidity of 18.5 NTU (Figure 70). The turbidity levels in Pond 2 ranged from 83.25 in August 2009 to 3.01 in June 2009 with an average turbidity of 21.8 NTU (Figure 70). The turbidity levels in Pond 3 ranged from 50.7 in July 2010 to 4.6 in June 2009 with an average turbidity of 20 NTU (Figure 70). Overall turbidity levels were typically greater than 10 NTUs in all of the Ponds which is considered unhealthy for salmonids (UWE 2006). In 2010 turbidity levels in Ponds 1 and 2 were lower during the spring and summer months (March – July) than previous years (Figure 70). No other major changes in turbidity levels were observed between sites and/or across years (Figure 70).

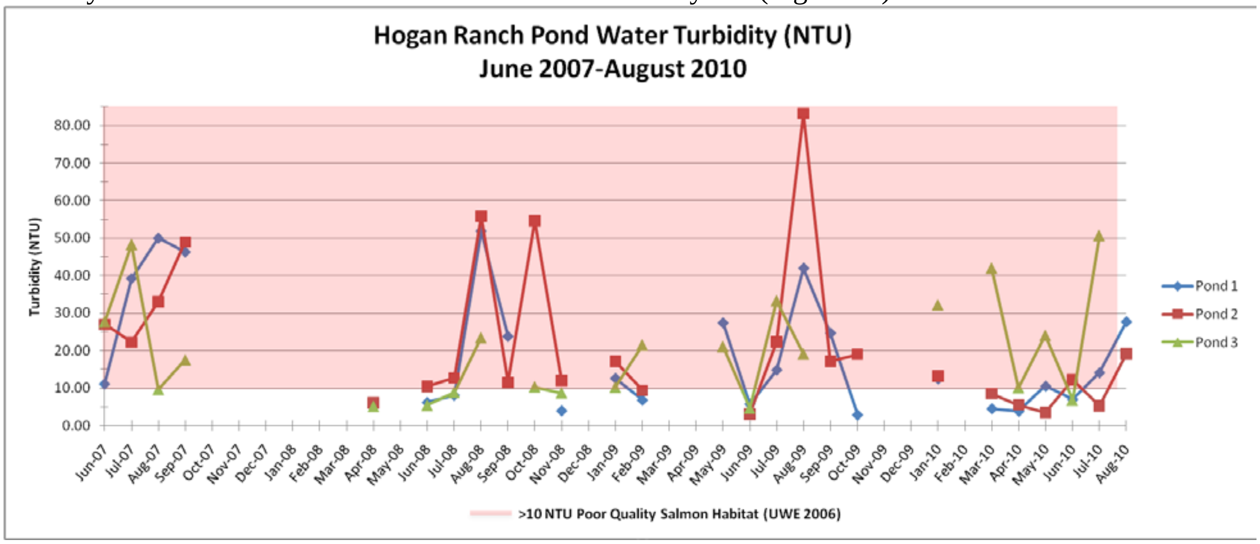


Figure 70. Hogan Ranch Ponds monthly turbidity (NTU) data for July 2008-August 2010. Gaps in graph indicate no data was collected for those months. Water turbidity >10 NTUs is considered poor for salmonids (UWE 2006).

Between June 2007 and August 2010 the conductivity levels of Pond 1 ranged from 205.8 µS/cm in September 2008 to 57.7 µS/cm in January 2010 with an average of 114.2 µS/cm (Figure 71). The conductivity levels of Pond 2 ranged from 146.5 µS/cm in September 2008 to 59.5 µS/cm in January 2010 with an average of 105.3 µS/cm (Figure 71). Pond 3 conductivity levels ranged from 298.5 µS/cm in March 2010 to 35.6 µS/cm in October 2008 with an average of 129.8 µS/cm (Figure 71). Over the study period all of the sites' conductivity levels were on average less than 150 µS/cm which is considered typical for the Willamette Basin and the North Coast regions (OWEB 2001). Throughout the study period pond water conductivity (µS/cm) levels were similar between Ponds 1 and 2 (Figure 71). Pond 3 had higher fluctuations in conductivity levels than Ponds 1 and 2, with several readings over 250 µS/cm in 2009 and 2010 (Figure 71).

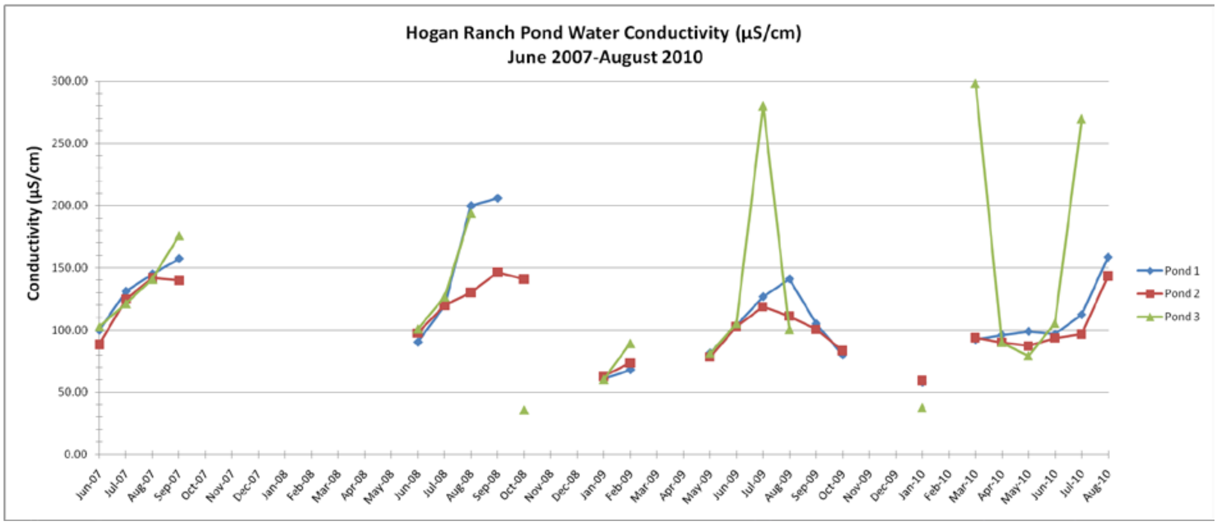


Figure 71. Hogan Ranch Ponds monthly conductivity (µS/cm) data for June 2007-August 2010. Gaps in graph indicate no data was collected for those months. Water conductivity <150 µS/cm is considered typical for the Willamette Basin and the North Coast (OWEB 2001).

Bacteria levels within Ponds 1-3 were monitored from June 2008 through August 2010. E. coli (*Escherichia coli*) bacteria are used as indicator organisms for fecal contamination. High E. coli levels in water ways and ponds is associated with poor water quality (possible harmful bacteria presence) for human exposure (OWEB 2001). The ODEQ recommends no single water sample should exceed an E. coli MPN of 406 MPN/100mL and the EPA recommends that water should not exceed 235 MPN/100 mL (EPA 2001, ODEQ 2003). Between June 2008 and August 2010 the average E. coli MPN of Pond 1 was 147 MPN/100mL and the E. coli MPN ranged from 980.4 MPN/100mL in June 2009 to 2 MPN/100mL in April 2010 (Figure 72). Over the study period Pond 2 had an average E. coli MPN of 112.2 MPN/100mL and a range of 613 MPN/100mL in October 2008 to 1 MPN/100mL in January 2010 (Figure 72). Pond 3 had an average E. coli MPN of 144.2 MPN/100mL and a range of 1203 MPN/100mL in October 2008 to 3.1 MPN/100mL in February 2009 (Figure 72). All Ponds showed a decrease in E. coli bacteria levels between 2008 and 2010 (Figure 72). During the 2010 study period none of the Ponds had E. coli bacteria levels over 224.7 MPN/100mL and all Ponds averaged less than 50 MPN/100mL for the year (Figure 72).

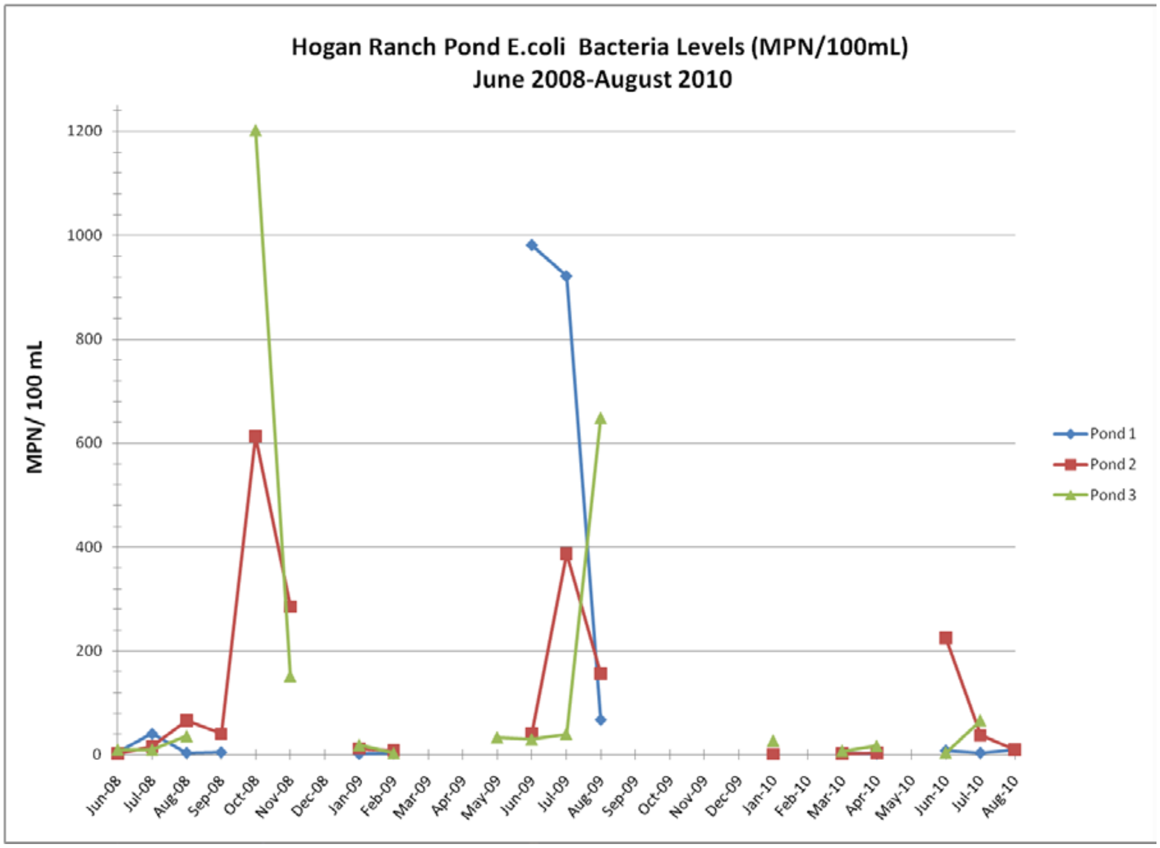


Figure 72. Hogan Ranch Pond E. coli levels (MPN/100mL) between June 2008 and August 2010.

6.4.2 Data Logger Water Quality Data

Figures 73-88 show the water temperature and water depth data collected hourly from Teal Creek and Crooked Creek during the 2008 through 2010 study period. Data was collected from Teal Creek between July 16, 2008 through August 19, 2010 during four study periods: July 16, 2008 through September 10, 2008, September 10, 2008 through February 16, 2009, February 16, 2009 through October 6, 2009, October 6, 2009 through March 15, 2010 and March 15, 2010 through August 19, 2010. Depth data was not collected until the 2008 study season. Data was collected from Crooked Creek between February 16, 2009 through August 19, 2010 during three study periods: February 16, 2009 through October 6, 2009, October 6, 2009 through March 15, 2010 and March 15, 2010 through August 19, 2010. Throughout the study periods seasonal variation in the continuous water temperature and depth data was observed in both streams. According to the ODEQ salmonid spawning occurs in this watershed between January 15th through May 15th. During spawning water temperatures need to remain below 13°C to be classified as healthy salmon habitat (ODEQ 2003). To protect salmonids and other cold water fish species ODEQ has established a maximum total maximum daily load (TMDL) of 18°C (over a 7 day period) for streams throughout the year.

During the study period July 16, 2008 through February 16, 2009 the temperature was over 18°C in Teal Creek for 70 days occurring during the months of July 2008 through October 2008. During the study period February 16, 2009 through October 6, 2010 the temperature was over 18°C in Teal Creek for 146 days and in Crooked Creek for 106 days. During the study period October 6, 2009 through March 15, 2010 the temperature did not go over 18°C in either Teal or Crooked Creek. During the study period March 15, 2010 through August 19, 2010 the temperature was over 18°C in Teal Creek for 90 days and in Crooked Creek for 61 days. During the 2009 and 2010 spawning seasons stream temperatures were above 13°C during the months of April and May in both streams (Figures 73-88). Water depth varied seasonally in both streams with high levels (average >1 meter) observed late April 2009 through June 2009 and June 2010. Low water levels (average < 1 meter) were observed between July 2009 through May 2010 and July 2010 through August 2010.

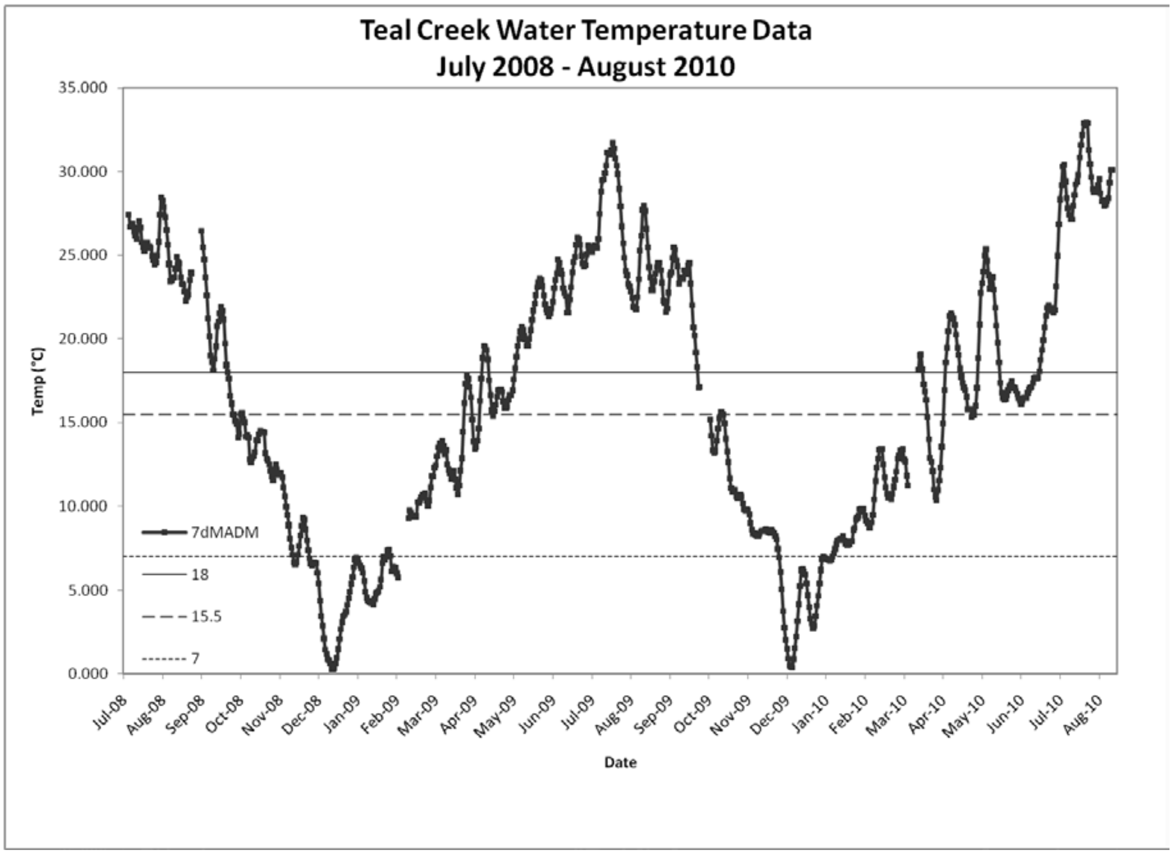


Figure 73. Teal Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) from July 16, 2008 through August 19, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

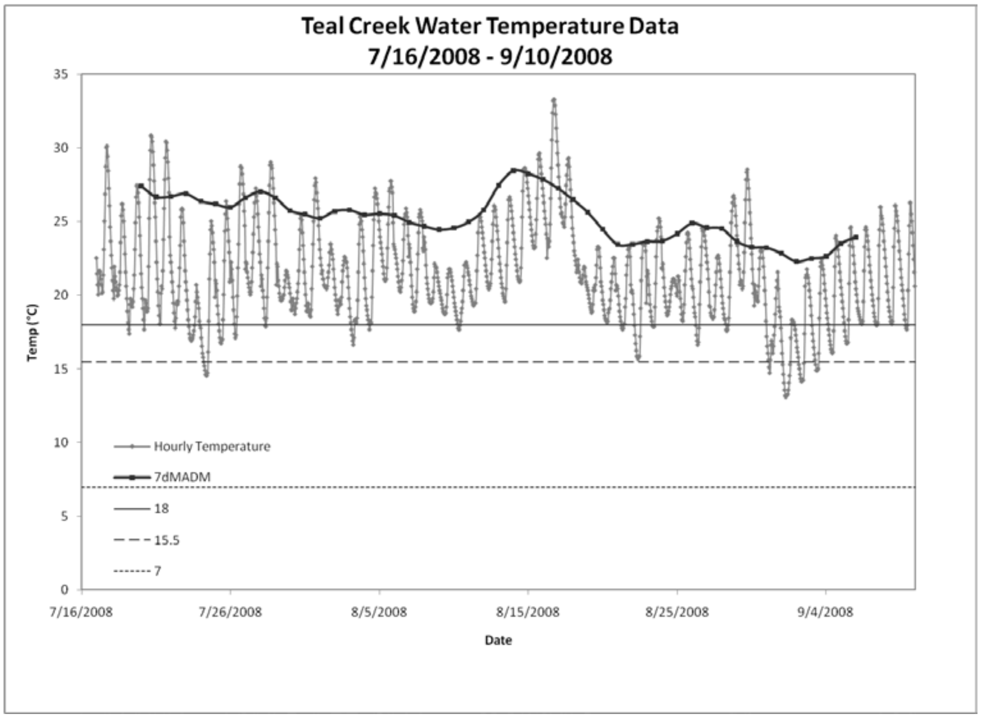


Figure 74. Teal Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from July 16, 2008 through September 10, 2008. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

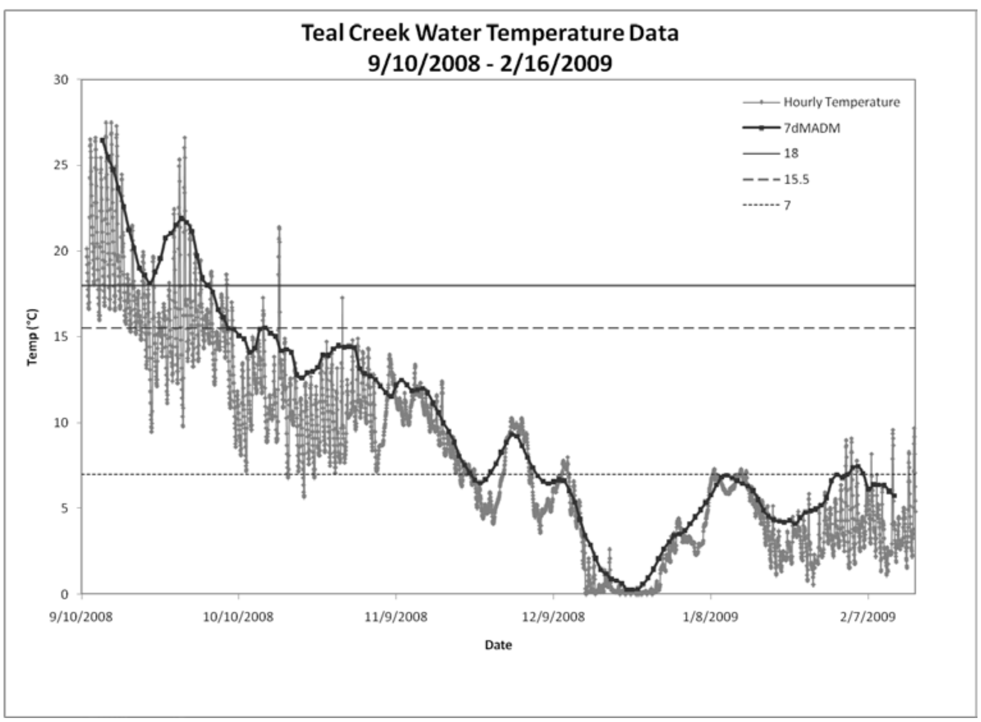


Figure 75. Teal Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from September 10, 2008 through February 16, 2009. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water

temperatures >18°C are considered poor for salmonids (ODEQ 2003).

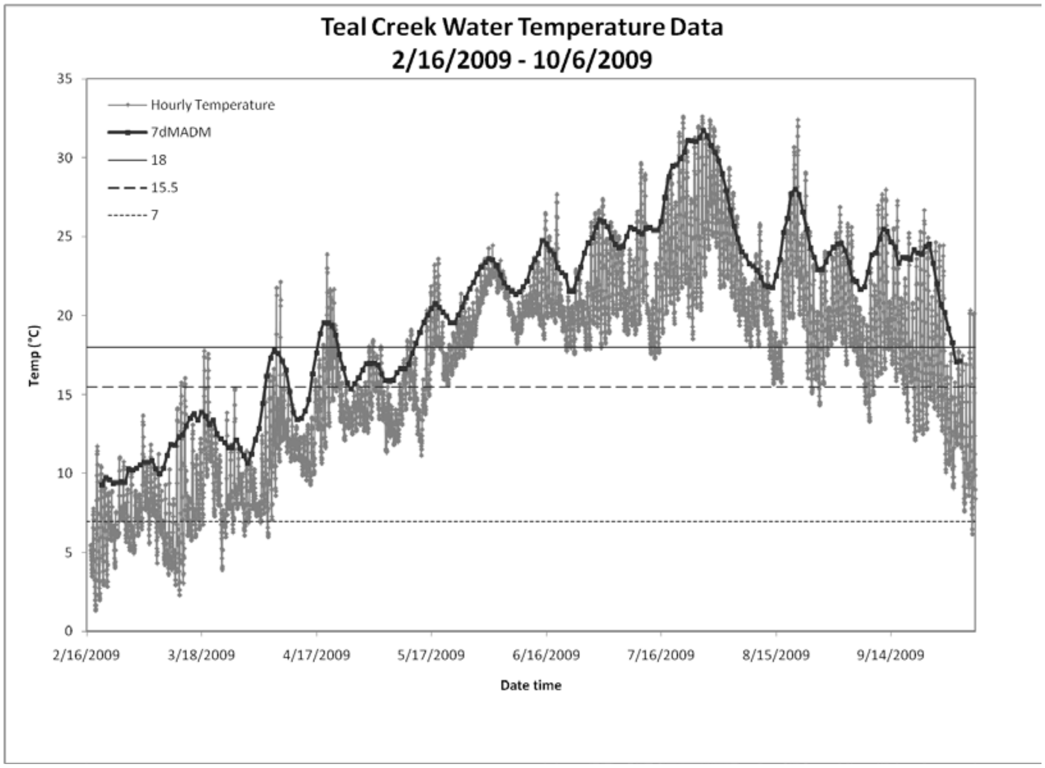


Figure 76. Teal Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from February 16, 2009 through October 6, 2009. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

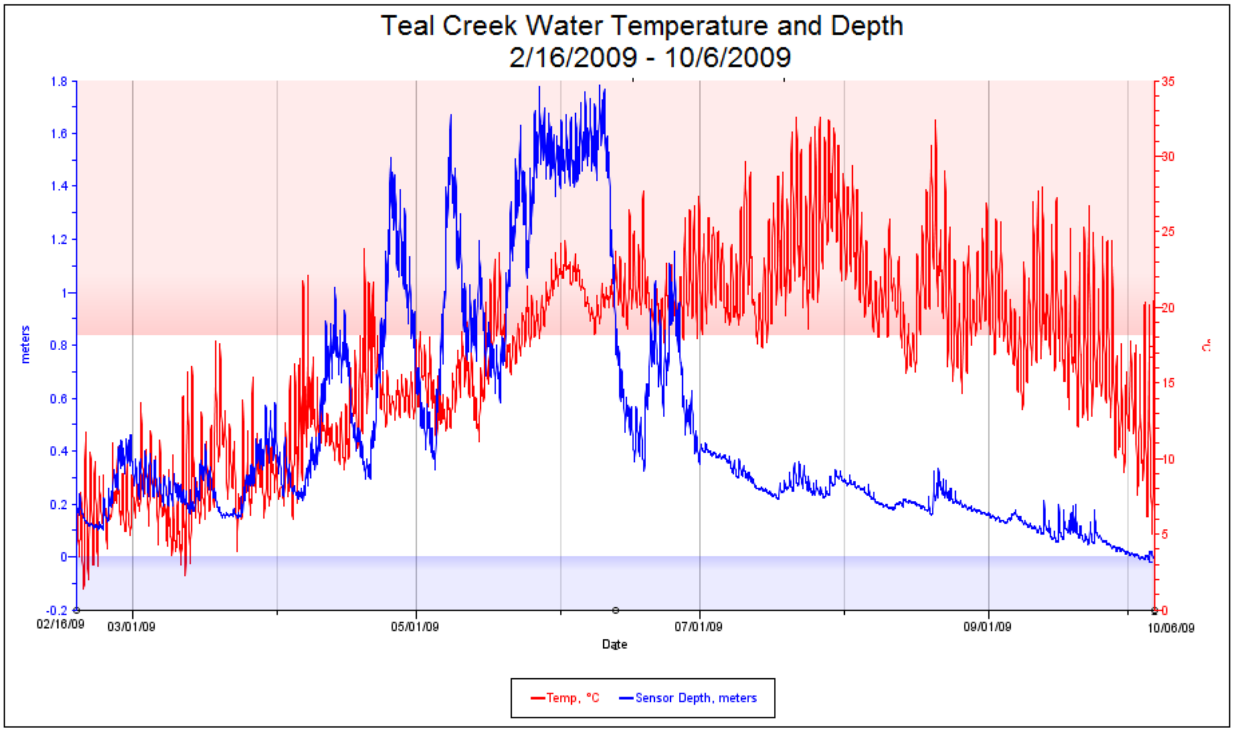


Figure 77. Teal Creek water temperature and depth data from February 16, 2009 through October 6, 2009.

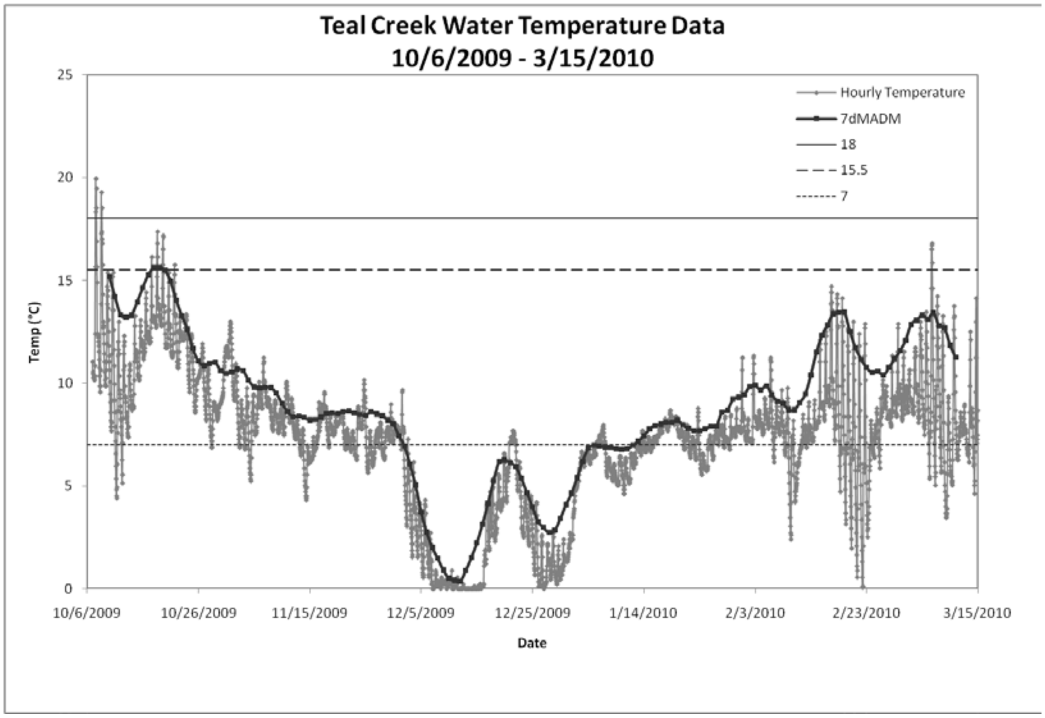


Figure 78. Teal Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from October 6, 2009 through March 15, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

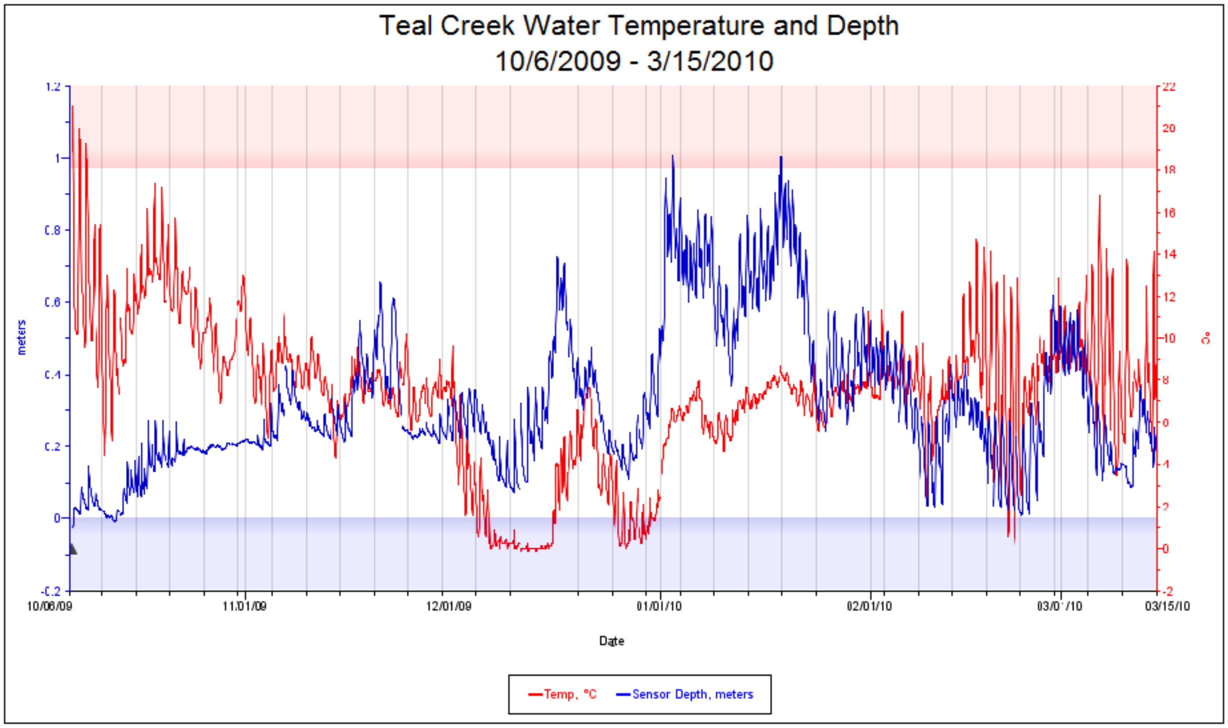


Figure 79. Teal Creek water temperature and depth data from October 6, 2009 through March 15, 2010.

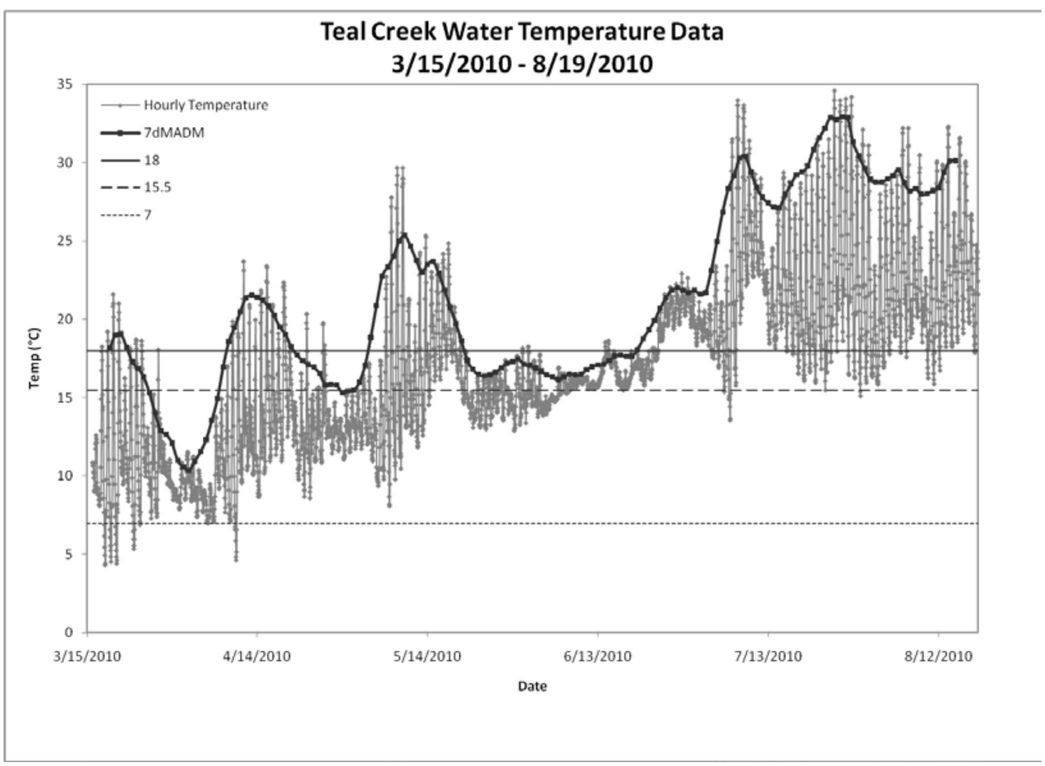


Figure 80. Teal Creek water temperature data of the 7 dMADM (day moving average of the daily

maximum) and hourly temperature from March 15, 2010 through August 19, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

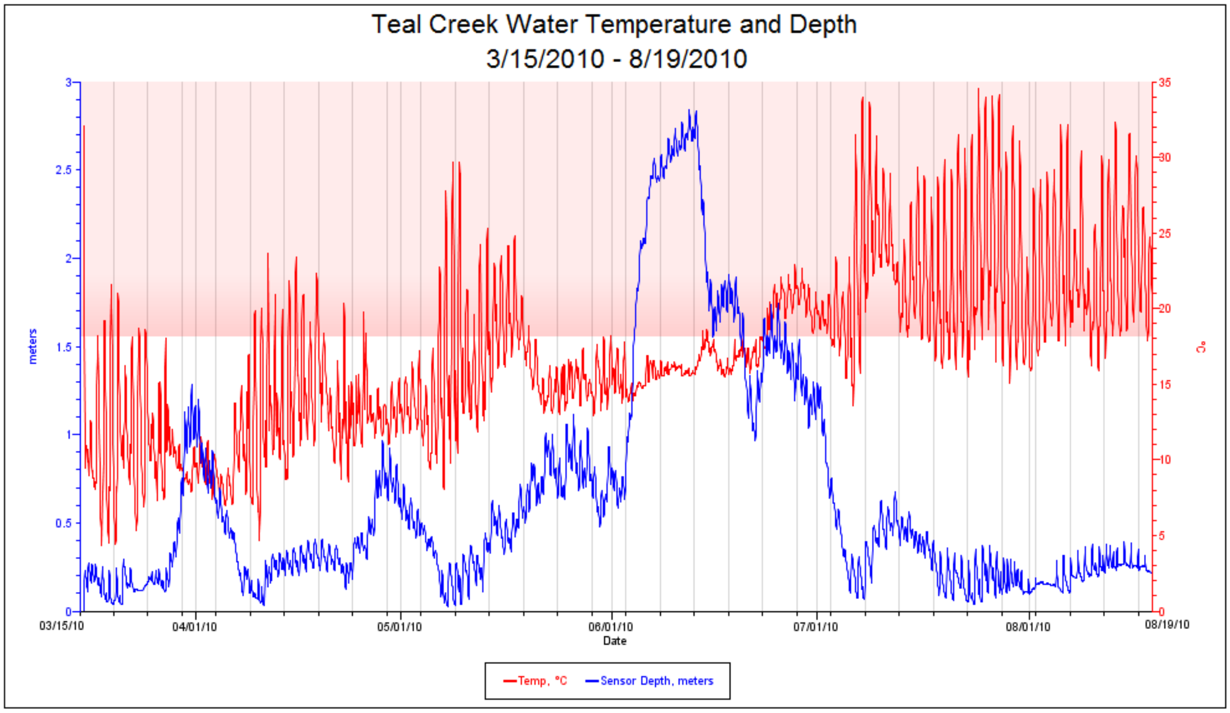


Figure 81. Teal Creek water temperature and depth data from March 15, 2010 through August 19, 2010.

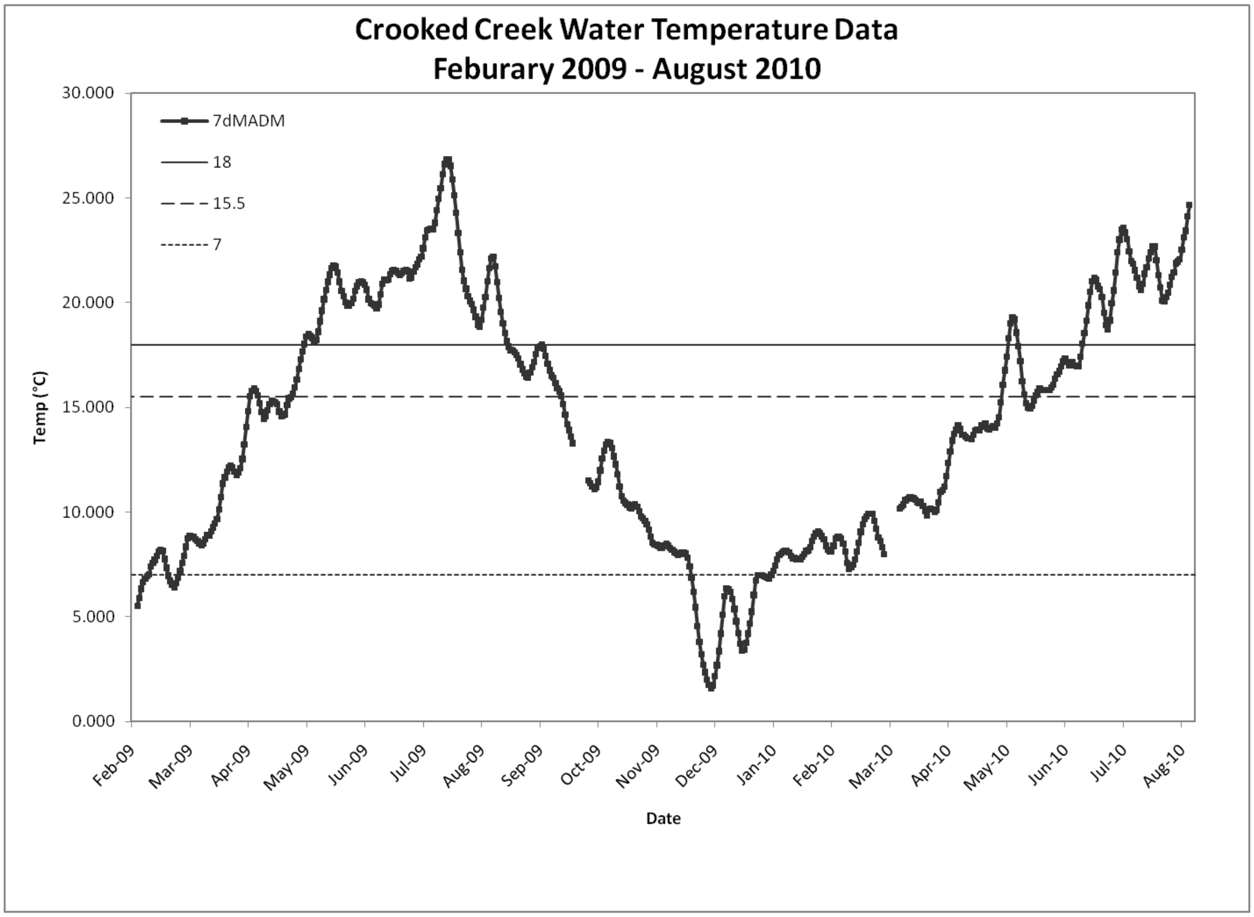


Figure 82. Crooked Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) from February 16, 2008 through August 19, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

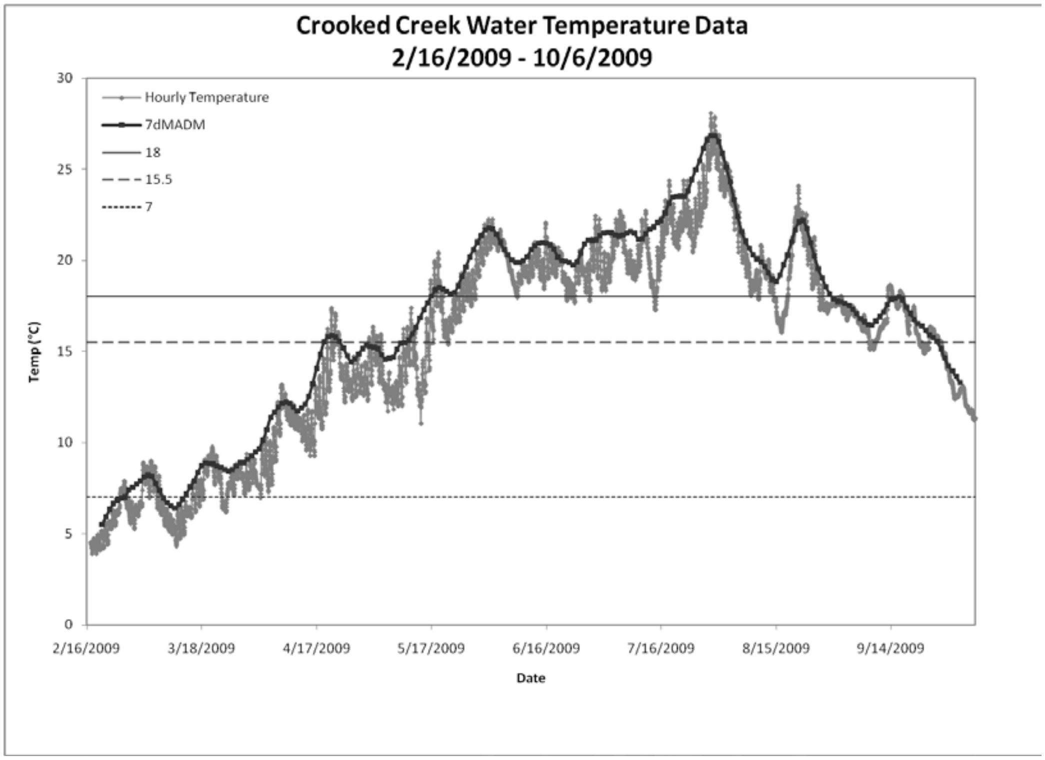


Figure 83. Crooked Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from February 16, 2009 through October 6, 2009. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

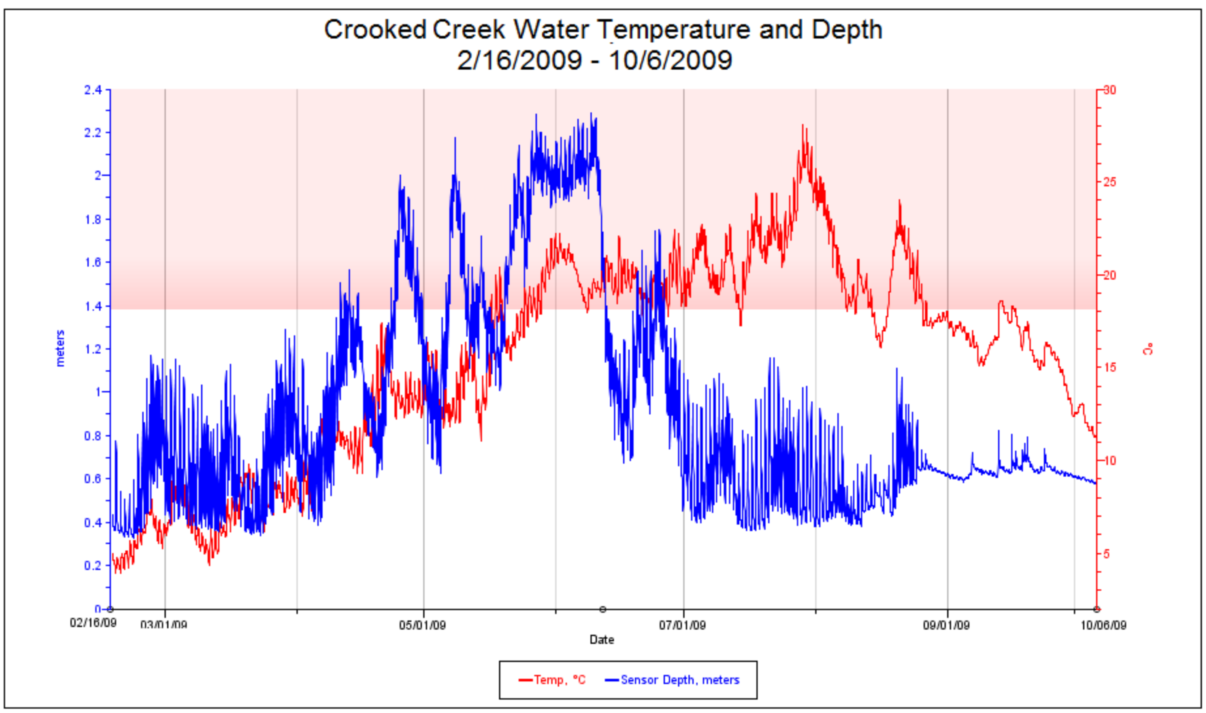


Figure 84. Crooked Creek water temperature and depth data from February 16, 2009 through October 6, 2009. The high fluctuation in water depth is from tidal influence.

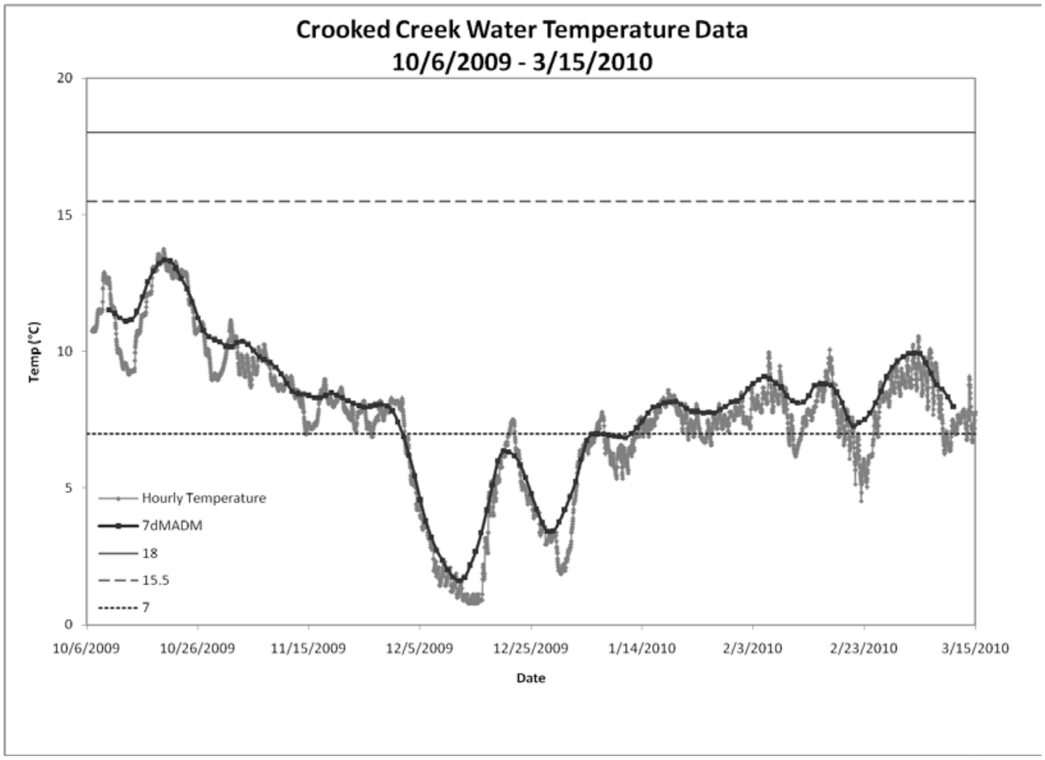


Figure 85. Crooked Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from October 6, 2009 through March 15, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

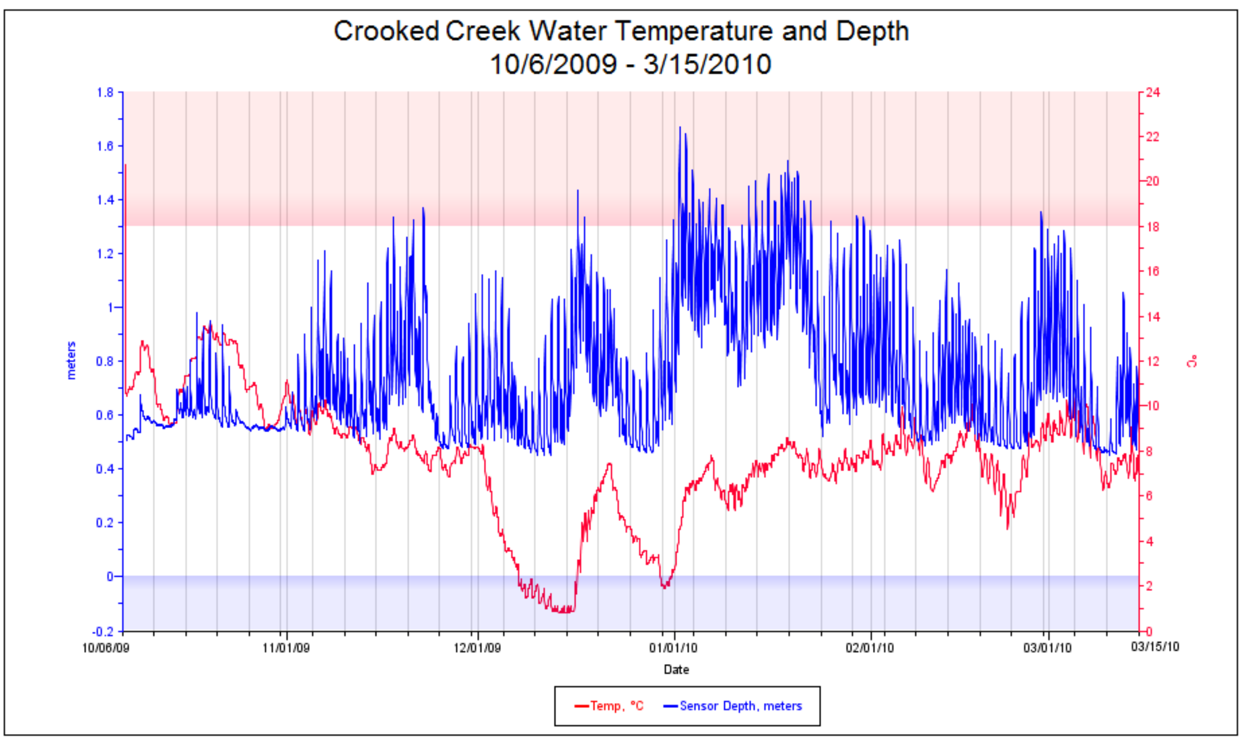


Figure 86. Crooked Creek water temperature and depth data from October 6, 2009 through March 15,

2010. The high fluctuation in water depth is from tidal influence.

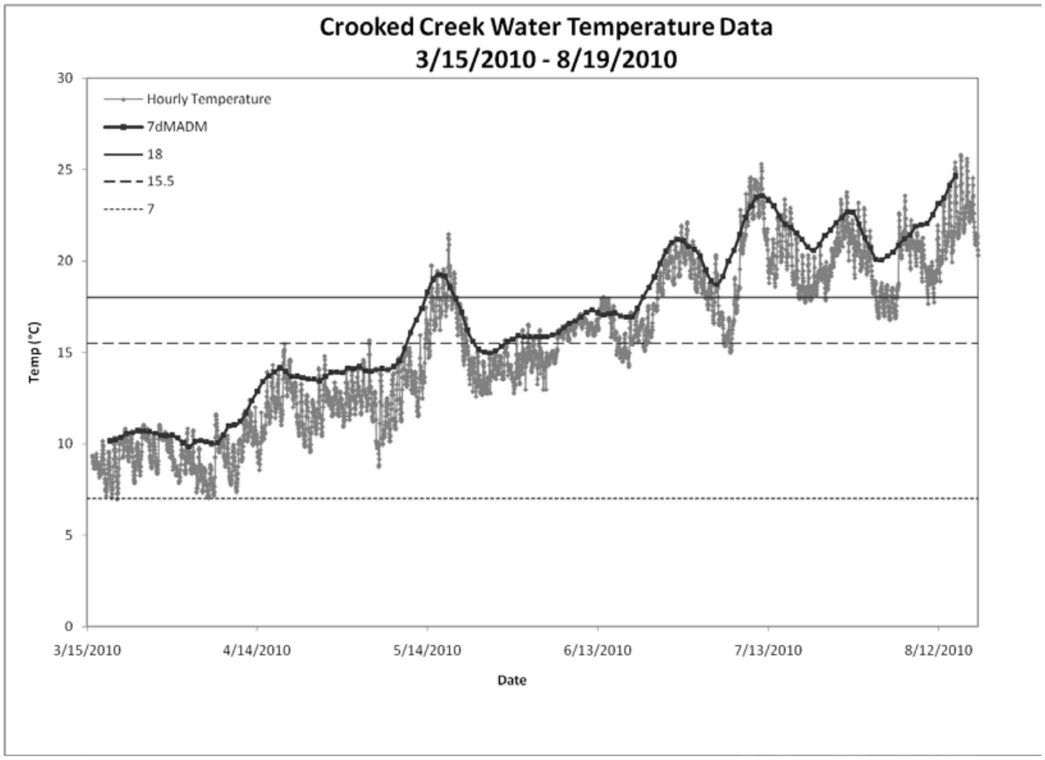


Figure 87. Crooked Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from March 15, 2010 through August 19, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

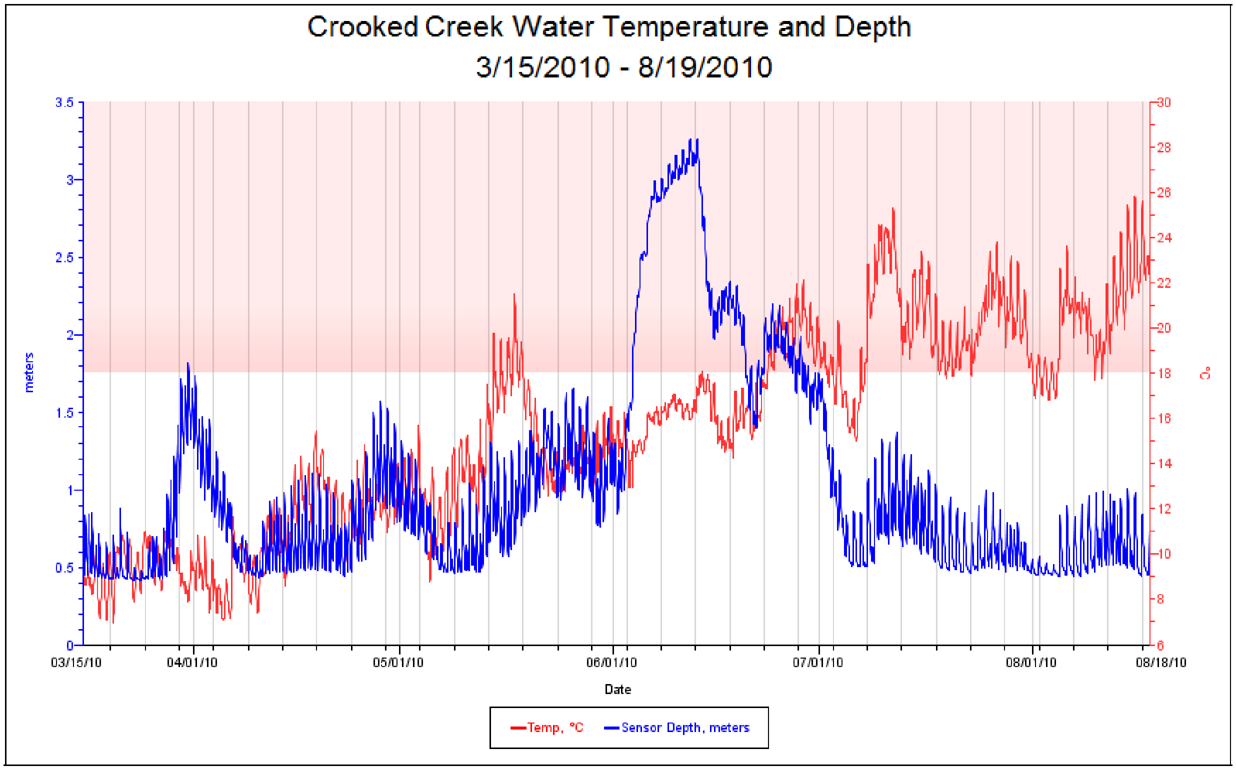


Figure 88. Crooked Creek water temperature and depth data from March 15, 2010 through August 19, 2010. The high fluctuation in water depth is from tidal influence.

6.5 Water Quality Discussion

Over the four year study period no large changes in the local seasonal or inter-annual water chemistry were observed between sites. The largest parameter change observed was a decrease in E. coli levels in all ponds from an average range of 121.2 to 395 MPN/100mL in 2009 to an average range of 5.6 to 46.5 MPN/100mL in 2010. This drop in E. coli levels can be contributed to the livestock exclusion which occurred on all of the sites in 2007. Throughout the study period water temperature, dissolved oxygen and turbidity levels fell within the "poor" water quality standard levels for all three ponds. Teal and Crooked Creek water temperatures were consistently high (>18°C) during the spring through early fall. Overall, these findings suggest the Ponds and Creeks on Hogan Ranch do not provide ideal habitat for salmonids, however these wetlands and streams are rich in wildlife and highly valued as waterfowl habitat. As the restoration plantings mature a decrease in stream and Pond temperatures and other water chemistry changes may be observed (Dosskey et al. 2010). Long-term observation is needed to determine the overall impacts of the riparian restoration on these ponds and streams water quality (Dosskey et al. 2010).

Scappoose Creek

Monthly Water Quality Data

These datasets are very similar due to the close proximity of the water quality sites along the stream (Figure 63). Water temperature varied seasonally at both sites and was closely related to average air temperature (Figure 89). Air temperature was taken at both sites and then averaged to represent the approximate air temperature found along the total 560 meters of the restoration riparian area (Figure 89). Between July 2008 and August 2010 the average air temperature ranged from 26.4°C in May 2009 to

1.2°C in January 2009 (Figure 89). The water temperature at Wilson ranged from 20.6°C in July 2008 to 3.2°C in January 2009 (Figure 89). The water temperature at LaCombe ranged from 20.4°C in July 2008 to 3.2°C in January 2009 (Figure 89). In September 2009 and July 2008 the water temperature was greater than 18°C, which is not optimal for salmonids (ODEQ 2003). No major changes in water temperatures were observed between sites and/or across years (Figure 89).

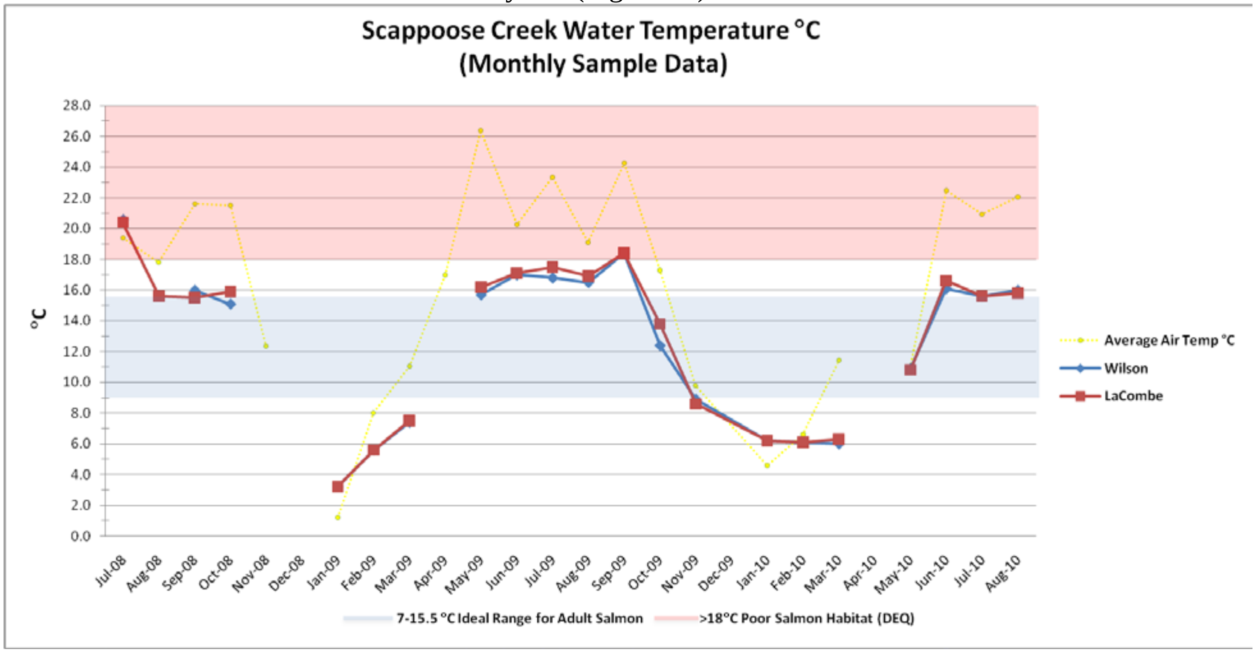


Figure 89. Scappoose Creek monthly water temperature and average air temperature data for July 2008-August 2010. Gaps in graph indicate no data was collected for those months. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

The concentration of dissolved oxygen (DO) in the water varied seasonally at both sites, with higher DO concentrations in the cooler winter months and lower DO concentrations in the warmer summer months (Figures 89 & 90). Between July 2008 and August 2010 the DO concentration at Wilson ranged from 12.8 ppm in January 2009 to 6.6 ppm in August 2010 (Figure 90). The DO concentration at LaCombe ranged from 13.1 in January 2009 to 7.6 ppm in July 2008 (Figure 90). The Wilson site generally showed lower DO concentrations than the LaCombe site (Figure 90). No major changes in DO concentrations were observed between sites and/or across years (Figure 90).

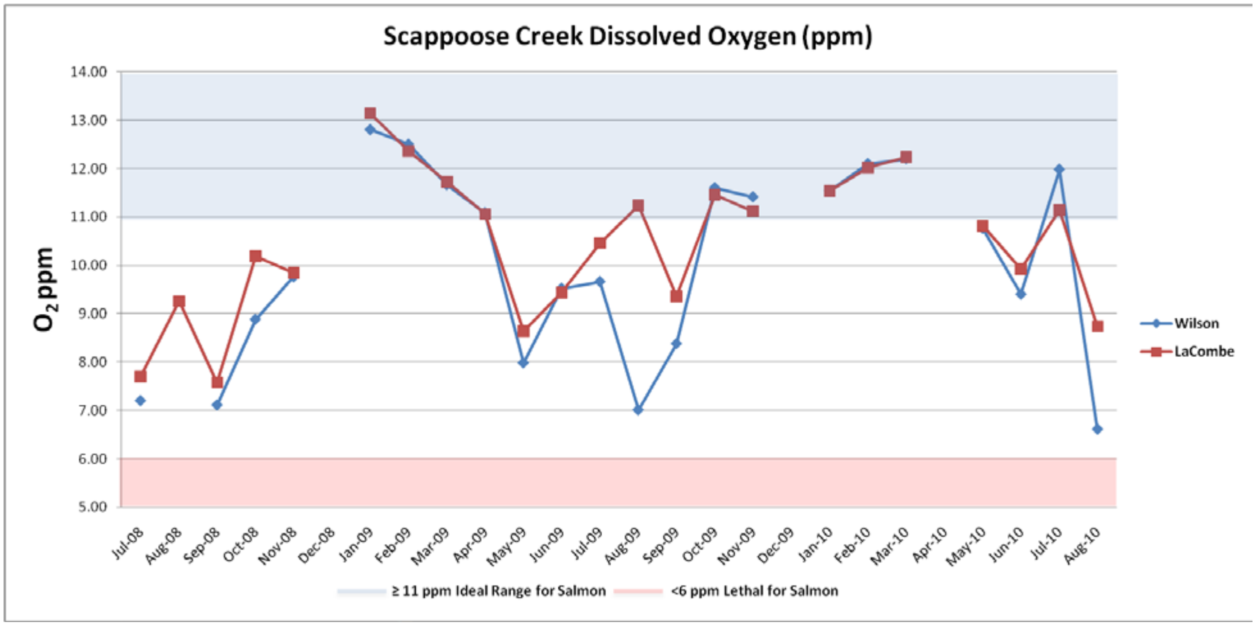


Figure 90. Scappoose Creek monthly dissolved oxygen (ppm) data for July 2008-August 2010. Gaps in graph indicate no data was collected for those months. Stream water dissolved oxygen concentrations ≥11ppm are considered ideal for salmonids (ODEQ 2003) and dissolved oxygen concentrations <6 ppm are considered lethal for salmonids (OWEB 2001).

Stream water pH levels were similar between sites with only a slight seasonal variation (Figure 91). Between July 2008 and August 2010 the pH levels at Wilson ranged from 7.9 in October 2009 to 6.4 in January 2009 (Figure 91). The pH levels at LaCombe ranged from 8.0 in October 2009 to 6.5 in January 2009 (Figure 91). No major changes in pH levels were observed between sites and/or across years (Figure 91).

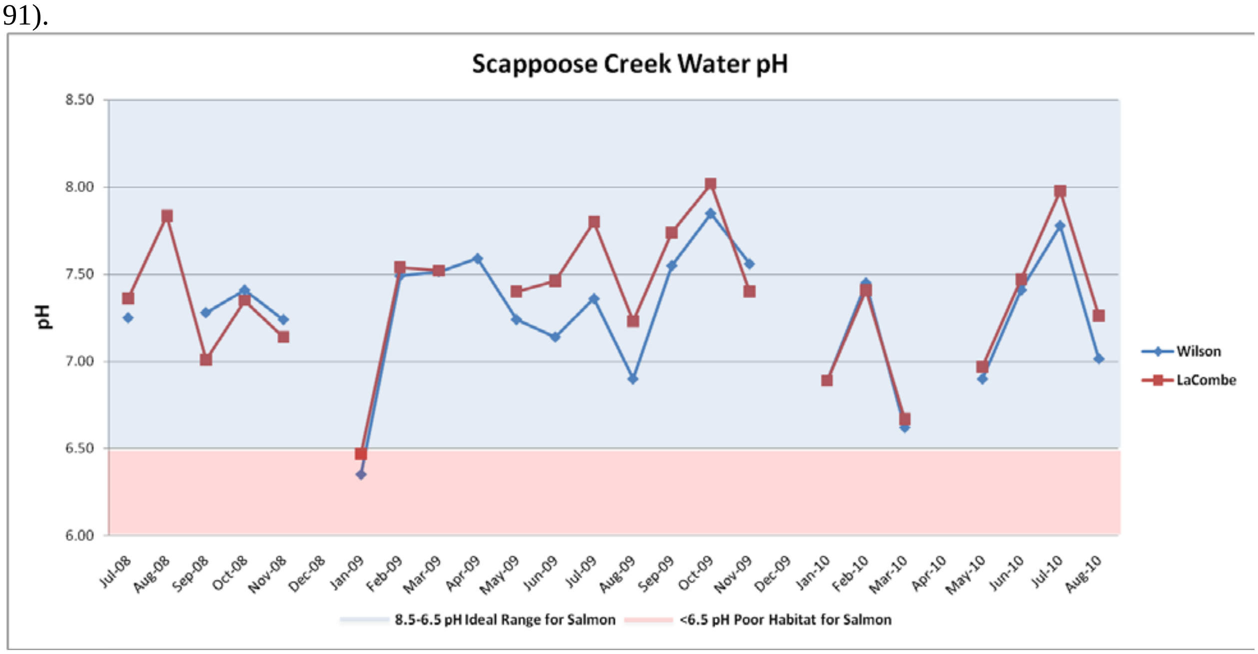


Figure 91. Scappoose Creek monthly pH data for July 2008-August 2010. Gaps in graph indicate no data was collected for those months. Stream water pH between 8.5-6.5 are considered ideal for salmonids and water pH <6.5 or >8.5 are considered poor for salmonids (OWEB 2001, ODEQ 2003).

Stream water turbidity (NTU) levels were similar between sites with some seasonal variation (Figure 92). Between July 2008 and August 2010 the turbidity levels at Wilson ranged from 15.0 in November 2008 to 1.9 in September 2009 (Figure 92). The turbidity levels at LaCombe ranged from 17.4 in November 2008 to 1.8 in August 2008 (Figure 92). In November 2008 both sites and in January 2010 LaCombe had turbidity levels greater than 10 NTUs which is considered unhealthy for salmonids (UWE 2006). No major changes in turbidity levels were observed between sites and/or across years (Figure 92).

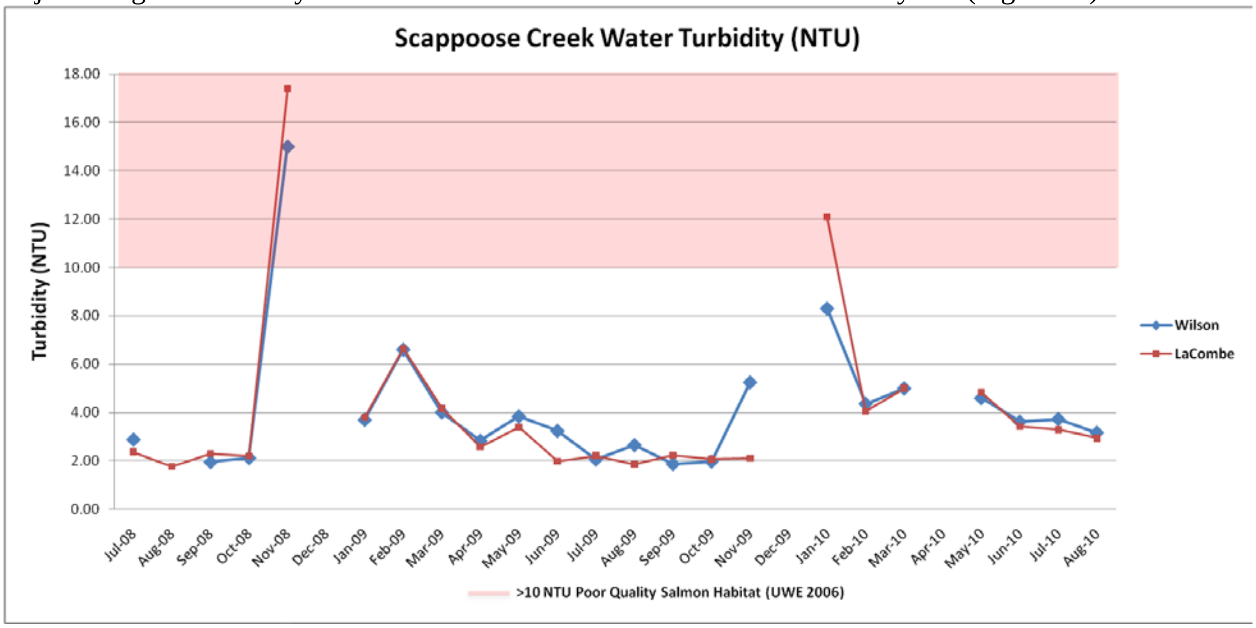


Figure 92. Scappoose Creek monthly turbidity (NTU) data for July 2008-August 2010. Gaps in graph indicate no data was collected for those months. Stream water turbidity >10 NTUs is considered poor for salmonids (UWE 2006).

Stream water conductivity (µS/cm) levels were similar between sites with seasonal variation (Figure 93). Between July 2008 and August 2010 the conductivity levels at Wilson ranged from 127.2 µS/cm in September 2009 to 34.5 µS/cm in January 2010 (Figure 93). The conductivity levels at LaCombe ranged from 124.7 µS/cm in September 2009 to 34.5 µS/cm in January 2010 (Figure 93). Over the study period both sites' conductivity levels were less than 150 µS/cm which is considered typical for streams in the Willamette Basin and the North Coast (OWEB 2001). No major changes in conductivity levels were observed between sites and/or across years (Figure 93).

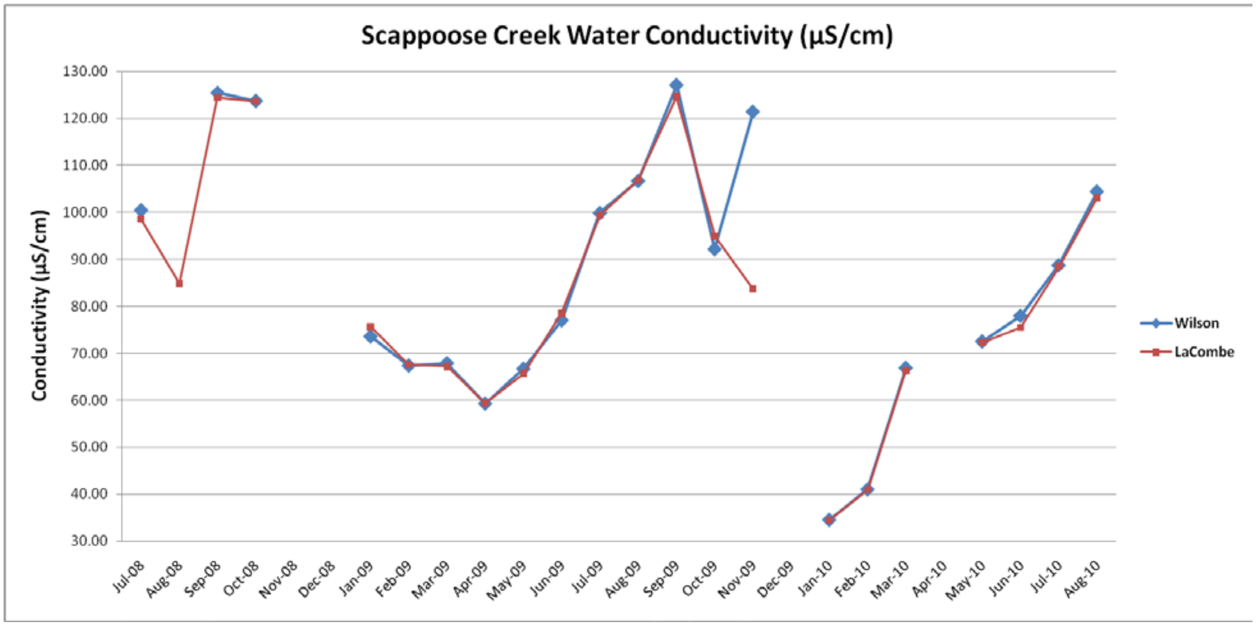


Figure 93. Scappoose Creek monthly conductivity (µS/cm) data for July 2008-August 2010. Gaps in graph indicate no data was collected for those months. Stream water conductivity <150 µS/cm is considered typical for streams in the Willamette Basin and the North Coast (OWEB 2001).

Data Logger Water Quality Data

Figures 94-100 show the water temperature and water depth data collected hourly during three study periods: September 11, 2008 through October 6, 2009, October 7, 2009 through March 14, 2010, and March 15, 2010 through August 24, 2010. Data between July 1, 2010 through August 24, 2010 was not included because the data logger was out of the water during this time (water level dropped) and accurate water temperature and depth data was not recorded. Season variation in the continuous water temperature and depth data was observed. According to the ODEQ salmonid spawning occurs in this area between January 15th through May 15th. During spawning water temperatures need to remain below 13°C to be classified as healthy salmon habitat (ODEQ 2003). To protect salmonids and other cold water fish species ODEQ has established a maximum total maximum daily load (TMDL) of 18°C (over a 7 day period) for this stream throughout the year.

During the study period September 11, 2008 through October 6, 2009 the temperature was over 18°C for 53 days occurring during the months of September 2008, July 2009 and August 2009. During the 2009 spawning period temperatures remained below 13°C. During the study period October 8, 2009 through March 14, 2010 the temperature was never over 18°C. During the 2010 spawning period temperatures remained below 13°C, expect in May when temperatures spiked to over 15°C. Water depth varied seasonally with high levels (average >2 meters) observed March 2009 (depth data collection started) through June 2009 and November 2009 through April 2010. Low water levels (average < 2 meters) were observed between July 2009 through October 2009 and May 2010 through June 2010.

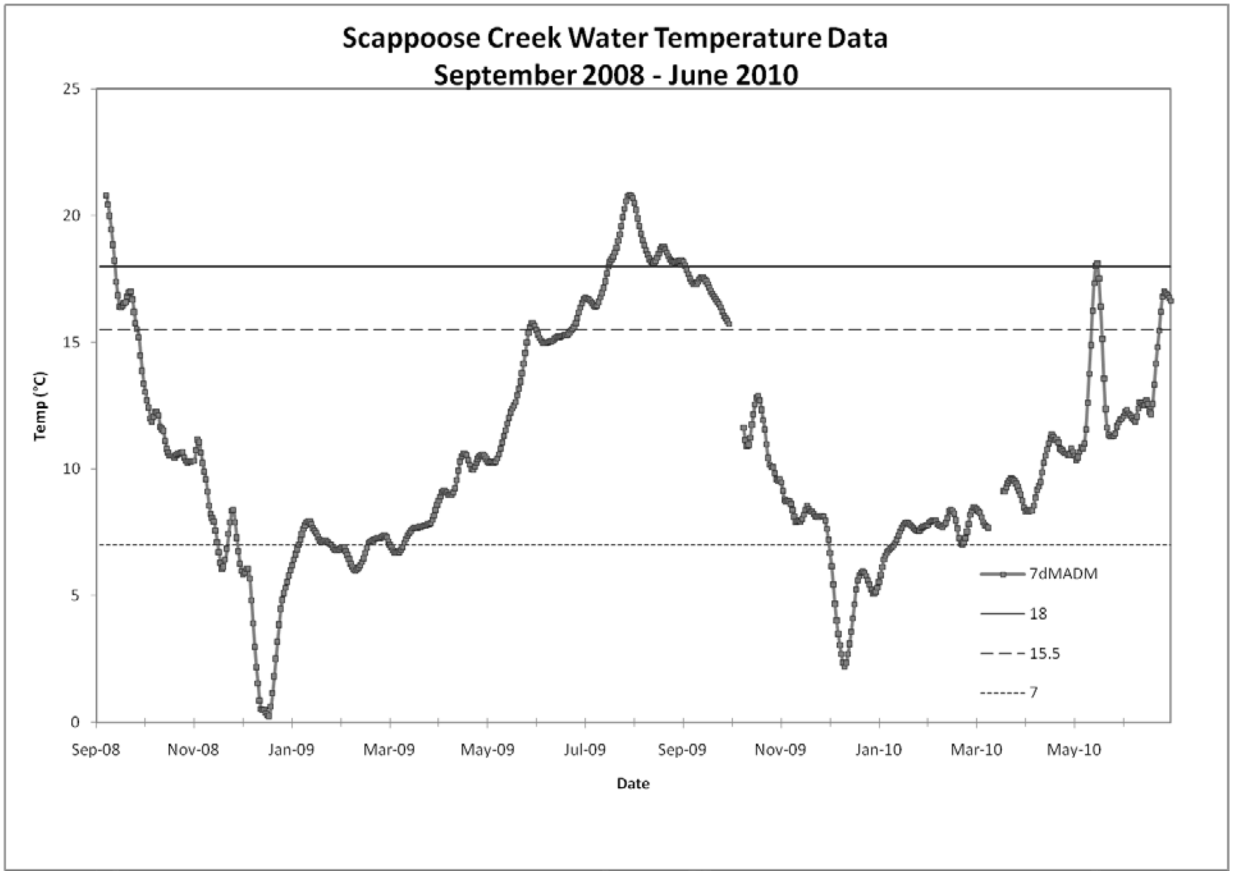


Figure 94. Scappoose Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) from September 11, 2008 through June 30, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

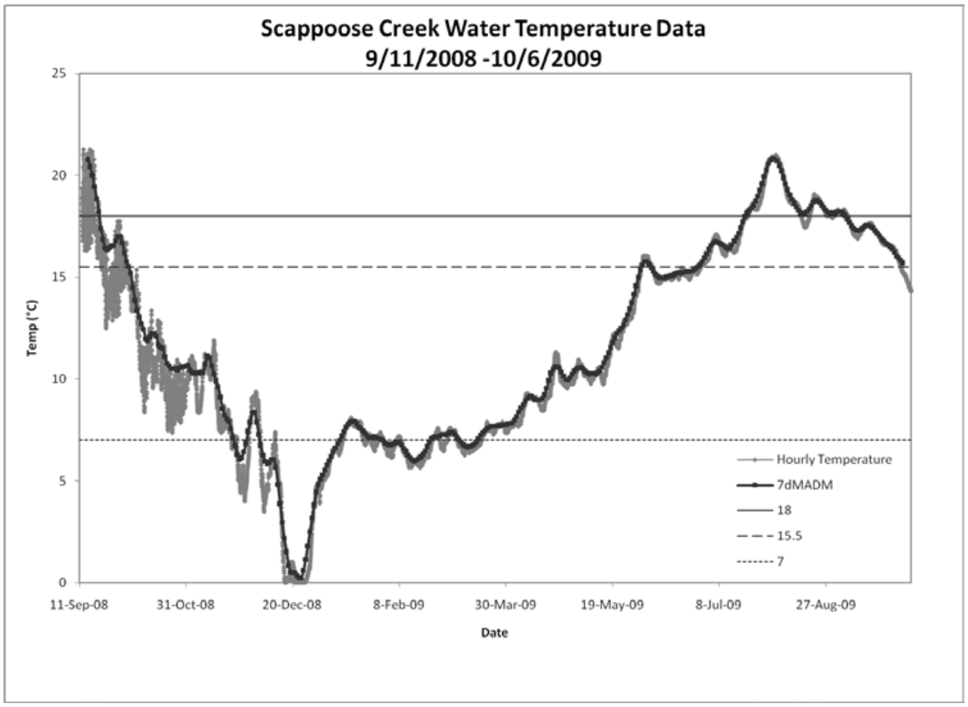


Figure 95: Scappoose Creek Water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from September 11, 2008 through October 6, 2009. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

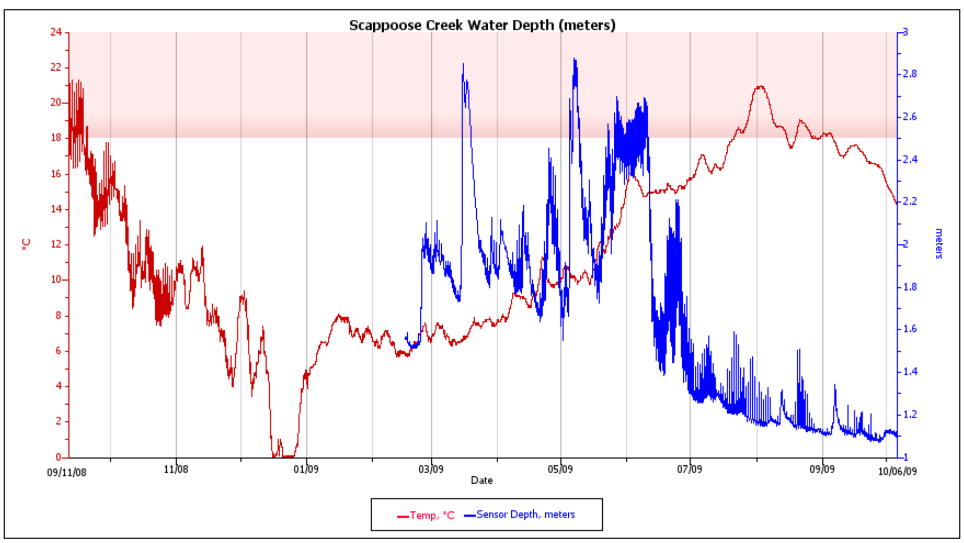


Figure 96. Scappoose Creek water temperature and depth data from September 11, 2008 through October 6, 2009. Depth data was only recorded for part of the study period.

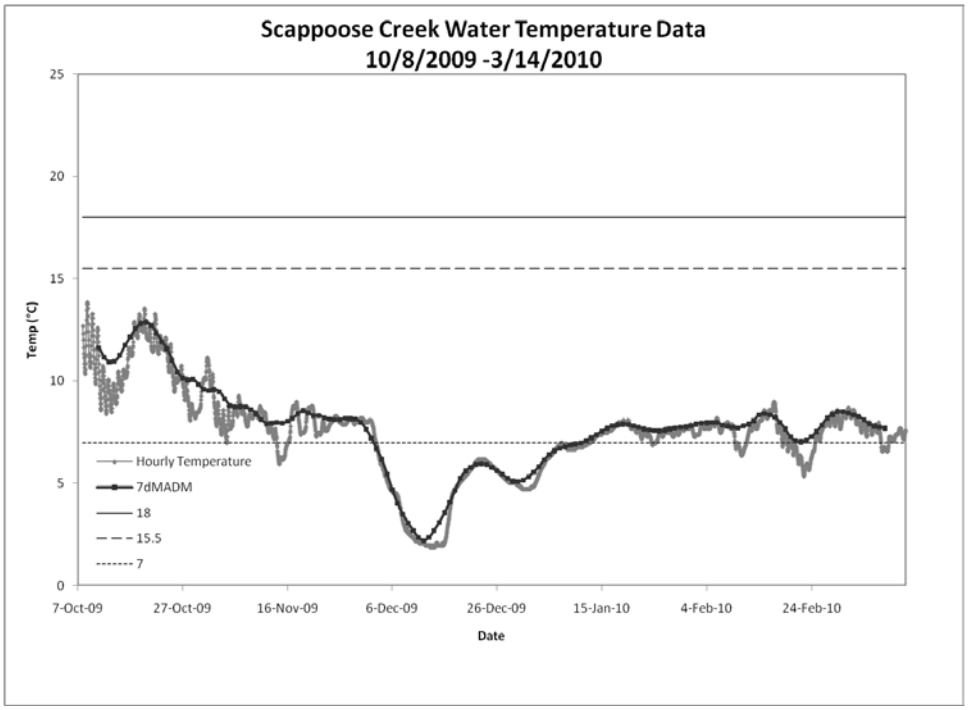


Figure 97. Scappoose Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from October 8, 2009 through March 14, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

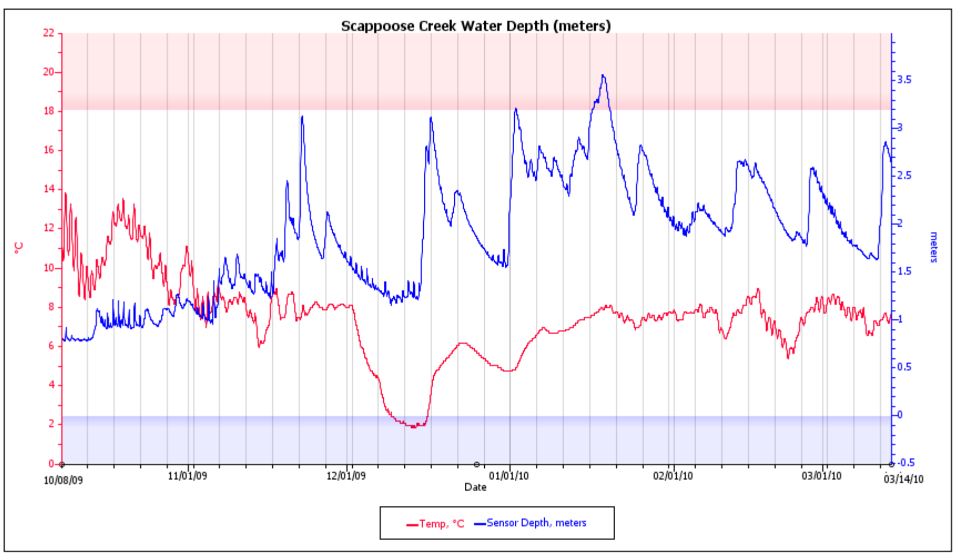


Figure 98. Scappoose Creek water temperature and depth data from October 8, 2009 to March 14, 2010.

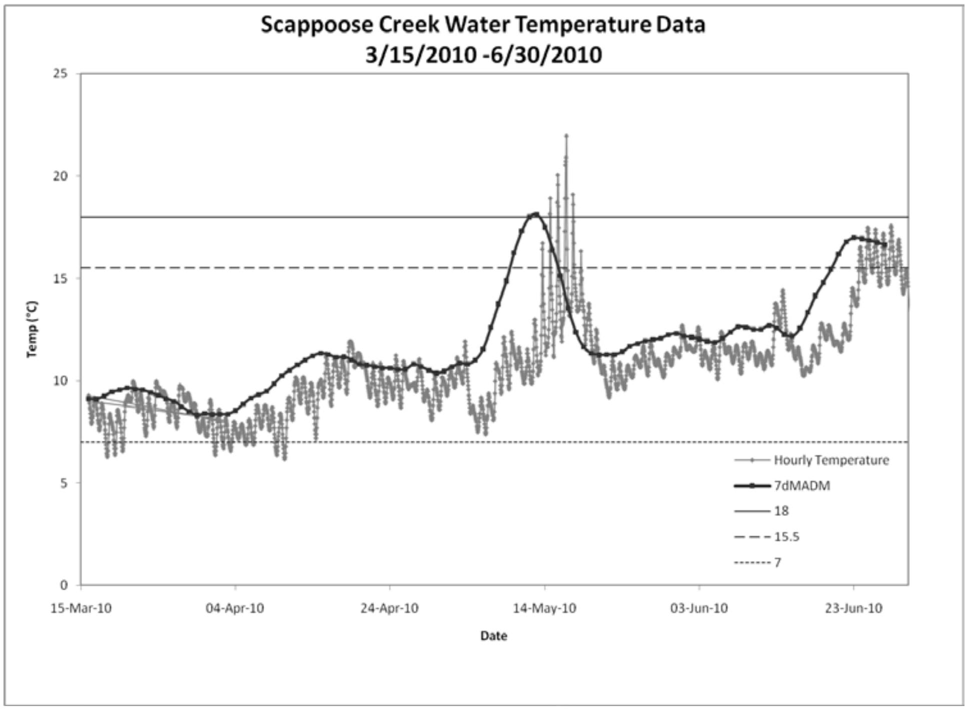


Figure 99. Scappoose Creek water temperature data of the 7 dMADM (day moving average of the daily maximum) and hourly temperature from March 15, 2010 through June 30, 2010. Stream water temperatures between 7-15.5°C are considered ideal for adult salmonids (OWEB 2001) and water temperatures >18°C are considered poor for salmonids (ODEQ 2003).

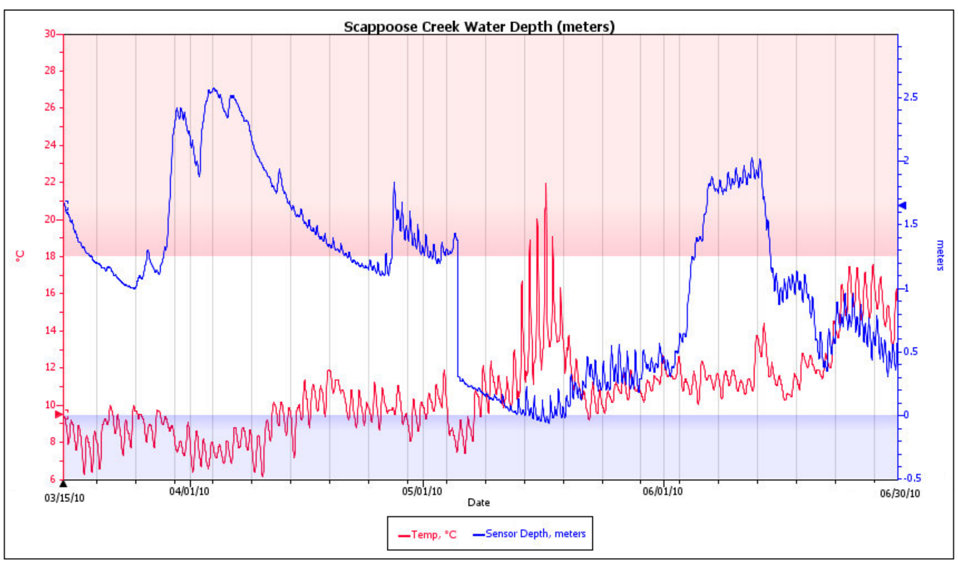


Figure 100. Scappoose Creek water temperature and depth data from March 15, 2010 through June 30, 2010.

Conclusions

Over the three year study period no large changes in the local seasonal or inter-annual water chemistry were observed between sites. During this time the only water quality parameter that consistently did not meet the prescribed salmon habitat water quality standards was temperature. During the summer low flow months (Late July-September) both sites experienced high water temperatures (>18°C) that would be considered “poor” with respect to conditions for salmon health (OWEB 2001, ODEQ 2003). However, after July many juvenile salmonids are expected to have already migrated through this stream and not be a threat of exposure (ODEQ 2003). Long-term observation is needed to determine the overall impacts of the riparian restoration on the stream’s water quality.

6.6 Vegetation Community Results

Pond 1
Plant community widths

In 2010 the marshy shore plant community width decreased in Pond 1 and the FACW plant community width increased (Table 26, Figure 101). No marshy shore plant community was recorded on the west side of Pond 1 and the marshy shore width decreased on the east side of Pond 1 (Table 26). The only plant community width that remained constant from 2009 to 2010 was the wetted area. Since 2004 plant community widths have shifted, showing a decrease in marshy shore and FACU and an increase in FACW and wetted area plant community widths (Table 26, Figure 101).

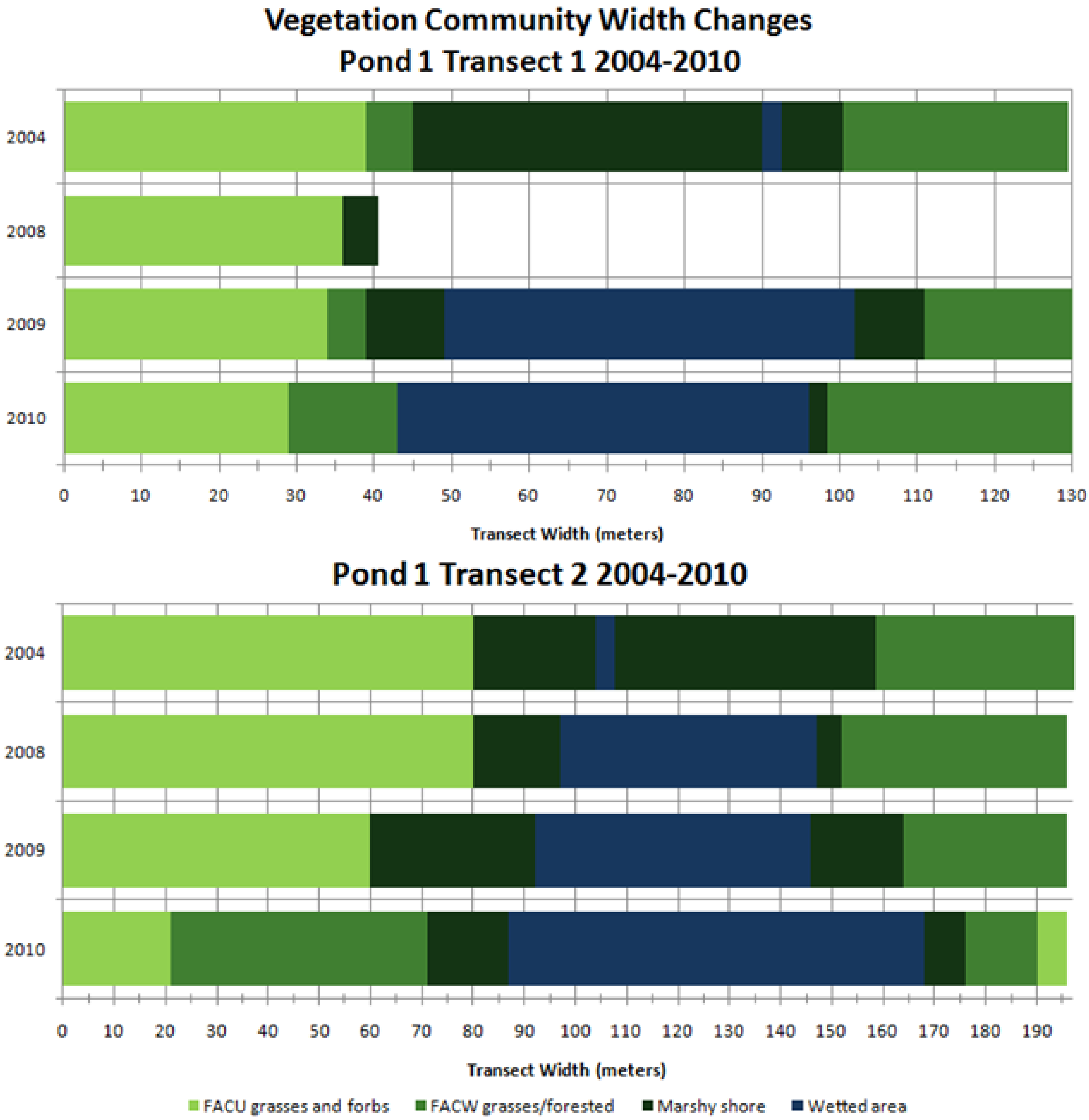


Figure 101. Pond 1 plant community widths along transects 1 & 2 for 2004 and 2008-2010. In 2008 only partial community width data was recorded for transect 1.

Pond 1, Transect #1	**2010**	**2009**	**2008**	**2004**
FACU grasses and forbs	29	34	36	39
FACW grasses/forested	14	5		6
Marshy shore	0	10	4.5	45
Wetted area	53	53		2.5
Marshy shore	2.5	9		8
FACW grasses/forested	31.5	19		29
Total:	**130**	**130**		**130**
Pond 1, Transect #2				
FACU grasses and forbs	21	60	80	80
FACW grasses/forested	50			
Marshy shore	16	32	17	24
Wetted area	81	54	50	3.5
Marshy shore	8	18	5	51
FACW grasses/forested	14	32	44	39
FACU grasses and forbs	6			
Total:	**196**	**196**	**196**	**198**

Table 27. Pond 1 plant community widths in meters along transects 1 & 2 for 2004 and 2008-2010. In 2008 only partial community width data was recorded for transect 1.

Plant community composition

In 2010 reed canarygrass (*Phalaris arundinacea,* introduced*)* was the dominant vegetation cover in the FACU (46 %), FACW (75%), marshy shore (48%) and wetted area (19%) plant communities of Pond 1 (Figure 102). The largest changes in cover observed between 2009 and 2010 was a decrease in reed canarygrass cover in the FACU (-31%), FACW(-18%) and marshy shore (-23%) plant communities and an increase in reed canarygrass cover in the wetted area (+13%). The wetted area of Pond 1 shifted from being co-dominated by 36% water purslane (*Ludwigia palustris,* native) and 27% water pepper (*Polygonum sp.*, introduced) in 2009 to a co-dominance of 19% reed canarygrass, 17% water purslane and 15% water pepper in 2010.

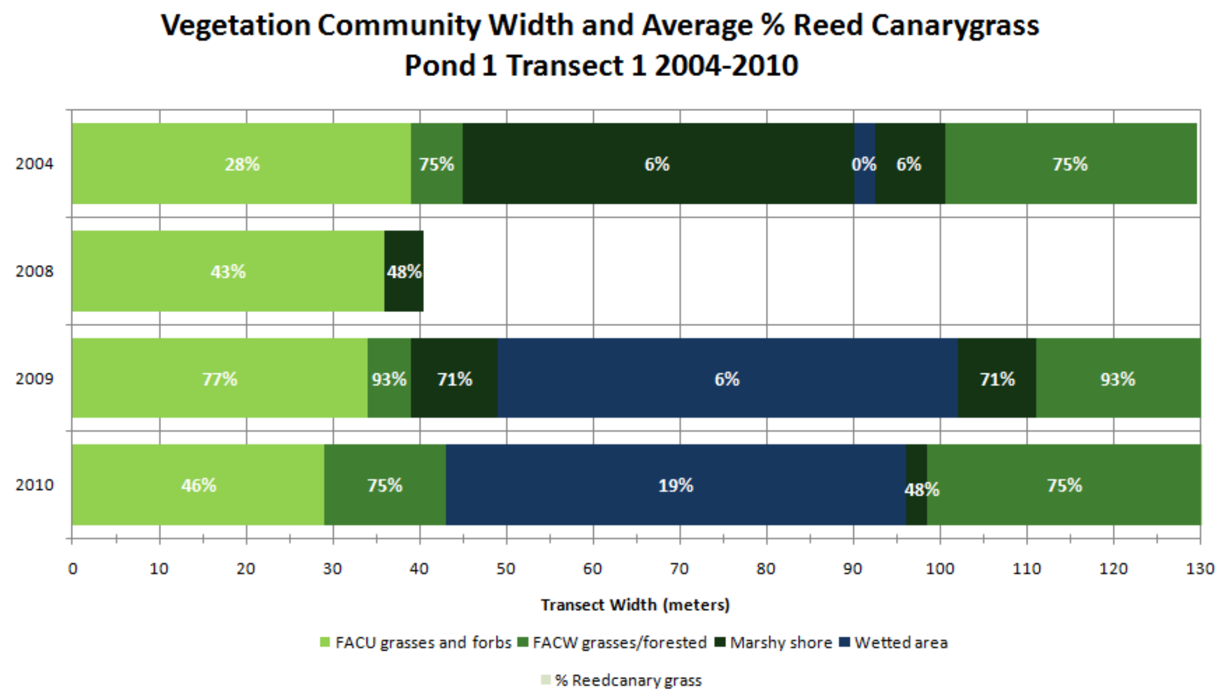
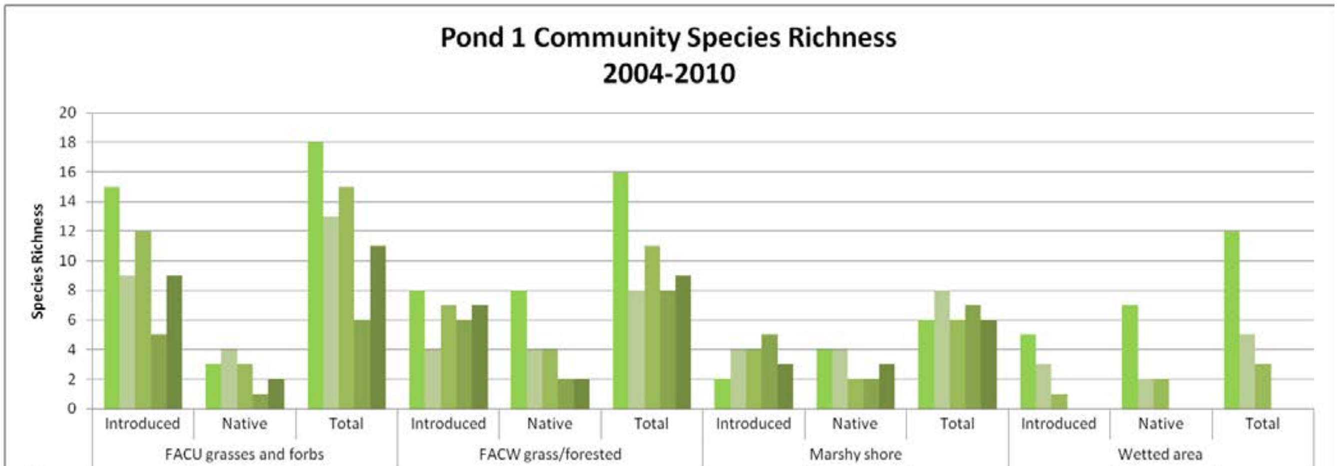


Figure 102. Pond 1 plant community widths along transect 1 and average % reed canarygrass cover for Pond 1 vegetation communities (average cover of both transects 1 and 2) for 2004 and 2008-2010. In 2008 only partial community width data was recorded for transect 1.

In 2010 species richness was higher than 2009 in all of Pond 1 plant communities except marshy shore (Figure 103). This may in part be due to the increased sampling effort which occurred in 2010. In 2010 the most species rich community was the FACU(18), followed by FACW(16), wetted area(12) and marshy shore(6). FACU, FACW and the wetted area showed an increase in introduced species richness. FACW and wetted area also showed a slight increase in native species richness. A decrease in native species richness was observed in the FACU plant community. The marshy shore plant community showed a decrease in introduced species richness.



	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total
	FACU grasses and forbs			FACW grass/forested			Marshy shore			Wetted area		
2010	15	3	18	8	8	16	2	4	6	5	7	12
2009	9	4	13	4	4	8	4	4	8	3	2	5
2008	12	3	15	7	4	11	4	2	6	1	2	3
2005	5	1	6	6	2	8	5	2	7	0	0	0
2004	9	2	11	7	2	9	3	3	6	0	0	0

Figure 103. Pond 1 native and non-native (introduced) plant species richness by plant community from 2004-2010. The wetted area of Pond 1 did not exist in 2004 and 2005.

Overall, Pond 1 has shown a shift from a co-dominant plant community with the top 6 plant species ranging from 8% to 26% cover in 2004, to a plant community dominated by reed canarygrass at 61% in 2010 (Figure 104 & 105). Total species richness for Pond 1 has increased from 2004 to 2010, with a trend of introduced species outnumbering native species (Table 28).

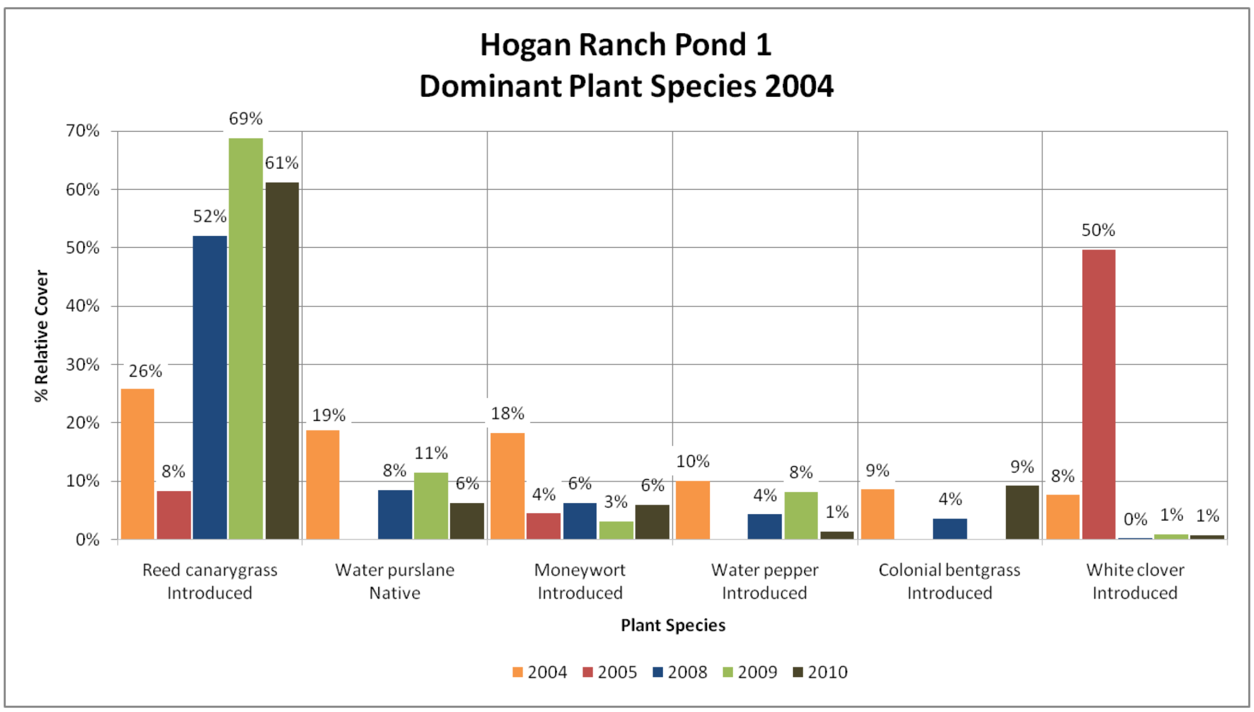


Figure 104. The top 6 dominant plant species of Pond 1 in 2004. 2005 and 2008-2010 cover percentages shown for comparison.

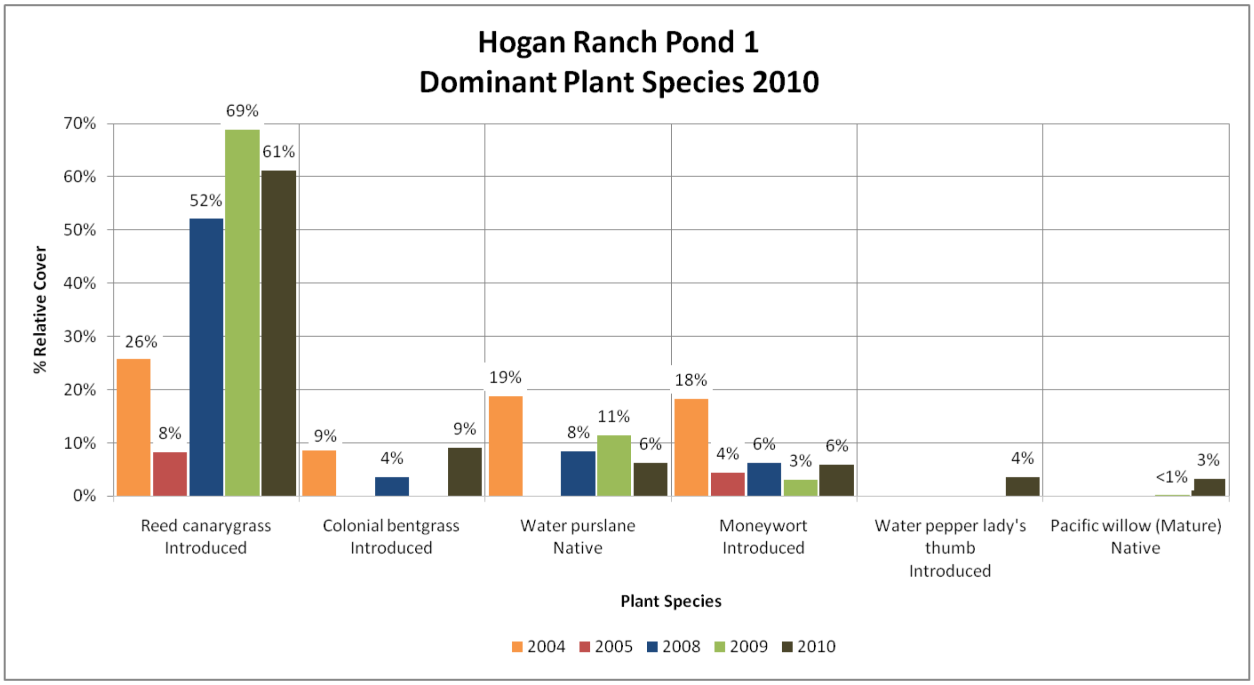


Figure 105. The top 6 dominant plant species of Pond 1 in 2010. 2004-2005 and 2008-2009 cover percentages shown for comparison.

Pond 1 Total Species Richness					
Year	2004	2005	2008	2009	2010
Introduced	9	7	15	12	19
Native	5	4	7	12	14
Unknown	7	10	4	3	3
Total	21	21	26	27	36

Table 28. Pond 1 total species richness 2004-2010

Pond 2

Plant community widths

In 2010 the wetted area split along transect 3 (Figure 106). This break in the wetted area of Pond 2 can be explained by a change in water level from previous years (being lower in 2009 than 2010). This break in the wetted area (at meter 80) is at a high elevation point along transect 3 and is composed of FACW and Marshy shore plant communities can be seen in Figure 106. In 2010 an overall increase in FACW and decrease in FACU and Marshy shore plant community widths was observed in Pond 2. The only plant community width that remained constant (from 2008 to 2010) was the wetted area along transect 4 (Table 29). Since 2004 plant community widths have shifted, showing a decrease in marshy shore and FACU and an increase in FACW plant community widths (Table 29).

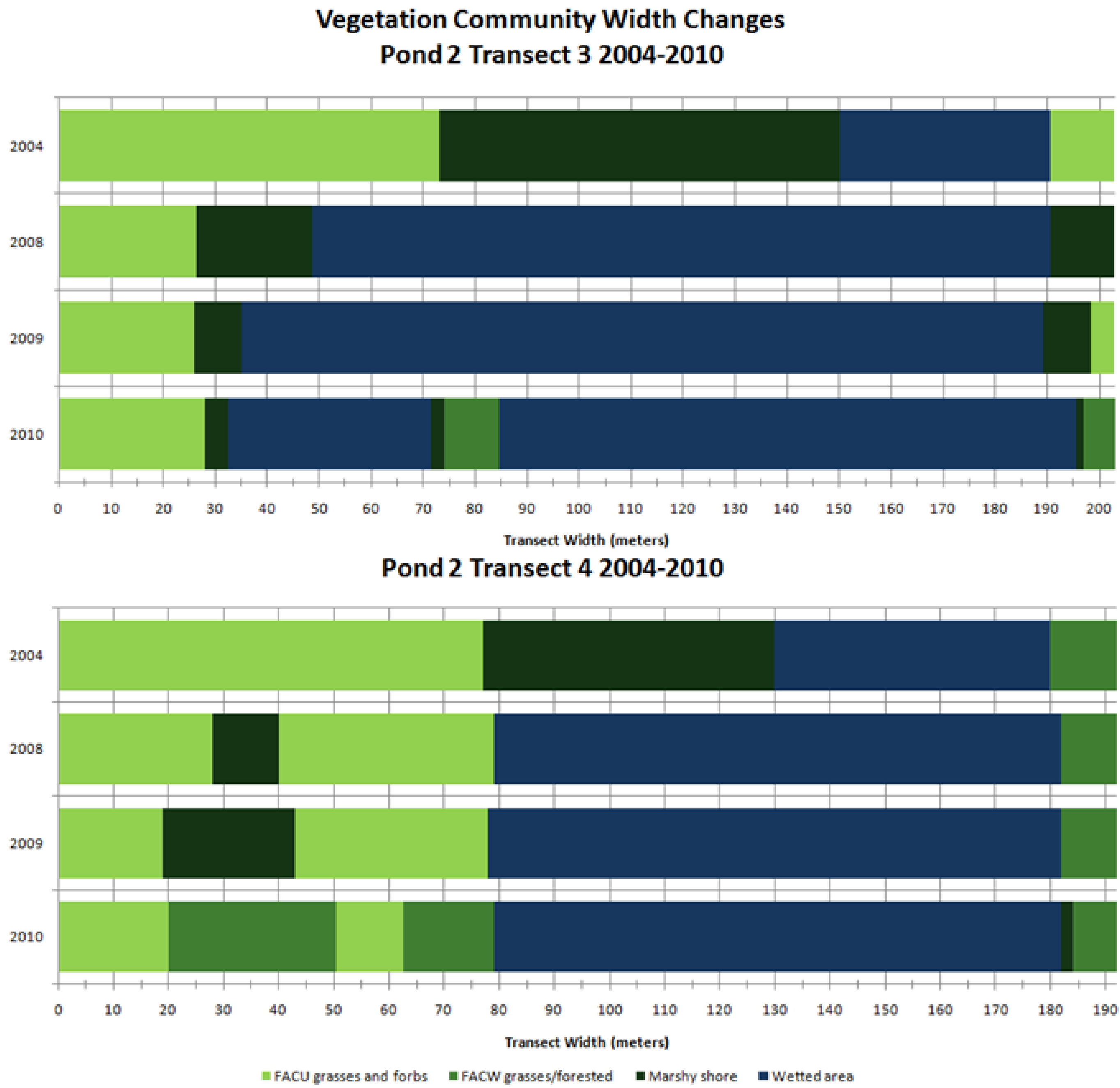


Figure 106. Pond 2 plant community widths along transects 3 & 4 for 2004 and 2008-2010.

Pond 2, Transect #3	**2010**	**2009**	**2008**	**2004**
FACU grasses and forbs	28	26	26.5	73
Marshy shore	4.5	9	22.1	77
Wetted area	39			

Marshy shore	2.5			
FACW grasses/forested	10.5			
Wetted area	111	154.3	142.1	40.7
Marshy shore	1.5	9	12	
FACW grasses/forested	6			
FACU grasses and forbs		4.5		12
Total:	**203**	**203**	**203**	**203**
Pond 2, Transect #4				
FACU grasses and forbs	20	19	28	77
FACW grasses/forested	30.5			
Marshy shore		24	12	53
FACU grasses and forbs	12	35	39	
FACW grasses/forested	16.5			
Wetted area	103	104	103	50
Marshy shore	2			
FACW grasses/forested	8	10	10	12
Total:	**192**	**192**	**192**	**192**

Table 29. Pond 2 plant community widths in meters along transects 3 & 4 for 2004 and 2008-2010.

Plant community composition

In 2010 reed canarygrass was the dominant vegetation cover in the FACU (24 %), FACW (60%) and marshy shore (30%) plant communities of Pond 2 (Figure 107). The largest changes in cover observed between 2009 and 2010 was a decrease in reed canarygrass cover in the FACU (-24%), FACW(-40%) and marshy shore (-17%) plant communities and an increase in western water milfoil (*Myriophyllum hippuroides*, native) cover in the wetted area (+20%) (Figure 107). The wetted area of Pond 1 shifted from being co-dominated by 14% water smartweed (*Polygonum amphibium*, native), 10% water pepper (*Polygonum sp.*, introduced) and 7% water purslane (*Ludwigia palustris*, native) in 2009 to a co-dominance of 28% western water milfoil, 13% Canadian waterweed (*Elodea Canadensis*, native) and 12% eurasian water milfoil (*Myriophyllum spicatum L.*, introduced) in 2010. The marshy shore plant community showed a 14% increase in creeping spike rush (*Eleocharis palustris*, native) and 9% increase in water purslane.

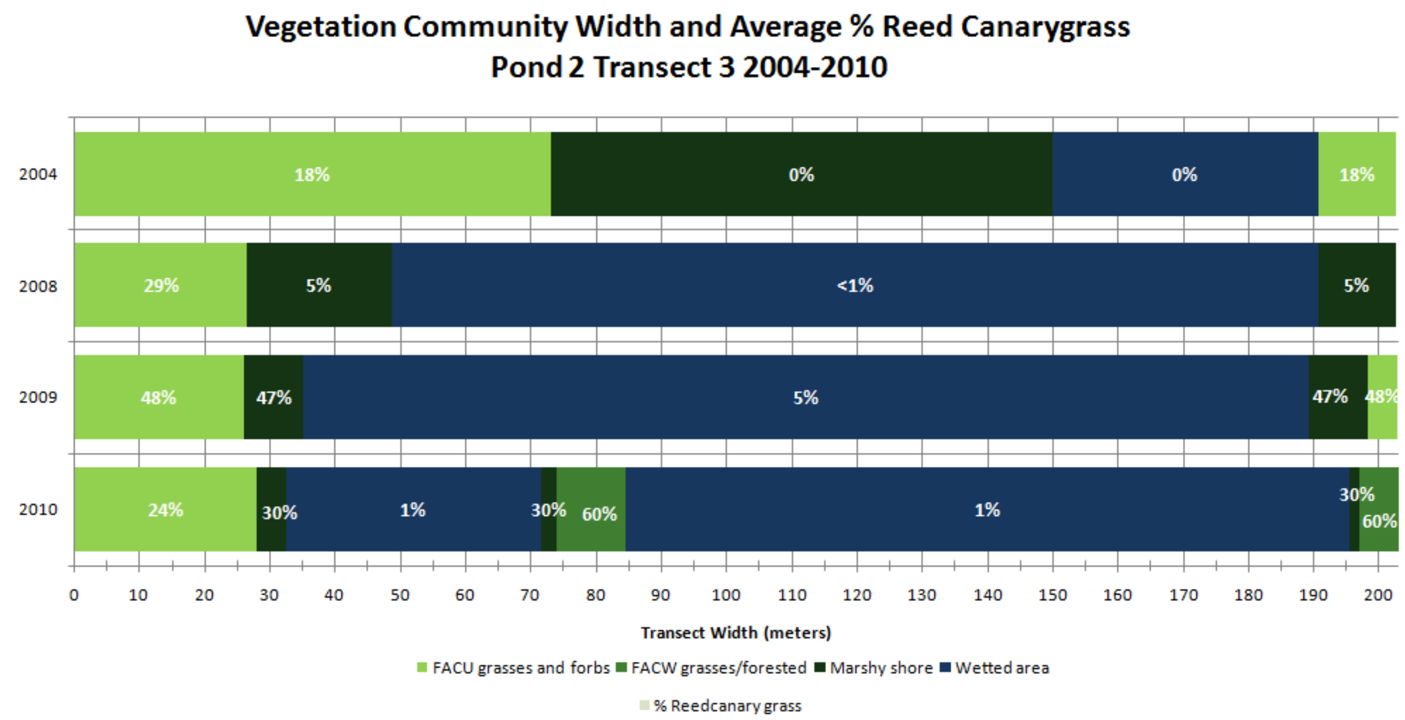
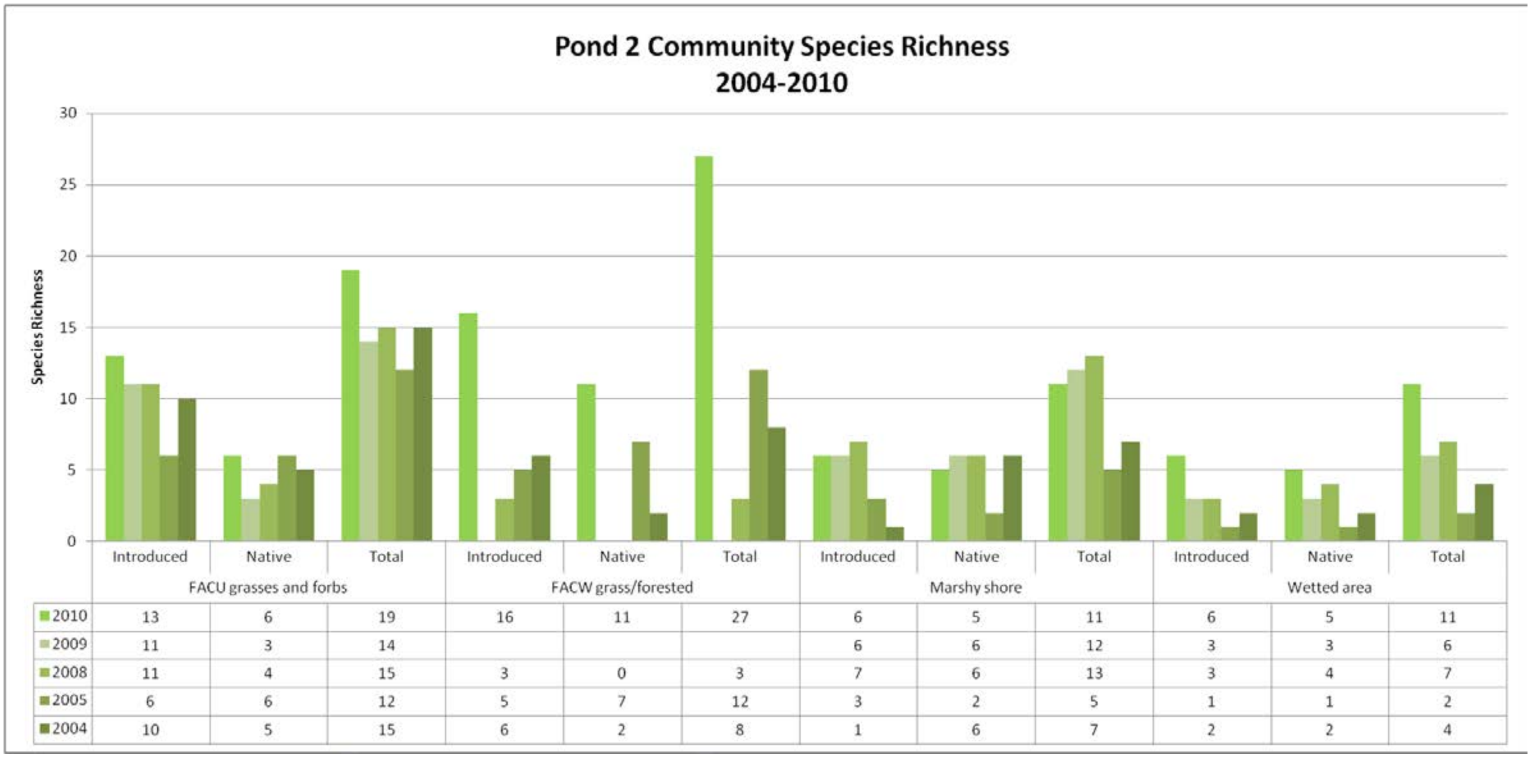


Figure 107. Pond 2 plant community widths along transect 3 and average % reed canarygrass cover for Pond 2 vegetation communities (average cover of both transects 3 and 4) for 2004 and 2008-2010.

In 2010 species richness was higher than in 2009 in all of Pond 2 plant communities except marshy shore (Figure 108). This may partially be due to the increased sampling effort which occurred in 2010. In 2010 the most species rich community was the FACW (27), followed by FACU (19), wetted area (11) and marshy shore (11) (Figure 108). FACU (+2), FACW (+13) and the wetted area (+3) showed an increase in introduced species richness. FACU (+3), FACW (+11) and wetted area (+2) also showed a slight increase in native species richness. The marshy shore plant community showed a decrease (-1) in native species richness.



	FACU grasses and forbs			FACW grass/forested			Marshy shore			Wetted area		
	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total	Introduced	Native	Total
2010	13	6	19	16	11	27	6	5	11	6	5	11
2009	11	3	14				6	6	12	3	3	6
2008	11	4	15	3	0	3	7	6	13	3	4	7
2005	6	6	12	5	7	12	3	2	5	1	1	2
2004	10	5	15	6	2	8	1	6	7	2	2	4

Figure 108. Pond 2 native and non-native (introduced) plant species richness by plant community from 2004-2010. In 2009 the FACW plant community species data of Pond 1 was merged with FACU and marshy shore plant communities due to difficulty in distinguishing these communities.

Overall, Pond 2 has shown a shift from a plant community dominated by water purslane (32%) , white clover (*trifolium repens*, introduced) (15%), water pepper (12%) and reed canarygrass (11%) cover in 2004, to a plant community dominated by reed canarygrass (30%), water purslane (9%), moneywort (*Lysimachia nummularia*, introduced) (8%) and creeping spike rush (7%) in 2010 (Figure 109 & 110). Total species richness for Pond 2 has increased from 2004 to 2010, with a trend of introduced species out numbering native species (Table 30).

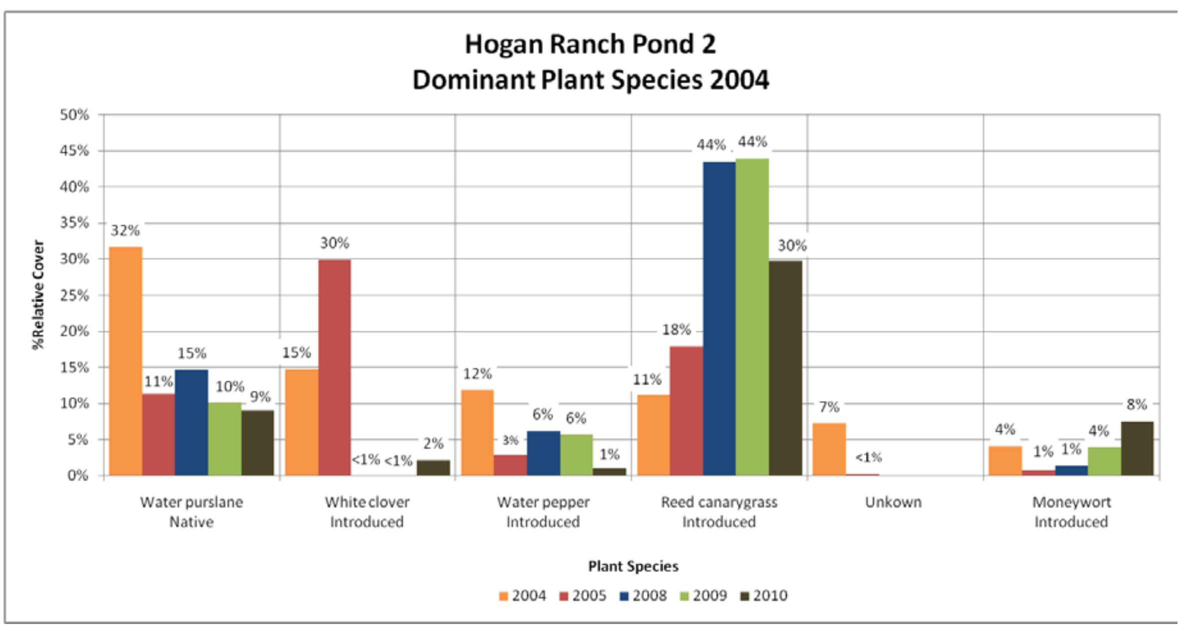


Figure 109. The top 6 dominant plant species of Pond 2 in 2004. 2005 and 2008-2010 cover percentages shown for comparison.

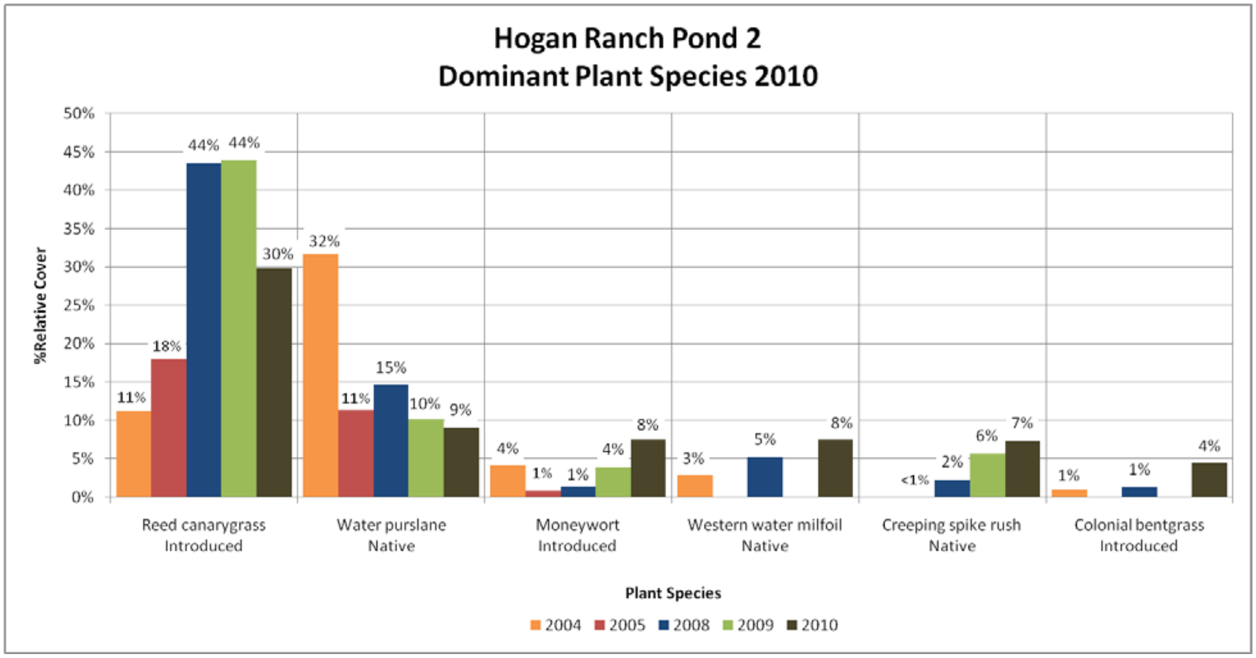


Figure 110. The top 6 dominant plant species of Pond 2 in 2010. 2004-2005 and 2008-2009 cover percentages shown for comparison.

Pond 2 Species Richness					
Year	2004	2005	2008	2009	2010
Introduced	12	9	13	14	22
Native	12	10	9	7	15
Unknown	5	11	4	1	4
Total	29	21	26	22	41

Table 30. Pond 2 total species richness 2004-2010

Pond 3

Plant community widths

In 2010 within Pond 3 there was a decrease in marshy shore and an increase in FACW plant community widths (Figure 111). There was a shift in plant community on the east side of Pond 3 from FACU to FACW (Figure 111). This area was considered FACU in 2008 and 2009, however the dominance of reed canarygrass in this area made it difficult to categorize. Because reed canarygrass has a WI of FACW the community characterization was changed to FACW in 2010. Overall, Pond 3 has showed only small changes in plant community widths since 2008 (Table 31, Figure 111).

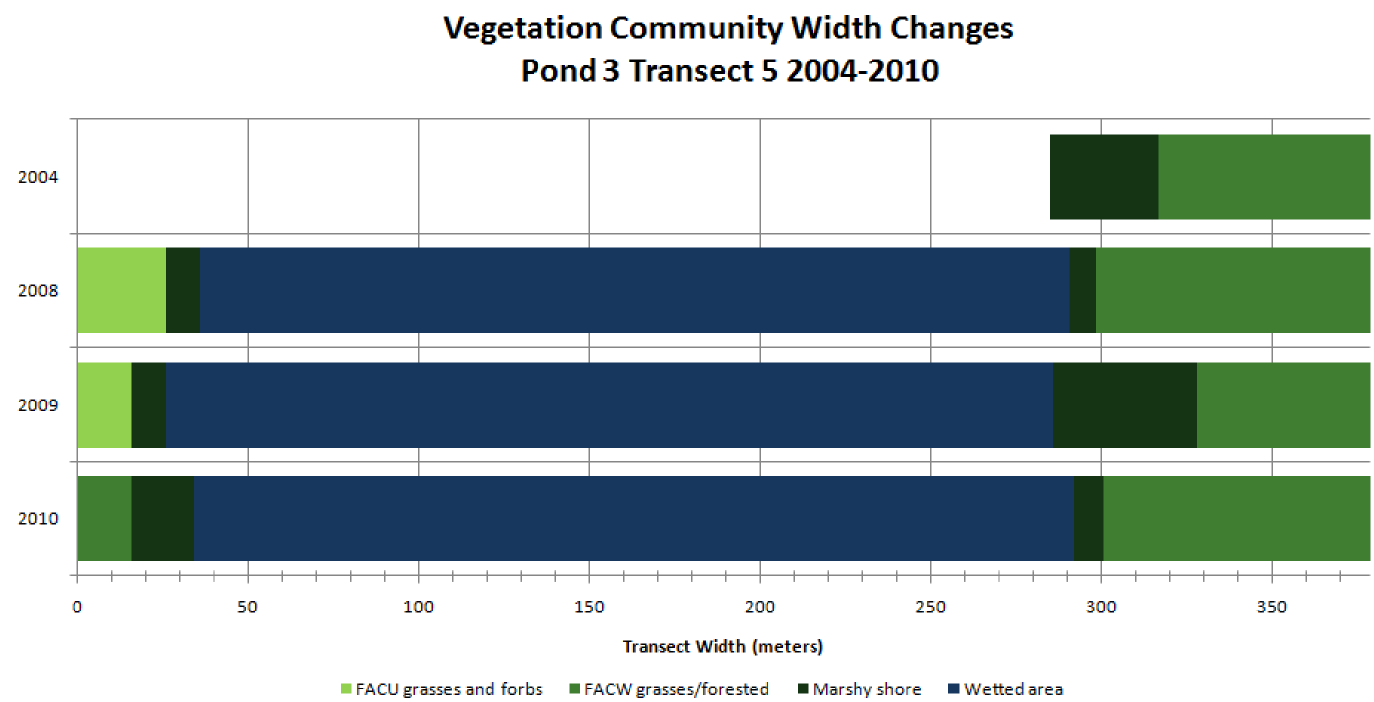


Figure 111. Pond 3 plant community widths in meters along transect 5 for 2004 and 2008-2010.

Pond 3, Transect #5	**2010**	**2009**	**2008**	**2004**
FACU grasses and forbs	16	16	26	0
Marshy shore	18.5	10	10	0
Wetted area	257.5	260	255	0
Marshy shore	9	42	7.5	32
FACW grasses/forested	78	51	80.5	62
Total:	**379**	**379**	**379**	**379**

Table 31. Pond 3 plant community widths in meters along transect 5 for 2004 and 2008-2010.

Plant community composition

In 2010 reed canarygrass was the dominant vegetation cover in the FACW (97%) and marshy shore (53%) plant communities and wapato (*Sagittaria latifolia*, native) (80%) was dominant in the wetted area of Pond 3 (Figure 112). The largest changes in cover observed between 2009 and 2010 was a decrease in reed canarygrass cover in the marshy shore (-23%) and an increase in wapato cover in the wetted area (+26%) (Figure 112). Reed canarygrass cover also increased in the wetted area from 5% to 10% and creeping spike rush decreased from 36% to 10% in 2010.

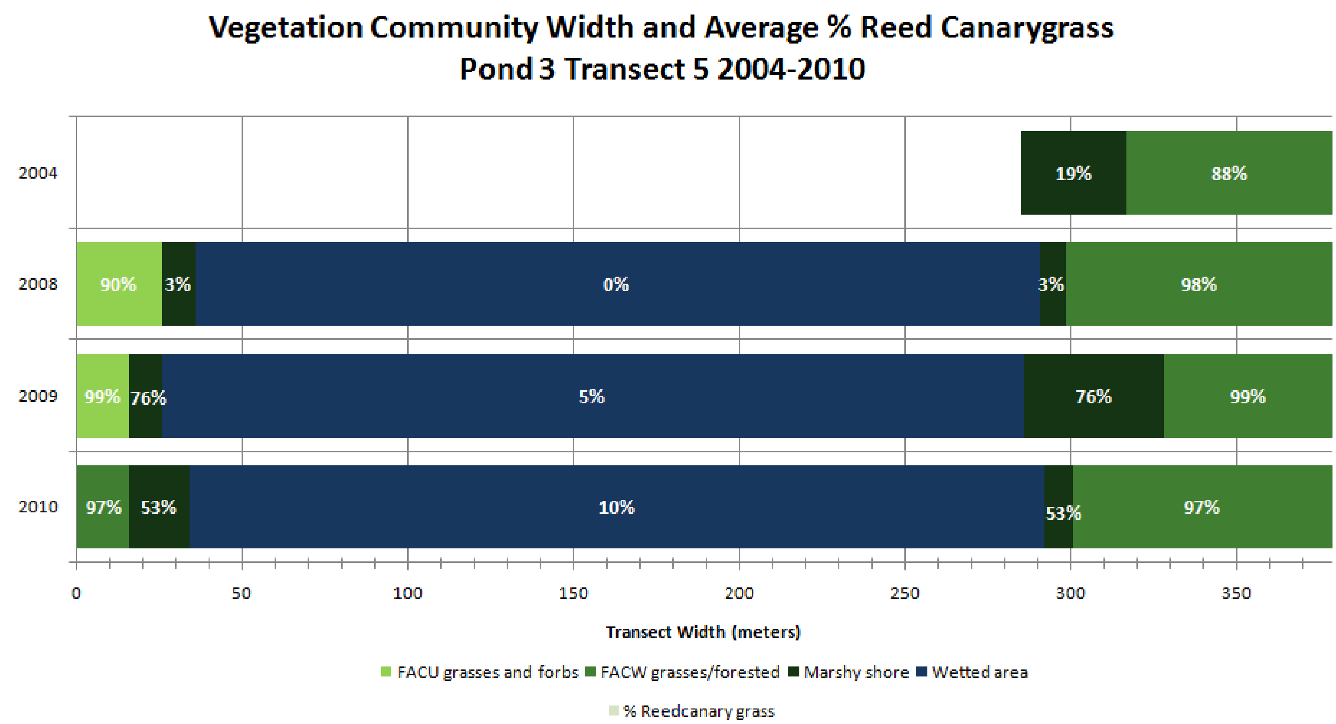


Figure 112. Pond 3 plant community widths along transect 5 and average % reed canarygrass cover for Pond 3 vegetation communities for 2004 and 2008-2010.

In 2010 and 2009 species richness of all Pond 3 plant communities were very similar. In 2010 the most species rich community was the marshy shore (5), followed by wetted area (4) and FACW (3) (Figure 113). The only changes in species richness from 2009 were an increase in native richness (+2, +1) and decrease in introduced species richness (-1, -1) in the marshy shore and FACW plant communities (Figure 113). Since 2004 the species richness in each plant community of Pond 3 has decreased (Figure 113).

Overall, Pond 3 has shown a shift from a plant community dominated by jointed rush (*Juncus articulates*, native) (31%), american speedwell (*Veronica americana*, native) (25%), and reed canarygrass (9%) in 2004, to a plant community dominated by reed canarygrass (25%), wapato (64%) and creeping spike rush (10%) in 2010 (Figure 114 & 115). Total species richness for Pond 3 has decreased from 2004 to 2010, with a trend of native species out numbering introduced species (Table 32).

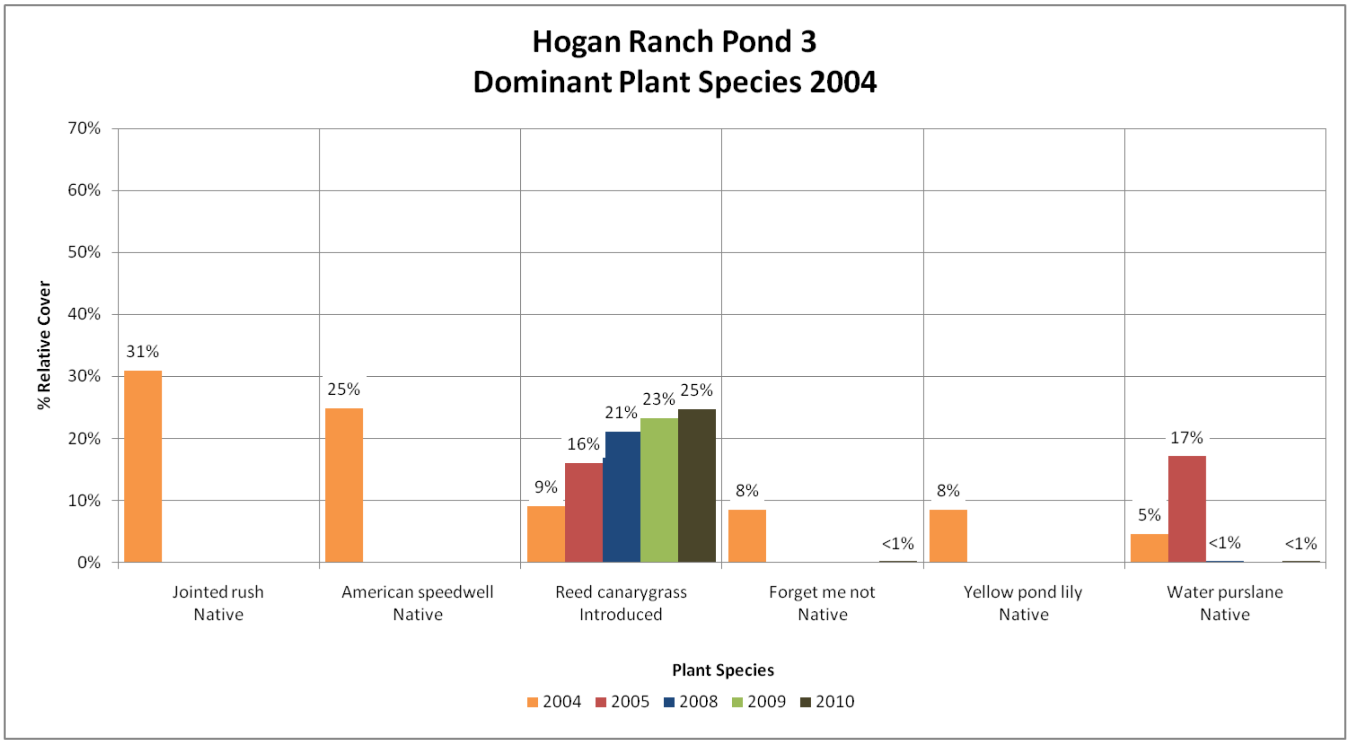


Figure 113. The top 6 dominant plant species of Pond 3 by estimated relative % cover in 2004. 2005 and 2008-2010 cover percentages shown for comparison.

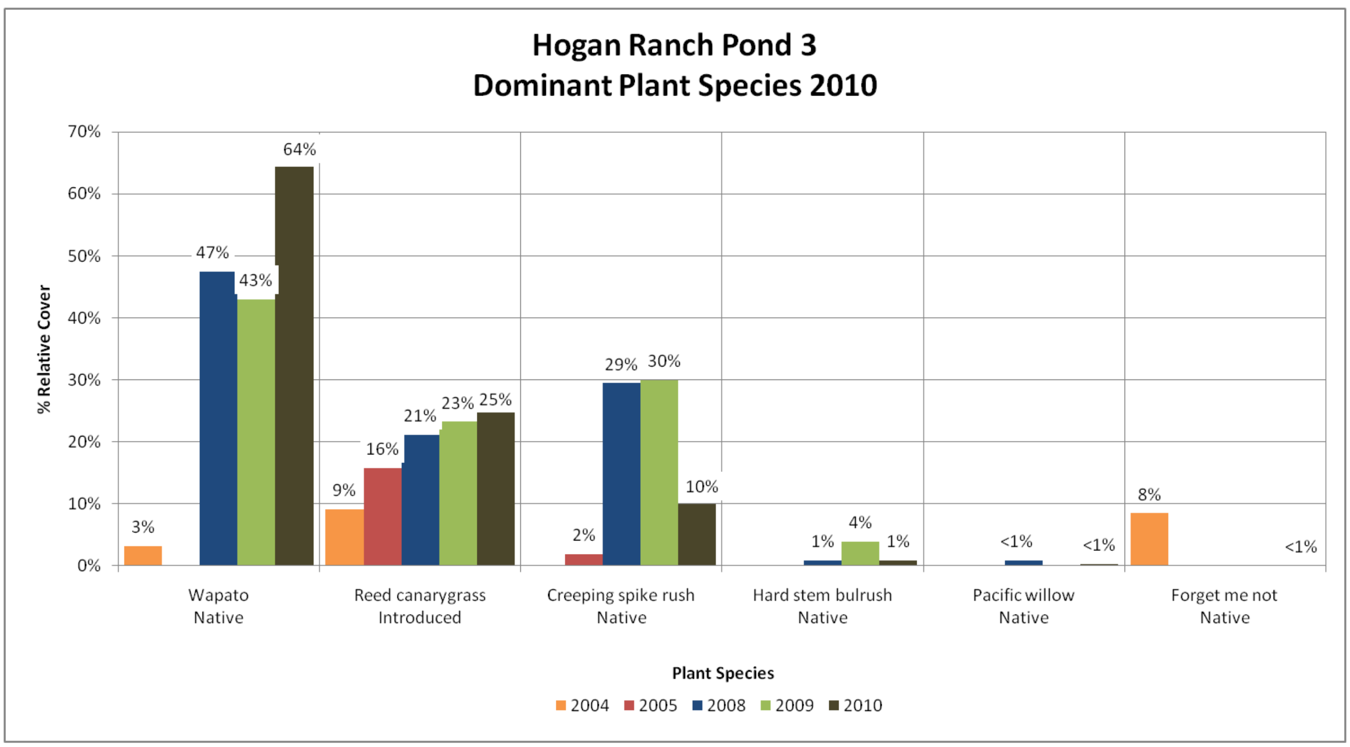


Figure 114. The top 6 dominant plant species of Pond 3 by estimated relative % cover in 2010. 2004-2005

and 2008-2009 cover percentages shown for comparison.

Year	2004	2005	2008	2009	2010
Introduced	7	7	4	2	1
Native	8	3	5	5	7
Unknown	4	4	0	0	1
Total	19	14	9	7	9

Table 32. Pond 3 total species richness 2004-2010

6.7 Vegetation Community Discussion

Plant community widths

From 2008 through 2010 the water level in Ponds 1 and 2 increased in response to water control structures that were installed in 2007. This increase in water level resulted in a continued increase in the width and overall area of the wetted area. This also caused changes to the marshy shore and FACW plant communities of these Ponds. 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 heading. This is possibly due to the lack of a willow/shrub plant community and an increase in the abundance of reed canarygrass around these Ponds. In 2010 FACW plant community was identifiable by the overall dominance of reed canarygrass and soil moisture gradient observed between the FACU and wetted area plant communities. In 2010 there was an increase in FACW plant community widths and a decrease in marshy shore and FACU plant community widths. The north side of Pond 2 (transect 3) showed a break in the wetted area with an increase in FACW plant community on a high point near the west side of transect 3. This reflects hydrological and morphological changes resulting from the excavation of that area in 2007.

The plant community widths on Pond 3 did not vary much between 2008 and 2010, 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 canarygrass and a lack of forest cover along the transect, which can make it difficult to distinguish between these plant communities.

Ponds 1 and 2

Wetted Area

In 2008 and 2009 the wetted Pond center community in Pond 1 was dominated by water purslane and water pepper. These species appeared to be increasing in cover. In 2009 reed canarygrass cover was only 6% in the wetted area of Pond 1. However in 2010 the wetted area of Pond 1 shifted from being co-dominated by water purslane (36%) and water pepper (27%) in 2009 to a co-dominance of reed canarygrass (19%), water purslane (17%) and water pepper (15%). The increased water level of Pond 1 since 2007 has increased the wetted area width in Pond 1, inundating areas that were previously marshy shore and FACW plant communities dominated by reed canarygrass. Depending on future water level fluctuations these new wetted areas may show a decrease in reed canarygrass cover over time, with high water (>.85m) suppressing reed canarygrass growth (Jerkins et al. 2008).

The wetted area of Pond 2 shifted from being dominated by water smartweed (14%), water pepper (10%) and water purslane (7%) in 2009 to a dominance of western water milfoil (28%), Canadian waterweed (13%) and Eurasian water milfoil (12%) in 2010. This shows a substantial increase in both western and Eurasian water milfoil from 2008 and 2009. Reed canarygrass cover decreased from 5% in 2009 to 1% in 2010.

Marshy Shore

Between 2004 and 2009 the width of the marshy shore community on Pond 1 and 2 showed a trend of increasing and a shift in community composition to more reed canarygrass dominance. The marshy shore zone of Pond 1 shifted from 6% reed canarygrass in 2004 to 71% reed canarygrass cover in 2009. However in 2010 the marshy shore plant community width decreased and reed canarygrass cover decreased on both Ponds. Reed canarygrass cover on Pond 1 decreased from 71% to 48% and Pond 2 showed a decrease in reed canarygrass cover from 47% to 30%. Pond 2 also showed a 9% increase in water purslane and a 14% increase in creeping spike rush. 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. In 2010 some of the area's previously considered marshy shore have transitioned to FACW or wetted area plant communities due to the spread and abundance of reed canarygrass and changes in water levels from 2007,which accounts for the decreased marshy shore community widths in 2010.

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 increasing in both Ponds. In 2005 it was dominated by white clover but has since returned to reed canarygrass (2008-2010). In 2010 there was an overall decrease in reed canarygrass cover and an increase in the FACW area's width on both Ponds. In Pond 1 reed canarygrass cover increased by 25% from 2008 to 2009 and then decreased from 93% to 75% in 2010. In Pond 2 the reed canarygrass cover decreased from 100% in 2008 to 60% in 2010. The diversity of this plant community has increased since native plant seeding (and planting), however it remains to be dominated by reed canarygrass and moneywort (both introduced species) with other species composing a very small percent of the overall plant community.

Facultative Upland

In 2010 the facultative upland community on Ponds 1 and 2 was composed mainly of reed canarygrass, pasture grasses (*Agrostis sp.*, introduced), self heal (*Prunella vulgaris*, introduced), moneywort, creeping buttercup (*Ranunculus repens*, introduced), Canada thistle (*Cirsium arvense*, introduced), pennyroyal (*Mentha pulegium*, introduced*)*, and English plantain (*Plantago lanceolata)* and white clover (*Trifolium repens*, introduced). This zone continues to have high species richness, but consists mostly of introduced species. Reed canarygrass cover is dominant in this community but has decreased since 2009, from 77% to 46% on Pond 1 and 48% to 24% in Pond 2. This is the first year reed canarygrass cover had decreased in the FACU plant community and we will continue to monitor the reed canarygrass on the site for future possible changes.

Pond 3

All plant communities

In 2008, Pond 3 showed dramatic changes in plant community composition as a result of cattle exclusion. Before cattle exclusion this area was dominated by 55% jointed rush (*Juncus articulates,* native) and 40% American speedwell (*Veronica Americana,* native). In 2010, 3 years after exclusion, Pond 3's central wetted area continues to be dominated by wapato (80%, up from 54% in 2009) and creeping spike rush

(10%, down from 36% in 2009). There was a continued increase in the wetted area community's reed canarygrass cover from 1% in 2004 to 5% in 2009 and 10% in 2010.

The marshy edges of Pond 3 have shown 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. In 2010 the marshy shore zone decreased in width and was dominated by reed canarygrass (53%, down from 76%), creeping spike rush (18%) and wapato (10%). The grassy outer ring of Pond 3 continues to be dominated by reed canarygrass and in 2010 was identified as FACW. The diversity of these communities has decreased since the first sampling period and reed canarygrass remains dominant. We will continue to carefully monitor the reed canarygrass and suggest action if appropriate. The grassy edges (FACW) of Pond 3 make up a relatively short distance along the transect compared to the wetted Pond center area (wetted area composes about 85% of the transect in 2010). Indicating that overall this FACW plant community composes only a small part of the overall Pond area. In 2010 the overall relative cover of Pond 3 was dominated by wapato (64%) and creeping spike rush (10%) and reed canarygrass (25%).

Conclusions

Three 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 water fowl 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 increase in the dominance of reed canarygrass and a decrease in FACU and marshy shore plant community widths as the FACW community (reed canarygrass zone) increases around the Ponds. However results from the 2010 vegetation survey indicate that reed canarygrass cover is decreasing within some Pond 1 & 2 communities. This may be a consequence of higher water levels and longer periods of inundation caused by the installation of water control structures in 2007. Continued monitoring will allow us to track the changes of dominant invasive species in these Ponds (such as reed canarygrass and Eurasian milfoil) to make sure this does not hinder the long-term outcome of this restoration project.

6.8 Planting Survival Results

The overall survival rate of plantings in 2010 on the Wilson/LaCombe property was 97% (73% adjusted) with an APD of 0.25 plants/m^2 (1,012 plants/acre) (Table 33, Figure 118). Adjusting the survival rate to account for missing (dead) plantings produced a 73% survival rate on Wilson/LaCombe (please see discussion section for details). On Hogan Ranch the overall survival was 84% with an APD of 0.21 plants/m^2 (850 plants/acre) (Table 33, Figure 118).

Table 33. Vigor of plantings, Total Survival and APD for Hogan Ranch and Wilson/LaCombe properties

Site and Year	Planting Vigor					Average Planting Density	
Wilson/LaCombe	**High**	**Medium**	**Low**	**Dead**	**Total Survival**	**APD (Plants/m2)**	**Plants/acre**
2008	25%	42%	16%	17%	80%	0.42	1700
2009	24%	32%	21%	23%	77%	0.33	1335
2010	66%	21%	9%	3%	97% (73%*)	0.25	1012
Hogan Ranch	**High**	**Medium**	**Low**	**Dead**	**Total Survival**	**APD (Plants/m2)**	**Plants/acre**
2008	25%	38%	17%	20%	83%	0.33	1335
2009	42%	35%	12%	11%	89%	0.16	647
2010	30%	38%	16%	16%	84%	0.21	850

2008-2010. * Wilson and LaCombe adjusted survival of 73%, see discussion section for details.

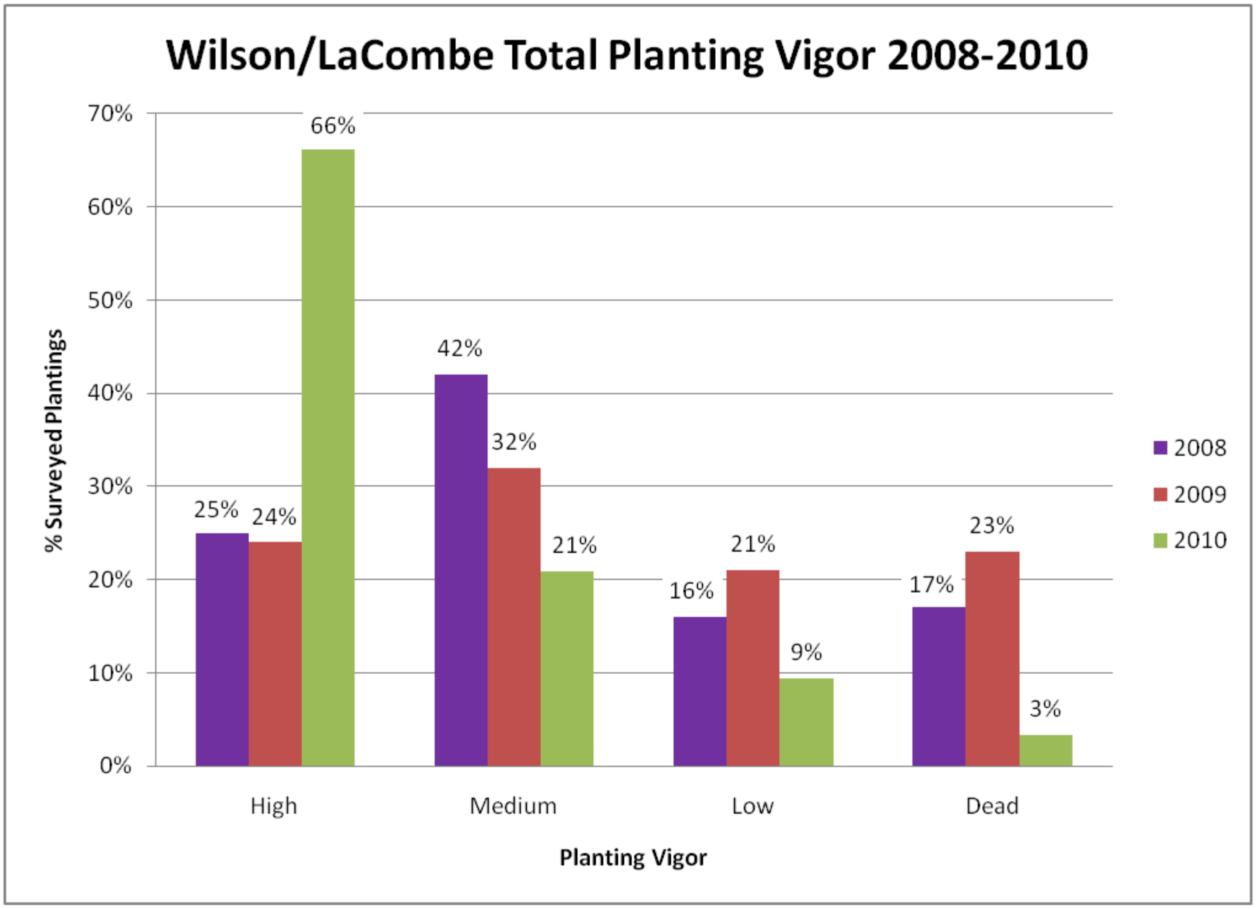


Figure 115. The vigor of plantings on Wilson/LaCombe properties 2008-2010

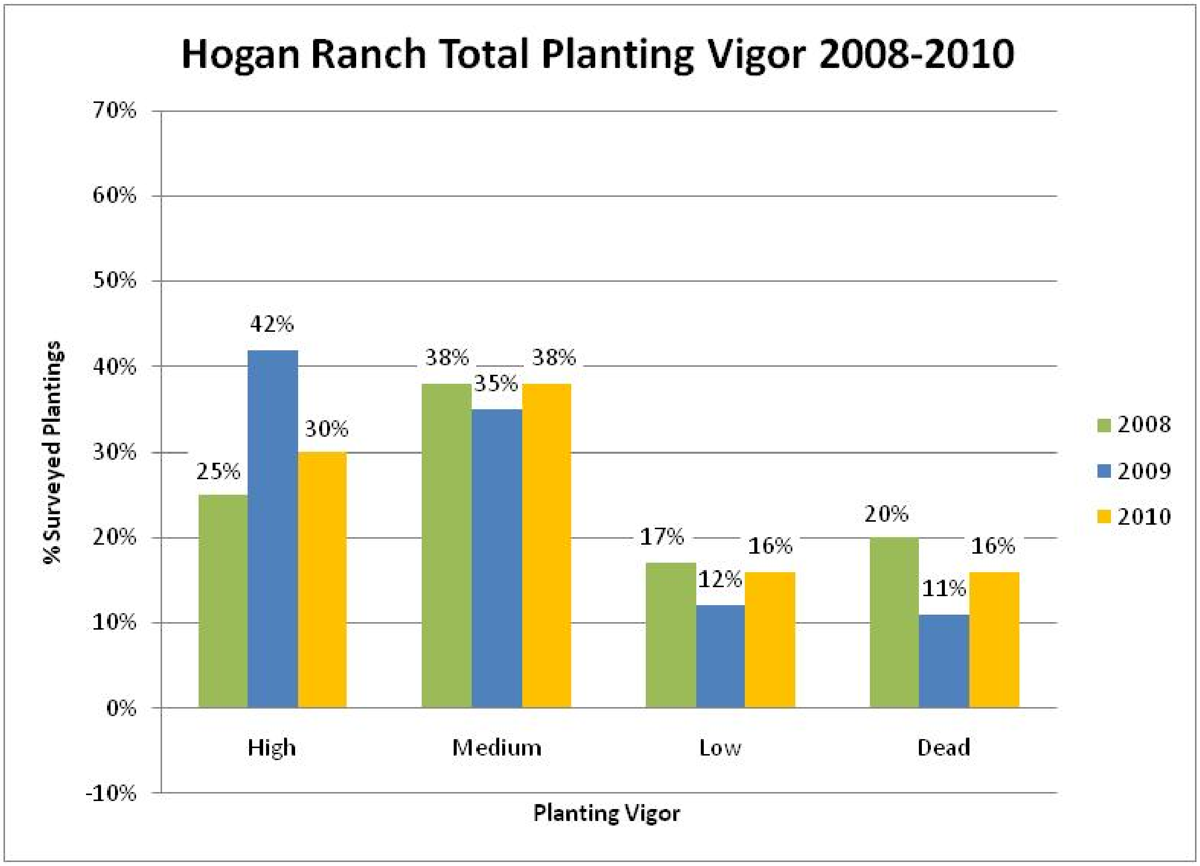


Figure 116. The vigor of plantings on Hogan Ranch 2008-2010.

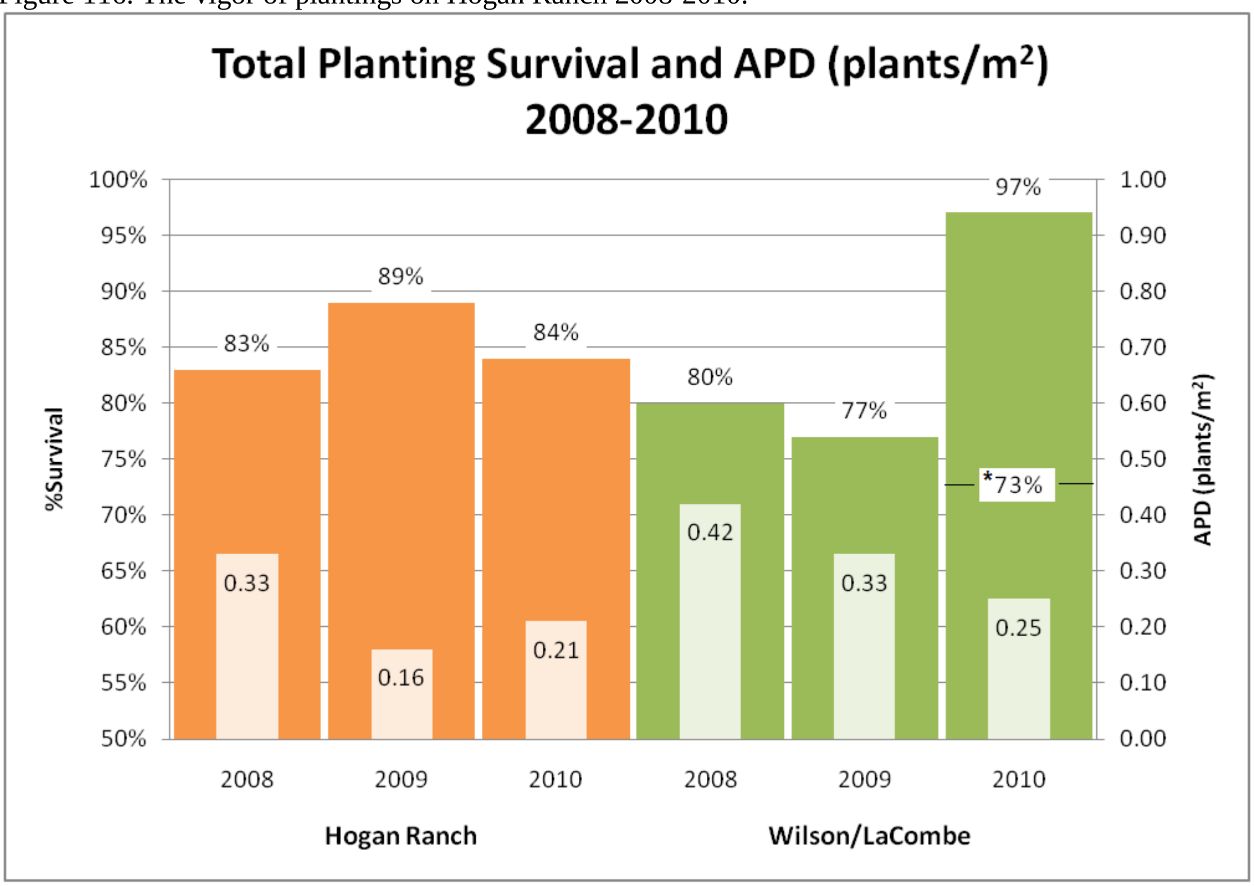


Figure 117. Total surveyed planting survival and APD for Hogan Ranch and Wilson/LaCombe properties from 2008-2010. * Wilson and LaCombe adjusted survival of 73%, see discussion section for details.

In 2010 the Hogan Ranch ash forest plant community had a total planting survival of 71% with an APD of 0.19 plants/m^2, the shrub plant community had a planting survival of 87% with an APD of 0.35, and the willow plant community had a planting survival of 89% with an APD of 0.49 (Figure 119). All plant community survival and APD (plants/m^2) from 2008 through 2010 can be seen in Figure 119.

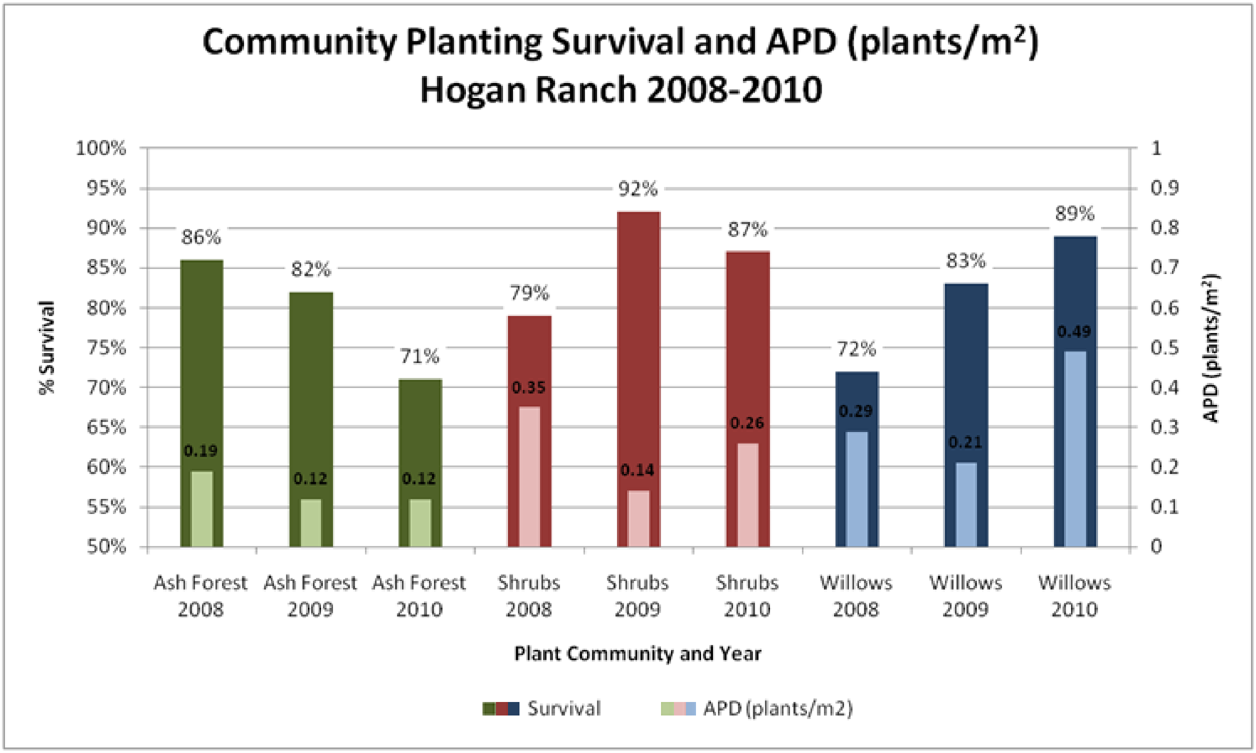


Figure 118. Community Planting Survival and APD (plants/m^2) for Hogan Ranch Ash Forest, Shrub and Willow Communities from 2008-2010.

Over the 3 years of survival monitoring on Wilson/LaCombe all planted species had high average survival rates of 86% or above (Table 34, Figure 120). However, low survey numbers for Thimbleberry, Indian plum, Willows and Western Serviceberry indicate that these species under performed and dead plants were missing during the survey inflating survival percentages (Table 34, Figure 120). At Hogan Ranch all species planted also had a high average survival rating with only one species (Twinberry) falling below 70% survival (Table 34, Figure 120). However, low survey numbers of Elderberry and Red-oiser dogwood indicate that these species under performed and dead plants were missing during the survey inflating survival percentages (Table 34, Figure 120). No change in canopy cover or dominant herbaceous layer was observed between 2008 and 2010 on Wilson/LaCombe or Hogan Ranch.

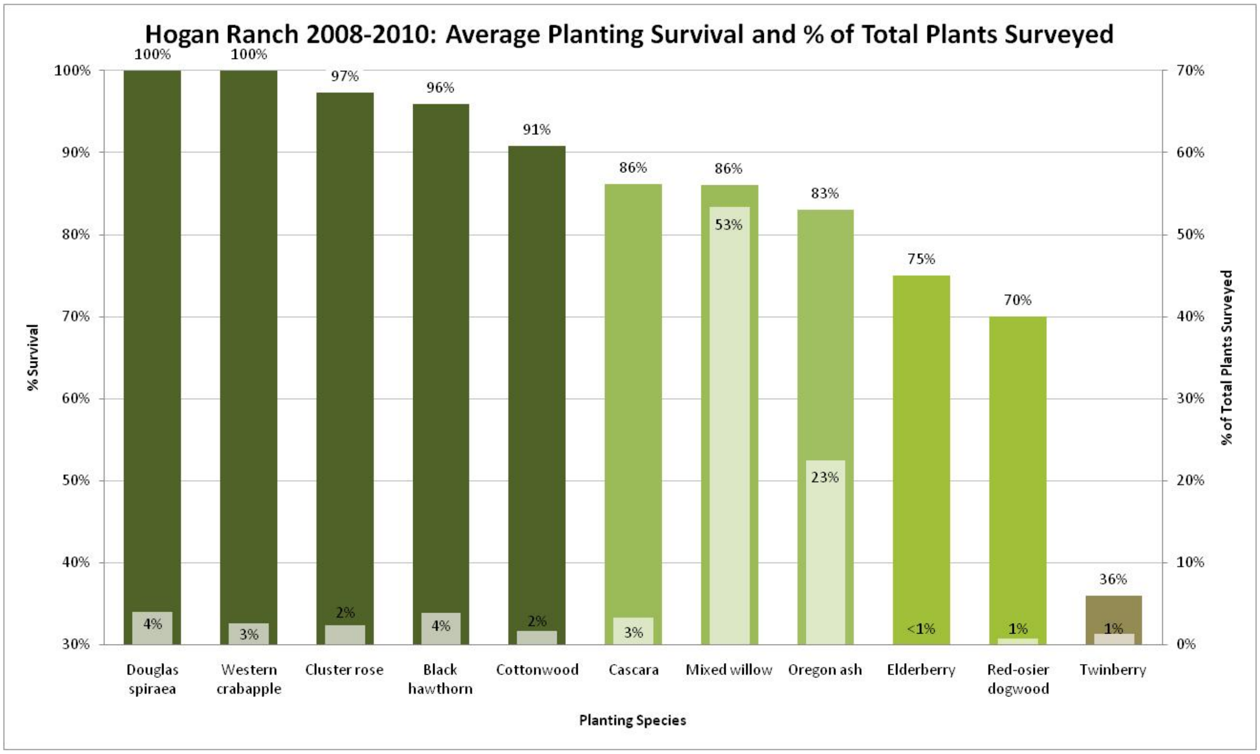


Figure 119. Hogan Ranch average planting survival and % of total plants surveyed by species for 2008 through 2010.

	2008 Hogan Ranch				2009 Hogan Ranch				2010 Hogan Ranch			
Species	**Total**	**Dead**	**Survival**	**% of total**	**Total**	**Dead**	**Survival**	**% of total**	**Total**	**Dead**	**Survival**	**% of total**
Black hawthorn	26	1	96%	9%	12	1	92%	2%	3	0	100%	0%
Cascara	13	4	69%	5%	10	0	100%	2%	19	2	89%	3%
Cluster rose	12	1	92%	4%	6	0	100%	1%	12	0	100%	2%
Cottonwood	9	1	89%	3%	1	0	100%	0%	12	2	83%	2%
Douglas spiraea	21	0	100%	7%	11	0	100%	2%	18	0	100%	3%
Elderberry	0	0		0%	0	0		0%	4	1	75%	1%
Mixed willow	100	17	83%	35%	352	32	91%	71%	382	60	84%	58%
Oregon ash	65	12	82%	23%	81	9	89%	16%	189	41	78%	29%
Red-osier dogwood	5	3	40%	2%	0	0		0%	1	0	100%	0%
Twinberry	11	7	36%	4%	0	0		0%	0	0		0%
Western crabapple	10	0	100%	4%	8	0	100%	2%	16	0	100%	2%
Unknown	11	11	0%	4%	17	15	12%	3%	0	0		0%
Total	**283**	57	80%		**498**	57	89%		**656**	106	84%	

Table 34. Hogan Ranch planting survival by species for monitoring years 2008 through 2010. *Note the larger total number of plants in 2009 and 2010 – this can be attributed to the 2009 inter-planting, the larger number of plots evaluated.

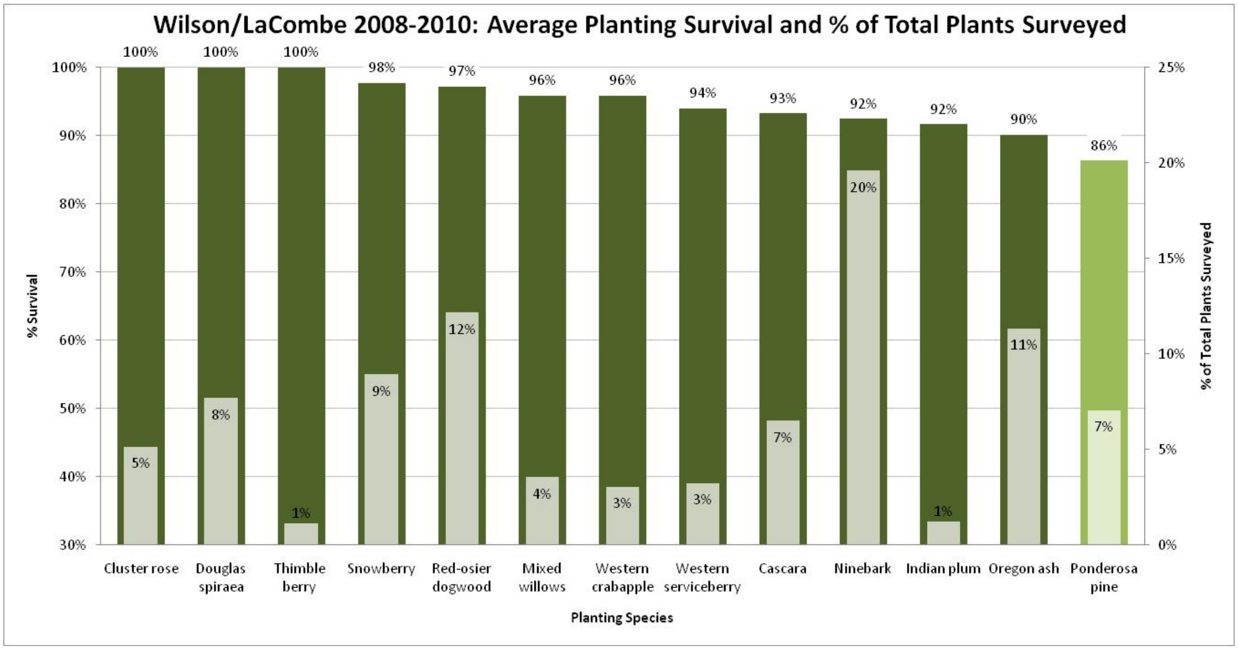


Figure 120. Wilson/LaCombe average planting survival and % of total plants surveyed by species for 2008 through 2010.

Species	2008 Wilson/LaCombe				2009 Wilson/LaCombe				2010 Wilson/LaCombe			
	Total	Dead	Survival	% of total	Total	Dead	Survival	% of total	Total	Dead	Survival	% of total
Cascara	17	0	100%	7%	8	1	88%	4%	13	1	92%	7%
Cluster rose	5	0	100%	2%	8	0	100%	4%	14	0	100%	7%
Douglas spiraea	18	0	100%	7%	13	0	100%	7%	14	0	100%	7%
Indian plum	4	1	75%	2%	3	0	100%	2%	1	0	100%	1%
Mixed willows	16	2	88%	6%	6	0	100%	3%	2	0	100%	1%
Ninebark	59	11	81%	23%	37	0	100%	19%	25	1	96%	13%
Oregon ash	20	5	75%	8%	21	1	95%	11%	23	0	100%	12%
Ponderosa pine	16	4	75%	6%	12	1	92%	6%	13	1	92%	7%
Red-osier dogwood	41	2	95%	16%	27	1	96%	14%	10	0	100%	5%
Snowberry	18	0	100%	7%	15	1	93%	8%	18	0	100%	9%
Thimble berry	7	0	100%	3%	0	0		0%	1	0	100%	1%
Western crabapple	7	0	100%	3%	2	0	100%	1%	8	1	88%	4%
Western serviceberry	11	2	82%	4%	4	0	100%	2%	5	0	100%	3%
Unknown	14	14	0%	6%	43	41	5%	22%	1	1	0%	1%
Total	**253**	41	84%		**200**	46	77%		**148**	5	97%	

Table 35. Wilson/LaCombe planting survival by species for monitoring years 2008 through 2010.

6.9 Planting Survival Discussion

The Wilson/Lacombe riparian planting showed an increase in survival from 77% in 2009 to 97% in 2010. At this site the APD decreased from 0.33 in 2009 to 0.25 in 2010. This large decrease in APD may help explain the large increase in total surveyed plant survival. A decrease in the average planting density shows that there was a decrease in the number of plants found in 2009 compared to 2010. This decrease was likely caused by a die off of plants from 2009 and 2010 that were no longer visible during the 2010 survey. After a planting event it becomes increasingly difficult to keep track of dead plantings which decay and/or are removed from the site by wildlife or flood waters. These missing (dead) plants were consequently not included in the 2010 survey and the total survival was inflated (because the number of dead plants surveyed was less than it should have been). The difference in APD between 2009 and 2010 was 0.08 plant/m^2 or 48 plants not accounted for in the 2010 survey. If these plants are added to the 2010 survey as dead plants it would give a total survival of 73% which is similar to the previous years' survival findings of 77% in 2009 and 80% in 2008. The percent of high vigor of plantings within the riparian community increased from 24% in 2009 to 66% in 2010, while the percent of medium and low vigor plantings decrease.

Individual planting species performed well on the Wilson/LaCombe site. The survival between 2008 and 2010 was high for all species planted. The herbaceous community on this site has not changed from 2008 and is dominated by reed canarygrass (*Phalaris arundinacea*) in addition to a diverse mix of non-native grasses and forbs typical of recovering pasture areas, including species such as oxeye daisy (*Leucanthemum vulgare*), curly dock (*Rumex crispus*), Canada thistle (*Cirsium arvense*), and Himalayan blackberry (*Rubus armeniacus*).

Survival and vigor of plantings on Hogan Ranch were comparable to the previous year's survival findings. The largest difference seen between years was at Hogan Ranch in 2009, with an increase in the number of high vigor plants. 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. High flood waters in the spring of 2010 may have contributed to the 12% drop in high vigor plants from 42% in 2009 to 30% in 2010.

On the Hogan Ranch site in 2010, the willow communities had the highest survival, followed by the shrub community. The APD was lowest in the ash (*Fraxinus latifolia*) forest community and highest in the willow and shrub areas. The willow community had a significantly higher APD of 0.49 compared to previous years. This difference in APD is likely due to the 2009 inter-planting (flood mortality mitigation) and random variation in survey plot location from year to year. The increased APD did not influence the planting survival in the willow community which was similar to 2009. Both 2009 and 2010 willow planting survivals were higher than 2008 due to the 2009 inter-planting. The ash forest survival decreased by 11% from 82% in 2009 to 71% 2010.

On Hogan Ranch individual species survival ranged from 75 to 100% . Species such as Red-osier dogwood (*Cornus sericea*) and twinberry (*Lonicera involucrata*), which underperformed in 2008, were not found during the 2009 survey, and only 1 Red-osier dogwood was found in 2010. Elderberry was found in the 2010 survey but not identified in 2009 or 2008 surveys. The significant increase in the number of mixed willow (*Salix sp.*) and Oregon ash (*Fraxinus latifolia*) plantings reported between 2008 and 2010 can be explained by the 2009 inter-planting.

The most abundant species surveyed on Hogan Ranch were Oregon ash and mixed willows. Combined these species composed 87% of the plants surveyed in 2010 and 2009. The willow community (*Salix sp.*) had good overall 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 11% (down further from 22% in 2009) compared to standard willow plantings which had a survival rate of 84%. The dominant herbaceous layer plant in all three communities for all years surveyed was reed canarygrass, no decrease in reed canarygrass cover has been observed.

Conclusions

Monitoring indicates that these restoration plantings are in good condition with overall survival of 84% on Hogan Ranch and 97% (or 73% adjusted) survival on Wilson/LaCombe. On both properties individual plant species are in good vigorous condition, with most species persisting at similar rates. Continued maintenance with mowing is suggested for both of sites until the plantings out grow the suppressive reed canarygrass herbaceous layer, which can grow to a height of 2-3 meters (Lavergne and Molofsky 2004, WRMWG 2009). As these plantings mature an increase in canopy cover and a decrease reed canarygrass cover is expected (Kim et al. 2006).

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