OWEB Project # 210-1023-8076

Elk Flats Restoration & Effectiveness Monitoring

This report details three years of effectiveness monitoring conducted by CREST at the Elk Flats restoration project site. CREST conducted fish community, vegetation, and water quality post-project implementation monitoring from 2012 - 2014. Effectiveness monitoring details the habitat conditions and fish use of restored habitat.

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1.0 Introduction

1.1 Executive Summary

The Columbia River Estuary Study Taskforce (CREST) completed three years of post-implementation effectiveness monitoring at Elk Flats. Effectiveness monitoring for this project evaluated the restoration activities implemented in 2012 by measuring physical and chemical habitat characteristics. The project goal was to create high quality tidal off channel habitat on the lower Ecola Creek mainstem. Monitoring of the project site included fish community, vegetation, and water quality. Results provide quantitative and qualitative evaluation of project success. CREST biologists completed the monitoring for this project following published standardized protocols.

Four species of fish were observed in the created channel during the years sampled; Coho (*Oncorhynchus kisutch*), Cutthroat trout (*Oncorhynchus clarkii*), Pacific staghorn sculpin (*Leptocottus armatus*), and threespine stickleback (*Gasterosteidae aculeatus).* Overall threespine stickleback were the most abundantly caught. Vegetation was surveyed in 2013 and 2014. Native plant species dominate the site, with slightly varying percent cover between plots and years. Water temperature and surface elevation were sampled hourly between November of 2013 and November of 2014. The average temperature difference between the created channel and the mainstem was only 0.9 degrees. The difference in average depth was only 0.1 ft. Photo points demonstrated little change over the course of one year, with similar channel structure, large woody debris, and plant cover remaining largely the same.

2.0 Monitoring Metrics & Protocols

Monitoring activities were implemented using the Roegner et al protocols. The methods for collecting fish community, water quality, vegetation, and photo point data were consistent between all years monitored.

FIGURE 1. Trapnet and livebox set up at confluence of Elk Flats channel and Ecola Creek mainstem.

2.1 Fish Community

Fish community sampling allows project managers to determine the diversity, abundance, and timing of fish species at restoration sites. A delay in the permitting process resulted in the lack of fishing at Elk Flats for the summer of 2014. Consequently, fish community sampling occurred from August to November and specific fishing days were scheduled on days with the most suitable tides. The fish community was sampled once a month in the created tidal channel with a trapnet and livebox.

The trapnet was set at the mouth of the created channel where it converges with the Ecola Creek main stem, at slack tide, just before the ebb, and remained deployed until low water. This method employs a passive technique in which the ebb tide encourages fish into the net and livebox as the water recedes from the channel. The livebox provides a shaded holding area for fish, continual water exchange from the channel, and low water velocity to reduce stress to fish. All species observed in the nets and livebox were collected into black buckets using dip nets. Water was collected from the channel at the time of each catch to maintain consistent water quality conditions with the channel. Portable aerators were inserted into the buckets to maintain static dissolved oxygen levels. All juvenile salmonids were measured, weighed, and checked for tags and markings prior to being placed in the recovery buckets. All non-salmonid fish were identified to species and measured. All fish were allowed ample recovery time and then released.

2.2 Water Quality

Simultaneously measuring water temperature and surface elevation both inside a project site and outside, in the adjacent mainstem Ecola Creek, assists in evaluating how successfully hydrologic processes were reconnected and/or restored. Tidal hydrology influences water temperature, depth, dissolved oxygen levels, and can increase macrodetritral and sediment transport between off channel and mainstem habitats.

Two In-situ LevelTROLL 300 series probes were installed, one in the created tidal channel at Elk Flats and another in Ecola Creek outside the project site. The probes were set in a perforated PVC housing secured to a T-post that was buried two to three feet into the substrate. The probes were set in November of 2013 and data collected hourly until November of 2014, providing a full year of water surface elevation and temperature data. Water level and temperature were recorded every hour. The probes were surveyed using an auto level and stadia rod, and the elevation data was corrected using atmospheric data also collected by CREST.

2.3 Vegetation

Vegetation is characterized in order to qualitatively assess the degree to which habitats have been disturbed from their native conditions, and to quantitatively measure the success of native plantings at habitat restoration sites. Only one side of the created channel was impacted during construction activities. A baseline was established on the impacted bank parallel to the restored channel to a length of 100 meters; the created tidal channel is approximately 90 meters. Three 20 meter long transects were set perpendicular from the baseline. Data plots were set at predetermined intervals along each transect, with random and permanent plots generated for each transect. Each permanent plot is sampled annually during a vegetation monitoring event. The size of data plots and methods for specific strata followed the Roegner et al. 2009 protocols for herbaceous and tree/scrub-shrub plots. The survey was reduced in size to accommodate the smaller size of the restoration area adjacent to the channel. Surveys were not

conducted on the far side of the channel where no work took place. Plant species name and percent cover were recorded for each plot on standardized data sheets.

2.4 Photo Points

Static photo points provide a qualitative record of successional changes at restoration sites, including plant species abundance and survival. Photo point locations were selected based on where change in the landscape is expected to occur. Photo points capture landscape features such as elevation, channel shape/depth, and plant community and locations were selected along the vegetation survey. GPS coordinates were recorded for each photo point and marked with a PVC stake in the field. Field notes include date, time, weather, compass bearing, GPS coordinates, model of camera used, and level of zoom.

2.5 Data storage

All data collected at Elk Flats was recorded on write in the rain data sheets, standardized for each monitoring metric. Data was entered into excel spreadsheets and scanned to create PDF copies. All files are stored on the CREST server, which is routinely backed up and files stored at an off-site location.

3.0 Sampling design

Sampling was originally scheduled to occur monthly, and was dependent partially on permitting, contracting, and funding. Fish sampling in 2012 began in October and continued through December. In 2013 sampling began in March and continued through August. Sampling in 2014 occurred from August to November, while vegetation data was collected in May, and photo points were taken in July. Water quality and level were measured every hour on the hour with one probe inside the restored channel and one anchored outside the Elk Flats channel in the mainstem Ecola Creek.

4.0 Changes to the original proposal

Changes that have occurred since the original proposal include the amendment of the time frame in which the monitoring will occur; a change resulting from the delayed completion date of the restoration project. In addition, the monitoring schedule was modified from the original proposal as a result of a delay in the permit process in 2013 and 2014. The 2014 fishing permit for Elk Flats was granted in July and fishing commenced in August.

5.0 Monitoring Results

5.1 Fish Community

The objectives for sampling the fish community at Elk Flats was to characterize the species composition, relative abundance, size class, and temporal distribution of fish, particularly ESA listed juvenile salmonids. In 2012, monthly sampling events from October to December yielded two different species of fish; one salmonid, and one native non-salmonid species. Fish species catch increased from March through August 2013 with a catch of five different species; two salmonids, four native non-salmonid species and one non-native non-salmonid species. Fish presence in the 2014 fishing season was similar to the 2013 fish season. The 2014 fishing season occurred from August through November 2014 and yielded four different species of fish; two salmonids and two native non-salmonid species. All fish species caught at Elk Flats during fishing events in 2014 were native. The four species observed at Elk Flats during the monitoring timeframe were Coho (*Oncorhynchus kisutch*), Cutthroat trout (*Oncorhynchus clarkii*), Pacific staghorn sculpin (*Leptocottus armatus*), and threespine stickleback (*Gasterosteidae aculeatus).*

5.1.1 Temporal Distribution

Coho were only caught in September of the 2014 field sampling season. Several factors may contribute to the low observance of Coho at Elk Flats, including water level, low velocity, and natural variations in migration behavior. At very low-tide/low-water events the channel is disconnected from the mainstem Ecola Creek inhibiting fish passage. This was only observed at the bottom of low tides in drier months in prior years. During fishing events from August to November 2014 the channel did not lose connectivity to Ecola Creek. Moderately sized pools hold water even during low tide/water events. These pools are well shaded and have large woody debris in them providing cover. Salmon were observed in the pools during low tide, demonstrating that fish were actively avoiding the trapnet and remaining in the channel. This behavior would result in catch numbers being lower than the

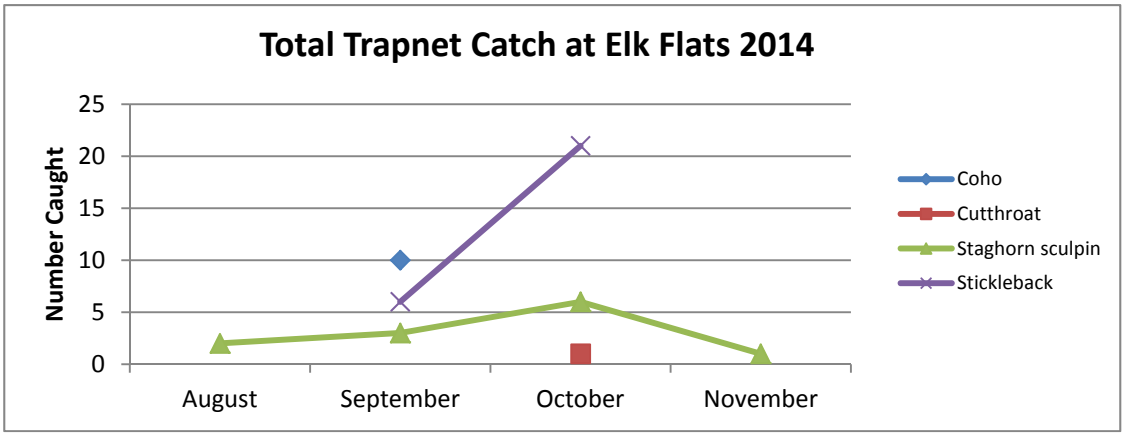

FIGURE 2. Total number of fish caught and sampled at Elk Flats in 2014 by species.

actual number of fish present in the channel.

In prior years CREST biologists walked down the channel, splashing, to encourage fish to move into the trapnet before the final pull. This resulted in high turbidity and salmon were observed swimming upstream into the turbid waters. Due to the disturbance and stress this posed to juvenile salmon the method was discontinued. The turbidity posed a significant issue largely because the created channel was disconnected from the mainstem, eliminating flow into the created channel. During 2014 the channel remained connected during low water events. It was decided that the connection to the mainstem would reduce turbidity and fish stress, so the "stomping" method was again implemented in August and repeated in September, October, and November 2014. The practice of walking down the tidal channel resulted in the highest catch rates in all events except for November. All Coho caught in September were caught on the last pull when biologists walked down the channel; therefore the actual number of Coho using the tidal channel is assumed to be greater than the catch reflects.

FIGURE 3. Coho sampled at Elk Flats on 9/22/2014.

One individual Cutthroat trout was caught in October 2014. This result was similar to the fishing season in 2013 which had one Cutthroat trout caught in May. No Cutthroat trout were observed in 2012. No current assumptions can be made of Cutthroat trout temporal distribution except that they are entering the tidal channel at different times of the year.

Pacific staghorn sculpin was the only species that was encountered in all fishing events in 2014. In August, two individual Pacific staghorn sculpins were caught and sampled. The catch rate increased in September (3) and October (6), then decreased in November to a single individual caught. In 2012 and 2014, the tidal creek was fished in the colder fall months, in 2013 fishing occurred during the warmer spring and summer months. This difference resulted in a difference in sculpin species observed. Pacific staghorn were caught during the colder months while prickly sculpin were caught in the spring and summer months.

Observance of threespine stickleback varied between both years and months sampled. One threespine stickleback was observed in August of 2013 but none were encountered in August 2014. Six were caught in September of 2014, 21 (the largest observed number) in October and none in November.

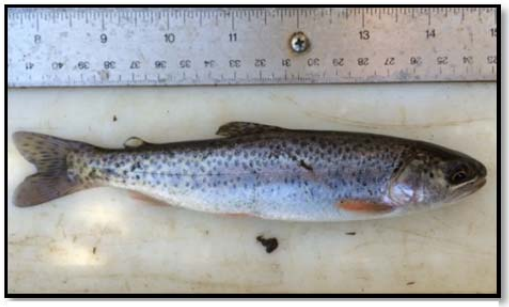

FIGURE 4. Coastal Cutthroat trout sampled at Elk Flats on 10/6/2014.

5.1.2 Length & Weight

Average length and weight was calculated for juvenile Coho caught at Elk Flats in September 2014, the only month Coho were observed. The average length of Coho sampled was 84.7 mm and the

average weight was 6.63 g which is comparable to the average length and weight of Coho sampled in October 2012 (as seen in Figure 5).

In 2013, Elk Flats was fished from March to August with a total of 22 Coho caught. The average length and weight of Coho sampled in the spring of 2013 (March, April, May) was 85.44 mm and 6.58 g. In the summer of 2013 (June, July, August) the average length and weight of Coho sampled decreased to 64.97 mm and 3.15 g. The difference in average length and weight in 2013 compared to 2014 suggests that juvenile Coho present in the channel are largest in the spring when they are preparing for smoltification and migration into the estuary. In the summer, water levels are at their lowest point which results in the highest water temperatures of the year. The elevated water temperature may slow the growth rate of juvenile Coho. In the fall, most of the juvenile Coho that are in the tributaries, fresh water streams, and creeks are in the parr stage, feeding in preparation for the smolt stage in spring (Lestelle 2007).

In May 2013, one Cutthroat trout was sampled with a length of 157 mm and a weight of 24.80 g. The Cutthroat trout caught in October 2014 measured 172 mm and weighed 51.80 g. A variety of year classes of Coastal Cutthroat trout are often found together in streams and pools along the Oregon coast (ODFW Southwest Regional Fish Management Meeting Report 1995); and streams may have both sea-run and resident cutthroat species. As a result of the low numbers observed, no conclusions can be drawn regarding residency or migration patterns of cutthroat in the created channel; the data merely demonstrates their presence in the system.

Pacific Staghorn sculpin was encountered in all four months of the fishing season. The smallest were caught in August when they averaged 29 mm. The largest catch coincided with the largest individuals, observed in September with an average length of 67 mm. In October the size and number of individuals observed decreased and in November only one individual was caught. Threespine stickleback were the fourth species of fish encountered at Elk Flats in 2014. Threespine stickleback were not encountered until September when six individuals were observed with an average length of 37.83 mm. In October, the average length of threespine stickleback reduced to 34.86 mm and in November none were observed.

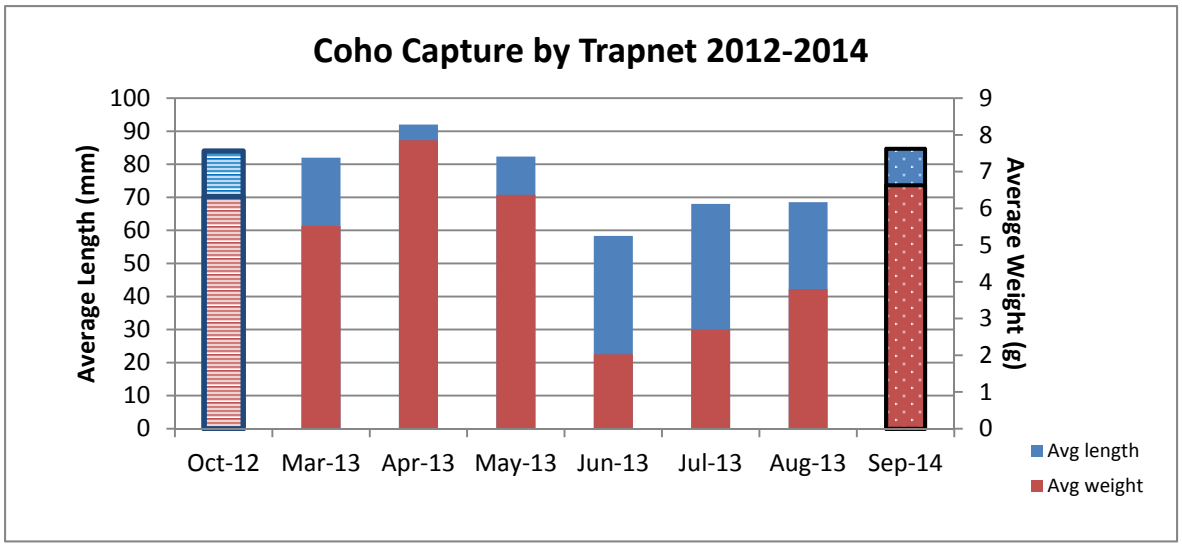

FIGURE 5. Average length and weight of all Coho sampled at Elk Flats from October 2012 (lines) through September 2014 (dots).

5.2 Water Quality

FIGURE 6. Water quality probe in Elk Flats channel.

Two probes measuring pressure, temperature, and depth were deployed for a full year (November 2013 to Novermber 2014) in the created channel at Elk Flats and in the mainstem Ecola Creek. The mainstem probe was placed approximately 50 yards up river from the restoration site, close enough that water surface elevetation data should be identical. A longer distance would create a delay in the tidal signature between the two sites. The probes were surveyed and depth data corrected using survey data, as well as atmospheric data collected at the CREST office in Astoria. Daily temperature and water level data were graphed to demonstrate the tidal hydrology and similar conditions inside and outside the project site; the 7-Day moving average for water temperature was calculated and compared to the maximum ideal temperature for juvenile salmonid growth and survival. Water temperatures were slightly higher in the created off channel than in the mainstem Ecola Creek. These higher temperatures occurred between March and July; and occurred again in the fall between the months of October and November of 2014.

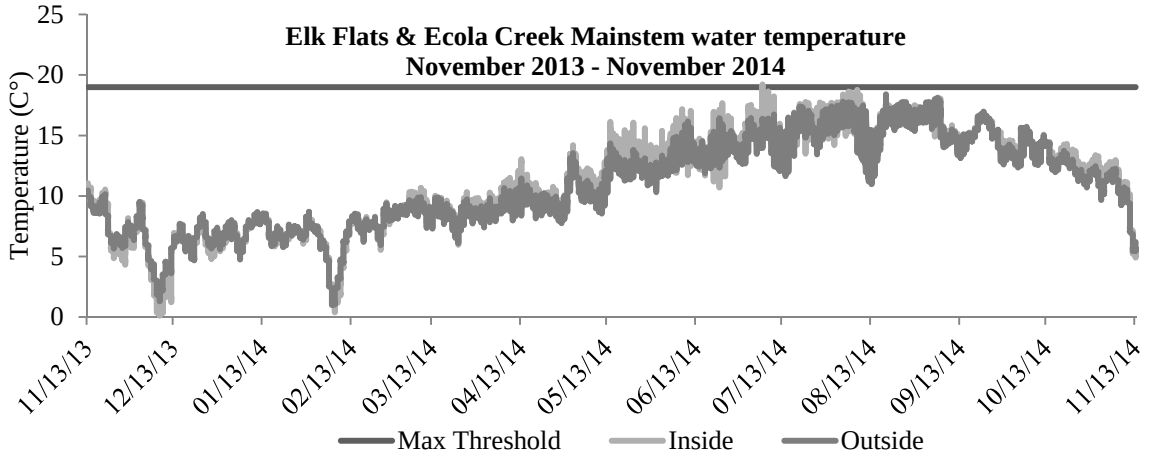

FIGURE 7. Hourly water temperatures inside Elk Flats and in the Ecola Creek mainstem.

The maximum temperature inside Elk Flats was 19.2°C, which is 0.8 degrees less than the maximum temperature measured in the mainstem Ecola Creek (18.4°C). The minimum temperature inside Elk Flats was 0.13°C, which was actually 0.85 degrees warmer than the mainstem whose lowest measured temperature was 0.98°C. This less than one degree difference in temperature attests to the congruous conditions inside and outside the restoration site. The average temperature difference was 0.9 degrees. The maximum ideal temperature for juvenile salmonids, above which growth rates are poor to none, is 19°C (U.S. Environmental Protection Agency. 1999). The mainstem Ecola Creek never reached this temperature, and the restoration channel only had one single reading during the entire year that was 19°C or higher; this occurred in July.

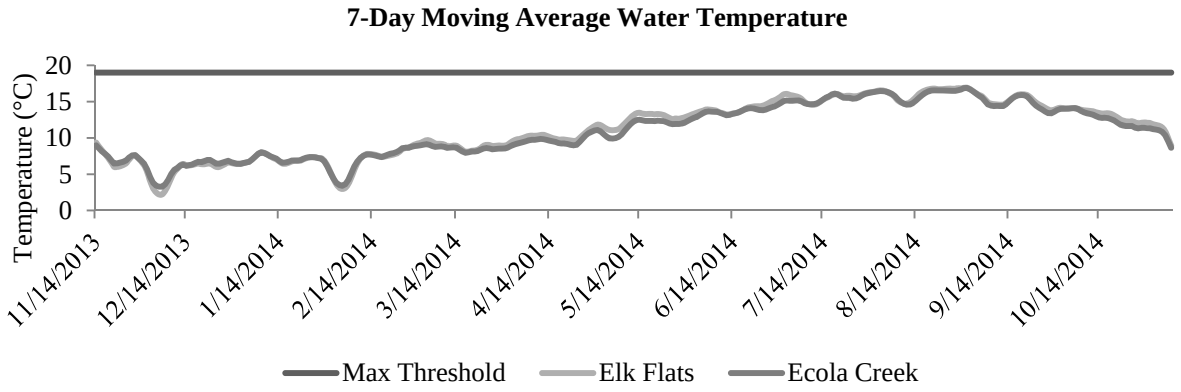

FIGURE 8. 7-Day moving average water temperature inside Elk Flats and outside the project site in the Ecola Creek mainstem.

Water surface elevation was remarkably similar inside and outside the restoration site. The maximum recorded depth was 8.28 feet inside the created channel and 8.34 feet in the mainstem, for a difference of only 0.06 feet in maximum depth. The lowest recorded depth inside the created channel was 1.817 feet and outside was 1.844 feet, for a difference of 0.027 feet. The average depth was 3.5 feet inside and 3.6 feet outside.

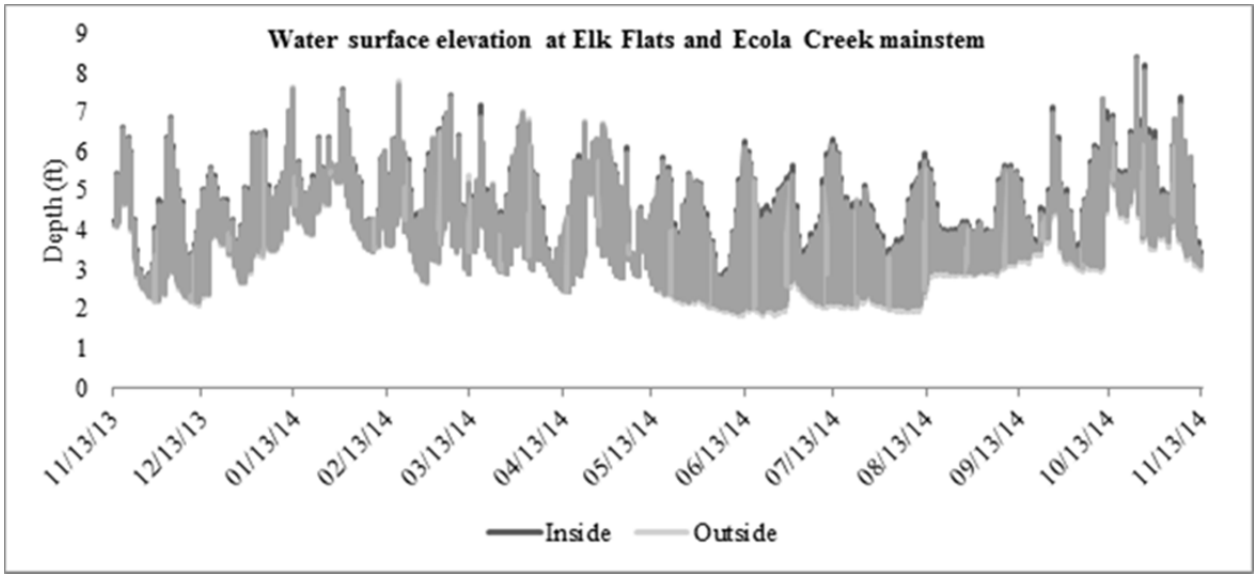

Figure 9. Water surface elevation and temperature inside Elk Flats and outside the project site in the Ecola Creek mainstem.

5.3 Vegetation

The Elk Flats restoration site reflects a natural system that seems as if it was never disturbed or restored. The only disturbances that were noticeable were elk tracks and droppings. The upper canopy continues to be dominated by Douglas Fir (*Pseudotsuga menziesii*) and Red Alder (*Alnus rubra*) throughout the entire site. Like 2013, the dominant shrubs within the plots were: Salmonberry (*Rubus spectabilis*), Nootka Rose (*Rosa nootkana*), and Red Elderberry (*Sambucus racemosa*). Cooley Hedge-Nettle (*Stachys cooleyae*) and Pacific Water Parsley (*Oenanthe sarmentosa*) were the most dominant herbaceous species found amongst the three permanent plots in the 2014 vegetation survey.

Vegetation data was compared between the surveys conducted in 2013 and 2014 using the three permanent plots: Transect 1 Quadrat 3, Transect 2 Quadrat 4, and Transect 3 Quadrat 3 (Figure 10). Vegetation surveys completed in late 2012 and summer of 2013 confirmed the dominance of native plant species throughout the site. Native vegetation species continue to dominate the restoration site in 2014. A total of 23 distinct plants were observed during the 2014 survey; two were not identified to species and one was Moss. All of the 20 identified plant species at Elk Flats are considered native vegetation. In 2012, thirteen species of plants were encountered and in 2013 there were 19 plant species identified within the survey plots. In 2014 the vegetation survey revealed 11 additional plant species within the permanent plots: 1 rush, 2 trees, 3 shrubs, and 5 herbs. The vegetation survey conducted in 2012 was during the month of October, consequently foliage and percent cover as a whole was diminished compared to surveys in 2013 and 2014. Percent cover data cannot be directly correlated unless data collection occurs during a similar season. Therefore, data from 2012 is included in the figures but most of the data analysis comes from 2013 and 2014 data.

TABLE 1. Elk Flats Plant Species List 2014		
Latin Name	**Code**	**Common Name**
Oenanthe samentosa	OESA	Pacific Water-Parsley
Carex obnupta	CAOB	Slough Sedge
Rubus spectabilis	RUSP	Salmonberry
Polystichum munitum	POMU	Sword Fern
Equisetum arvense	EQAR	Common Horsetail
Maianthemum dilatalum	MADI	False Lilly of the Valley
Stachys cooleyae	STCO	Cooley Hedge-Nettle
Athyrium felix-femina	ATFE	Lady Fern
Rosa nootkana	RONO	Nootka Rose
Rhamnus purshiana	RHPU	Cascara
Sambucus racemosa	SARA	Red Elderberry
Dryopteris austraca	DRAU	Wood Fern
Claytonia lanceolata	CLLA	Western Spring Beauty
Rubus ursinus	RUUR	Trailing Blackberry
Rumex obtusifolius	RUOB	Bitter Dock
Blechnum spicant	BLSP	Deer Fern
Juncus effusus	JUEF	Common Rush
Picea sitchensis	PISI	Sitka Spruce
Alnus rubra	ALRU	Red Alder
Veronica scuttela	VESC	Marsh Speedwell
	DW	Dead Wood
	MOSS	Moss Species
	GRSP	Grass Species
	BG	Bare Ground
	HESP	Herb Species

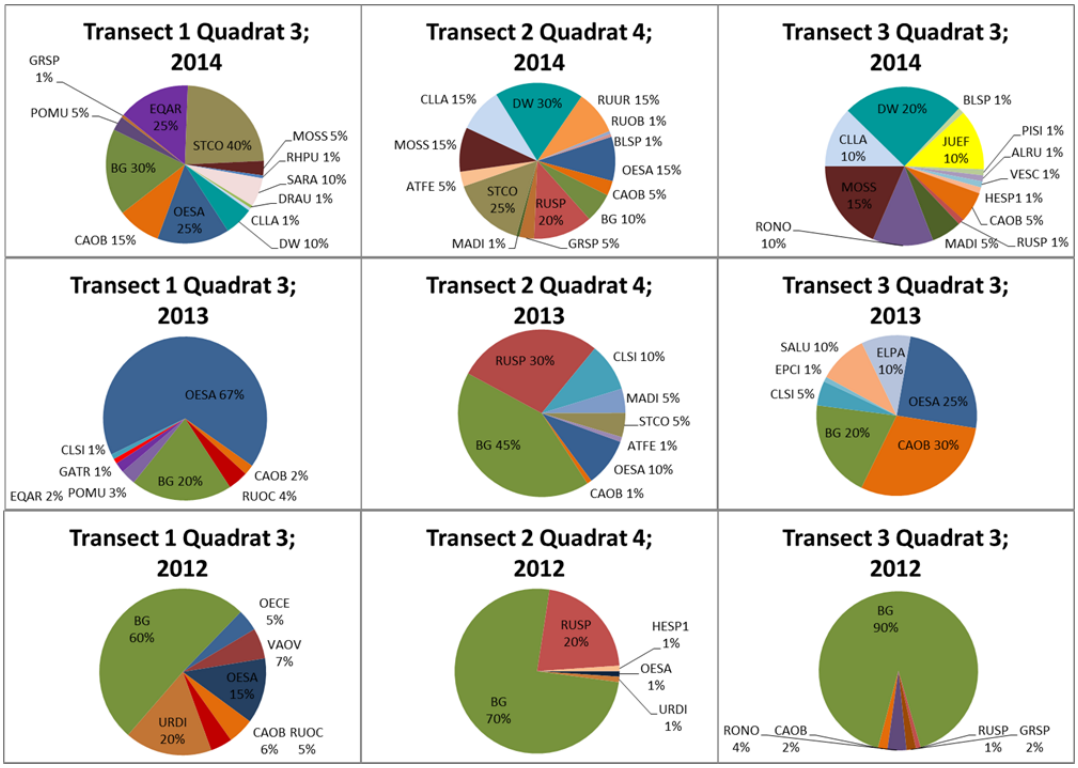

FIGURE 10. Vegetation presence within permanent plots at Elk Flats from 2012 to 2014.

Bare ground decreased from 2013 to 2014 by an average of 15% within the permanent plots. Transect 1 Quadrat 3 (T1Q3) bare ground increased by 10% but the number of plant species increased from 7 to 12, or 71%. The most dominant species in 2013 at T1Q3 was Pacific Water-Parsley (67%) but in 2014 the amount of Pacific Water-Parsley decreased to 25%. In 2014, the dominant species was Cooley Hedge-Nettle (40%) which was not present in 2013 at T1Q3. The species that had the largest increase in percent cover from 2013 to 2014 in T1Q3 were Common Horsetail (*Equisetum arvense*) and Slough Sedge (*Carex obnupta*). Common Horsetail percent cover increased from 2% to 25% and Slough Sedge increased from 2% to 15%.

Transect 2 Quadrat 4 (T2Q4) had a dramatic decrease in bare ground percent cover from 45% in 2013 to 10% in 2014. The difference in bare ground is attributed to the presence of dead wood (30%) within the quadrat in 2014. The percentage of four of the seven species present in 2013 increased in 2014. The species that showed an increase in T2Q4 included Slough Sedge, Pacific Water-Parsley, Lady Fern (*Athyrium felix-femina*), and Cooley Hedge-Nettle. False Lily of the Valley (*Maianthemum dilatalum*) and Salmonberry were the only species that showed a decrease in percent cover and Siberian Miner's Lettuce (*Claytonia sibirica*) was entirely absent in 2014 compared to its presence in 2013. Additional species that appeared in 2014 were Western Spring Beauty (*Claytonia lanceolata*), Trailing Blackberry (*Rubus ursinus*), Bitter Dock (*Rumex obtusifolius*), Deer Fern (*Blechnum spicant*), and an unidentified grass species (GRSP).

The percent cover of bare ground in 2014 at Transect 3 Quadrat 3 (T3Q3) was not detected compared to 20% cover in 2013. Similar to T2Q4, bare ground percent cover was replaced with dead wood within

the permanent plot. Slough Sedge was the only species that persisted from 2013 to 2014; although percent cover decreased from 30% to 5%. The other five plants present in 2013 were not apparent in 2014 within T3Q3 and were replaced by ten additional plants. The plot was dominated equally at 10% cover each by Nootka Rose, Western Spring Beauty, and Common Rush (*Juncus effuses*).

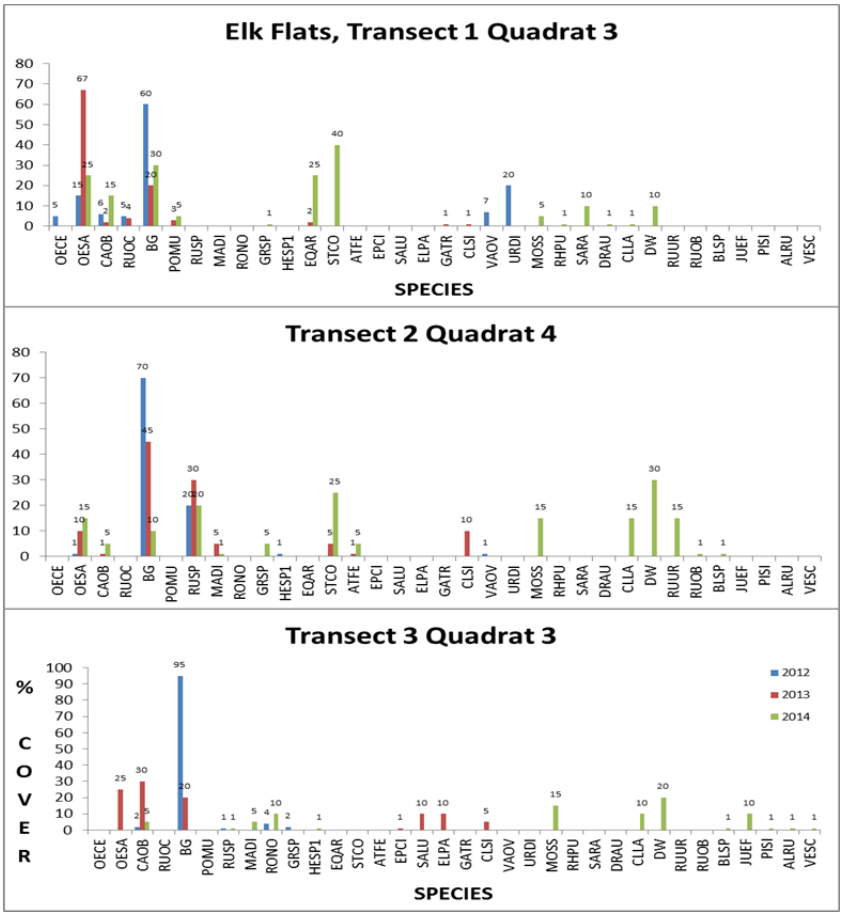

FIGURE 11. Vegetation presence within permanent plots at Elk Flats from 2012 to 2014.

5.4 Photo Points

A series of six photos were taken at two photo point locations during the summers of 2013 and 2014. The photos were taken on the east side of the channel where restoration activities were staged. The project was completed in 2012 allowing almost a year for vegetation to recover from construction impacts, and planting to become established. The photos display a native emergent plant community, with a healthy forested canopy. Very little difference is noticeable in the vegetation or channel shape between the two years. The site shows little to no signs of impact, and the abundance of native plant cover leaves very little open or disturbed areas for non-native species to persist.

TABLE 2. Photo Point 1 Meta Data				
Point I.D.	**Azimuth**	**Latitude**	**Longitude**	**Camera Model**
1.1	**230**	**45.89917N**	**123.95450W**	Olympus TG830
1.2	**200**	**45.89917N**	**123.95450W**	Olympus TG830
1.3	**170**	**45.89917N**	**123.95450W**	Olympus TG830

FIGURE 12. Photo Point 1: near mouth of channel at start of vegetation transect 1. The three photos on the left are from 2013 and the three photos on the right are from 2014. Photo Point 1.1 is shown in the top two photos. Photo Point 1.2 is shown in the middle two photos. Photo Point 1.3 is represented in the bottom set of photos.

TABLE 3. Photo Point 2 Meta Data				
Point I.D.	**Azimuth**	**Latitude**	**Longitude**	**Camera Model**
2.1	**180**	46.89893N	123.95459W	Olympus TG830
2.2	**60**	46.89893N	123.95459W	Olympus TG830
2.3	**330**	46.89893N	123.95459W	Olympus TG830

FIGURE 13. Photo Point 2: at start of vegetation transect 2. The three photos on the left are from 2013 and the three photos on the right are from 2014. Photo Point 2.1 is represented in the top two photos. Photo Point 2.2 is shown in the middle set of photos. Photo Point 2.3 is shown in the bottom two photos.

6.0 Conclusions

Sampling was implemented over the course of three years. Project completion and permitting resulted in fish sampling occurring in different months over the course of the three years. This did result in multiple seasons (spring, summer, fall & winter) being sampled. This data assists in determining the presence or absence of fish species during different months of the year. Water quality data was initially collected only in the created channel; in 2013 CREST was able to provide an additional probe allowing for the comparison of off channel and mainstem water temperature and water surface elevation for an entire calendar year. Photo points and vegetation were sampled during similar times of the year in 2013 and 2014.

6.1 Fish Community

Early stages of effectiveness monitoring at the Elk Flats restoration site have revealed the use of newly restored off channel habitat by ESA listed salmonids, specifically Oregon Coast Coho salmon. The fish community data collected from October through December of 2012, March through August of 2013, and August through November 2014 helps confirm other research suggesting that residence times within particular habitats and timing of movements between habitats is likely an outcome of complex interactions between an individual fish and its environment (Stearns 1976).

Salmonid presence and absence during different months could be attributable to a combination of biological and environmental factors that can cause a fish to move into and out of a site. Biological factors include fish size, growth rate, physiological state, and intra- and inter-specific interactions (Bottom et al. 2005a). Environmental factors such as river discharge, temperature, photo-period, and lunar cycle also contribute to fish movement (Bustard and Narver 1975, Hartman et al. 1982). Whether residence time and timing of movements between habitats is a result of environmental, physical, or a combination of both factors, several studies support our findings by suggesting that sub-yearling salmonids emigrate from the estuary upon achievement of a threshold size, usually between 70 and 90 mm in length (Tschaplinski 1988, Johnson et al. 1992, Murphy et al. 1997).

6.1.1 Temporal distribution

As is seen by the data collected from the 2012, 2013, and 2014 seasons, temporal distribution of Coho has been highly variable. Given that fish were able to remain in the channel during the ebb, thus avoiding capture in the trapnet, it can be concluded that fish are present in the channel in higher numbers and perhaps in months when no fish were caught in the trapnet and/or months when the channel was not fished. The data we have collected informs us that the habitat is both suitable and consistently used during multiple Coho life history stages.

6.1.2 Length & Weight

The variation in the length of salmonids across the 2013 spring/summer sampling season and the 2014 fall sampling season indicate that different size classes and ages of juvenile Coho are utilizing the restoration site. The data collected in 2014 shows that the Coho entering the channel at Elk Flats were of parr size. Coho that are in the parr stage grow and expand their territories during the fall months by progressively moving into deeper water. In the winter food availability diminishes as does their growth rate. In the spring of their first year the Coho continue to feed and seek refuge in large cold pools and by July and August they inhabit the deepest pools. This is the period when water temperatures are highest, and growth slows once again. Food consumption and growth rate decrease during the winter months of highest flows and coldest temperatures (usually December to February). By March, parr again begin to feed heavily and grow rapidly. In the parr stage of development the Coho are in search of deeper water for colder water temperatures. The larger sub yearlings are migrating downriver towards the estuary to begin smoltification. The transition to smaller sized Coho from June to August suggests that more recently hatched Coho are moving out of the mainstem and into off channel habitat where forage and refuge opportunities are greater. The absence of Coho caught during three of the four months of the 2014 sampling season suggests that the parr sized Coho retreated from the channel in the fall in search of deeper water, forage, and/or refuge.
Staghorn sculpin spawn in brackish water from October to April and migrate to coastal habitat before the lower salinity spring months. During the fall of 2014, only Staghorn sculpin were sampled suggesting that they were using the tidal channel at Elk Flats for spawning. Pacific prickly sculpin spawn from February to June and migrate from brackish water into freshwater during the summer (Moyle, P.B., et al. 2004). Accordingly, none were encountered in the fall 2014 fishing season.

6.2 Water Quality

The almost identical temperatures and water depths inside and outside the project site demonstrate the success of restored tidal hydrology at the restoration site. The data indicates that the channel opening was designed in a manner that allows for unrestricted tidal acces, not being too shallow or narrow enough to restrict hydrologic processes which would result in greater differences in water depths. The created channel did maintain higher water levels throughout the year, however. This is the result of lower elevation pockets of water within the channel. In order to maintain the probe below the water surface during low water events the probe was placed in such a pocket.

6.3 Vegetation

Vegetation at the restoration site reflects its pre-restoration condition. The Ecola Creek Watershed as a whole is relatively pristine and undisturbed. Prior to creating off channel habitat the vegetation was well established and dominated by native plants. Minimal disturbance during construction maintained

the quality of riparian vegetation, and additional plantings were completed to enhance and promote native plant diversity and survival.

The east side on the site that parallels the highway is the higher elevation side. Moving west toward the created channel the elevation decreases. The three transects were laid out from east to west, channel to highway. For the most part, the higher the quadrat number within any given transect, the drier the soil conditions will be.

Cumulatively, the vegetation percent cover of all three permanent plots increased by 25% from 2013 to 2014. As stated above, this lead to the decrease of bare ground within the permanent plots. In 2013, species diversity was low and 33% of percent coverage was dominated by Pacific Water-Parsley. The other dominant species were Slough Sedge (11%) and Salmonberry (10%). In 2014, species diversity increased and percent coverage was shared by more plants. The species with the most percent coverage and highest increase from 2013 to 2014 was Cooley Hedge-Nettle. It accounted for 16% of total percent cover and it increased by 60% in one year. Other notable species in terms of dominance were Pacific Water-Parsley, Salmonberry, Common Horsetail, and Western Spring Beauty.

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