Initial Biological Responses at a Restored Floodplain Habitat, Hansen Creek, Washington

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Table of Contents

Figures

Tables

Abstract

Streams with intact floodplain connections are important to juvenile salmonids during their freshwater residence, providing refuge during periods of high flow as well as prey produced in emergent marsh and terrestrial riparian habitats. Habitat restoration was undertaken in 2009-2010 on lower Hansen Creek, Washington, with the goal of recovering these important lower elevation freshwater floodplain functions. The project converted 140 acres of isolated floodplain into 53 acres of alluvial fan and 87 acres of flow-through wetlands. To quantify the initial biological responses at the Hansen Creek alluvial fan restoration site and provide a baseline of data for future comparisons, we conducted invertebrate and fish sampling at the restored habitats. The study was conducted from September 2010 through September 2011 in three areas within the restoration site, and in one reference area outside the project area. We collected diets from juveniles of Coho salmon (*Oncorhynchus kisutch*) and Steelhead trout (*O. mykiss*), the two dominant salmonids in the creek. Salmonid abundances and diets were also sampled during periodic seasonal flooding that occurred on the restored floodplain. Insects were sampled with fallout traps once-monthly March through September, and neuston invertebrates were sampled once on the floodplain during an inundation event in April and once at the in-channel sites in June. Visual snorkel fish surveys were attempted January through May, and successfully completed June through August. Sampling to assess the Biological Index of Biotic Integrity (B-IBI) was completed in September 2010 and September 2011.

Diets of both Steelhead trout and Coho salmon consisted of aquatic drift, terrestrial insects, and benthic prey items. In general, higher instantaneous rations, a measure of feeding intensity, were recorded from diets of juvenile Coho salmon collected during periodic inundation events than during regular monthly sampling in the channels. Despite relatively warm water temperatures and decreased visibility due to high turbidity, the floodplain appeared to provide favorable feeding opportunities to salmonids, likely due to greater availability of drift and emergent insect prey. Terrestrial insect numbers peaked in July and August. The floodplain site had consistently higher insect abundances, and always had significantly different fallout trap assemblages compared to the other sites. Neuston organisms collected in the main channel habitats were dominated by chironomid larvae while those collected during inundation consisted of other types of insects and planktonic organisms. The three reaches sampled for B-IBI all scored in the fair range in both 2010 and 2011, except for one reach, which scored in the good range in 2010.

One of the goals of this study was to evaluate methods for future sampling at the Hansen Creek restoration site. Insect fallout trap and B-IBI sampling are common techniques that will provide data that is comparable to other sites, and our results from the neuston nets indicate that they can provide information that the other methods do not. The methods we used for catching salmonids were arrived at after trying several techniques early in the study. High flows and turbidity during much of the year precluded visual collection methods, and a combination of dip nets with block-and-sweep net samplings was conducted. These methods were probably not completely effective at capturing larger more evasive salmonids or at quantifying salmonids in complex habitats. In the future, a better method would be multiple-pass depletion electrofishing paired with visual snorkel surveys when visibility allows, such as the Basin-wide Visual Estimation Technique.

Pole seining in the inundated areas was effective for obtaining juvenile salmonids for diets, but we were not able to generate densities using this method. Also, fishing with pole seines in the floodplain area will likely become more difficult as the vegetation community matures. In this case, additional fishing methods such as fyke nets or traps could be used.

Introduction

Floodplains are highly productive ecosystems, and many fish species are adapted to use them as spawning, nursery, and forage habitats during seasonal inundations (Junk et al. 1989; Bayley 1991; Sommer et al. 2004, Van de Wolfshaar et al. 2010). In many cases fish biomass and growth correlate positively with flood magnitude and amount of inundated area (Sommer et al. 2001; Schramm and Eggleton 2006; Probst et al. 2009; Roni et al. 2006; Van de Wolfshaar et al. 2011). In tropical and temperate systems, flooding often corresponds to periods of favorable conditions when fish are intensively foraging and breeding (Junk et al. 1989; Castello 2008; Jiménez-Segura 2010). In contrast, in the north Pacific region most flooding occurs during periods of less favorable conditions, such as decreases in temperature and photoperiod that accompany transition of fall into winter (Swales and Levings 1989; Colvin et al. 2009). In this region, most studies of fish that use intermittently flooded areas have focused on juvenile salmon (*Oncorhynchus* spp.) in a variety of habitats across a range of human impacts (Roni et al. 2010). Juvenile salmon and trout use floodplains and other off-channel habitats as refuge from high water velocities that occur in the main stream channels, and also benefit from increased growth and foraging opportunities in these habitats (Brown and Hartman 1988; Nickelson et al. 1992a, 1992b; Giannico and Healey 1998; Bryant et al. 2005; Sommer et al. 2001, 2005; Giannico and Hinch 2007; Limm and Marchetti 2009; Eberle and Stanford 2010).

Juvenile Coho salmon (*Oncorhynchus kisutch*) are particularly prone to use seasonally inundated and other off-channel habitats, especially during winter (Peterson 1982; Brown and Hartman 1988; Swales et al. 1989; Nickelson et al. 1992a, 1992b; Henning et al. 2006, 2007). The loss of off-channel and floodplain habitats is of major concern to resource managers who are responsible for Coho salmon stocks, and there are at least 75 examples of floodplain and off-channel restoration projects in Washington State alone that target this species (Roni et al. 2006). Common restoration techniques used to reconnect main-stem and floodplain habitats include dam removal, levee removal or setback, direct reconnection of floodplain channels, the creation of new floodplain channels, and culvert replacement or removal (Pess et al. 2005). Studies of restored sites have demonstrated the benefits of restored floodplain and off-channel habitat for juvenile Coho salmon. Most of these have evaluated benefits of the restored habitat to the salmon by comparing densities or production of juveniles from restored sites to those from natural or reference sites (Roni et al. 2006, 2010). Although a recent book chapter on monitoring floodplain restoration efforts lists invertebrate and fish diets as potential indicators of fitness of the restored habitats (Pess et al. 2005), these attributes have seldom been measured at these types of restoration sites. One exception to this is a study by Morley et al. (2005) that compared benthic invertebrates in addition to Coho salmon densities at 11 constructed side channel habitats and paired reference channels. In this

study we sampled juvenile salmonid abundances and diets, and salmon invertebrate prey assemblages at a recently restored floodplain habitat at Hansen Creek, Washington.

Hansen Creek is part of the Skagit River watershed, located in Washington State. It has a 30.6 square-kilometer watershed and flows into the Skagit River at approximately river kilometer 40. The study site is approximately 4.5 kilometers upstream from where Hansen Creek enters the Skagit River. The Hansen Creek Watershed Management Plan (Miller Consulting and Watershed Professionals Network 2002) defined lower Hansen Creek in terms of five reaches, and we retained these reach designations in our study (Figure 1). In the 1940s, this part of the creek was straightened and channelized to enhance agriculture, and the surrounding floodplain was largely cut off from seasonal flooding by diking and channel dredging (Fig. 1). This severed the hydrologic connection between Hansen Creek and adjacent floodplains, and limited salmonid use to the main channel of the creek. In 2007, a conceptual design for restoration of alluvial fan and floodplain habitat in this part of Hansen Creek was completed (Herrera Environmental Consultants 2007). In 2009 this project was initiated when the Upper Skagit Indian Tribe (USIT) and Skagit County began restoration of 140 acres of Hansen Creek's alluvial floodplain in and adjacent to Reaches 3 and 4 (Fig. 1). Restoration activities included breaching dikes to allow seasonal inundation of the floodplain, addition of large woody debris and grade control structures, excavation of alluvial channels, and planting of native vegetation. It was intended that restoration of inundation to the floodplain would allow access by juvenile salmonids to wetland vegetation communities, edge habitat, and woody debris and provide them with improved refuge and foraging opportunities. Construction began in July 2009 and was mostly completed and vegetation planted by November 2009. In October 2009 a high flow/sediment deposition event caused the creek to avulse from the historic main stem near the fan-wetland boundary and flow into the constructed channels in the east wetland. This was in accord with the design, but was several years ahead of schedule. During winter 2009-2010 extensive braiding developed in the east wetland and sediment was deposited. Due to the sediment deposition in the wetland during summer and fall 2010, flow there diverged from one into two main channels. In summer 2010 wetland grades were adjusted, additional plantings were made, and a berm adjacent to the state highway on the south side of the site was completed. In December 2010 the main stem avulsed from the historic channel into designed channels at the main stem grade control structures farther up in Reach 3. This is the present location of the Hansen Creek main stem, though it is expected to change over time in response to flow regimes and sediment transport.

The main goal of this study was to provide an evaluation of the biological attributes of the restoration site in its early stages of development. To do this, we undertook the following:

- Comparison of insect assemblages that are potential juvenile salmon prey among different reaches and in different hydrological conditions.

- Measuring biotic integrity (using Benthic Index of Biotic Integrity) in different reaches and before and after restoration took place.

- Comparison of juvenile salmonid densities and diets among different reaches and time periods.
- Sampling the restored floodplain during inundation events to document juvenile salmon presence and diets in the newly available habitat.

A secondary goal was to test and evaluate methods for catching and observing juvenile salmon and their invertebrate prey at the site.

The results of this study are intended to (1) demonstrate the extent to which juvenile salmonids use the newly restored habitats at Hansen Creek; (2) provide biological data that will provide a benchmark for comparison to data taken in the future as the restoration site matures; (3) allow refinement of methods for biological sampling at the site in the future; and (4) help to design sampling strategies that will best characterize developing habitat functions at the site over time.

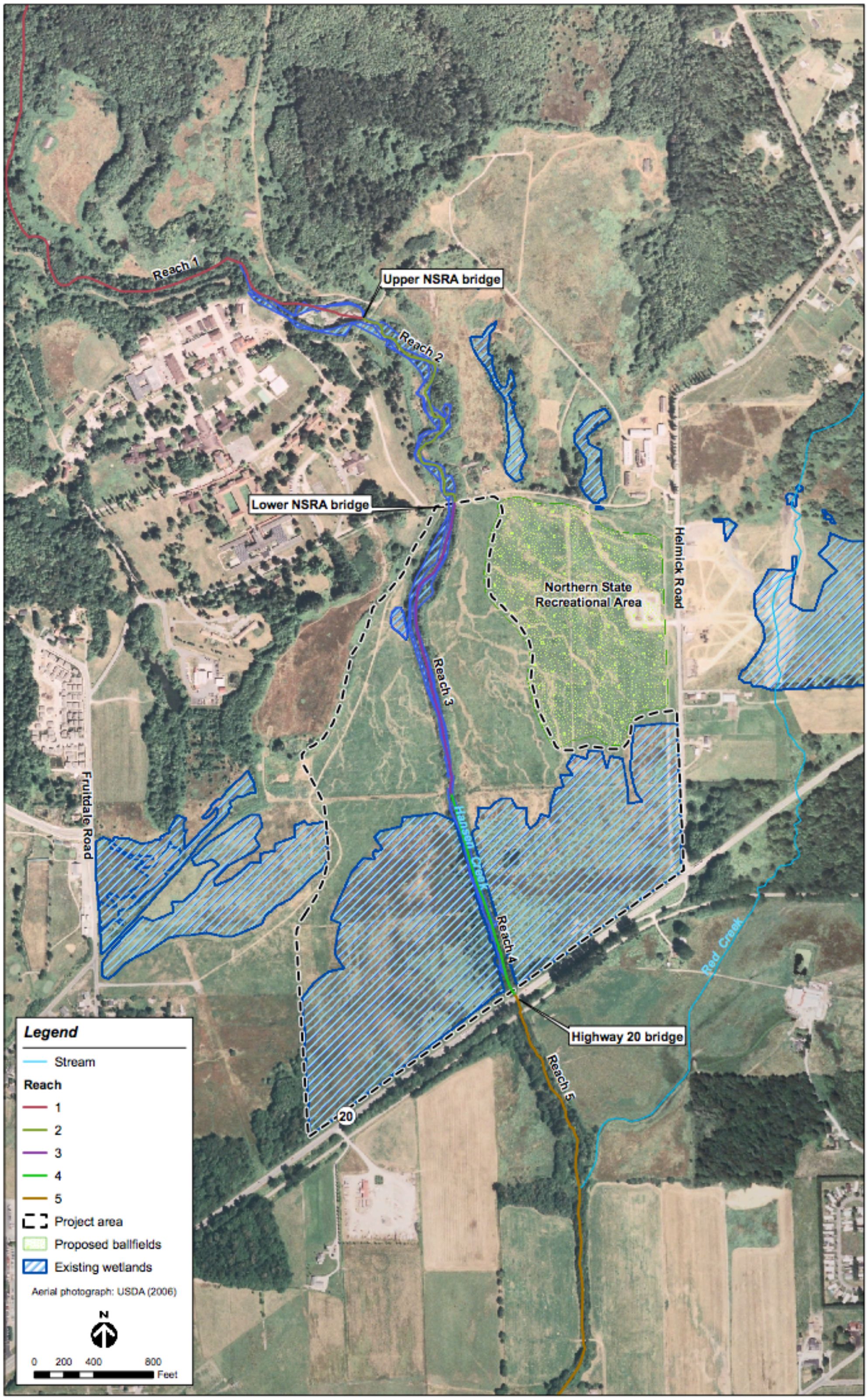


Figure 1. Hansen Creek alluvial fan site before restoration. From Herrera Environmental Consultants 2007.

Methods

Sampling Sites

The Hansen Creek alluvial fan restoration project took place in Reaches 3 and 4 (Fig. 1). Based on previous designations in the conceptual design by Herrera Environmental Consultants (2007) we defined Reach 3 as alluvial fan habitat and Reach 4 as wetland habitat (Figure 2). However, for sampling each of these two reaches was subdivided as follows (Table 1): For insect fallout sampling and in-channel neuston sampling, Reach 3 was divided into habitat where Hansen Creek was within the original channel bank and had existing established riparian cover (3 Established), and habitat consisting of the dynamic section of the channel on the newly restored area (3 New); For fish and invertebrate sampling Reach 4 was also divided into two sections, the channelized portion where the creek is usually constrained to the stream bed (4 Channel), and the unconstrained, off-channel portion of the wetland (4 Wetland). Fallout trap sampling was also conducted on the higher elevation part of Reach 4 (Floodplain) to characterize insect production in a habitat that is usually not accessible to fish, but may export prey resources to other parts of the project area. For fish and invertebrate sampling, we selected the previously restored Reach 2 as a reference site outside of but adjacent to the current project area. Sampling took place September 2010—September 2011 (Table 2).

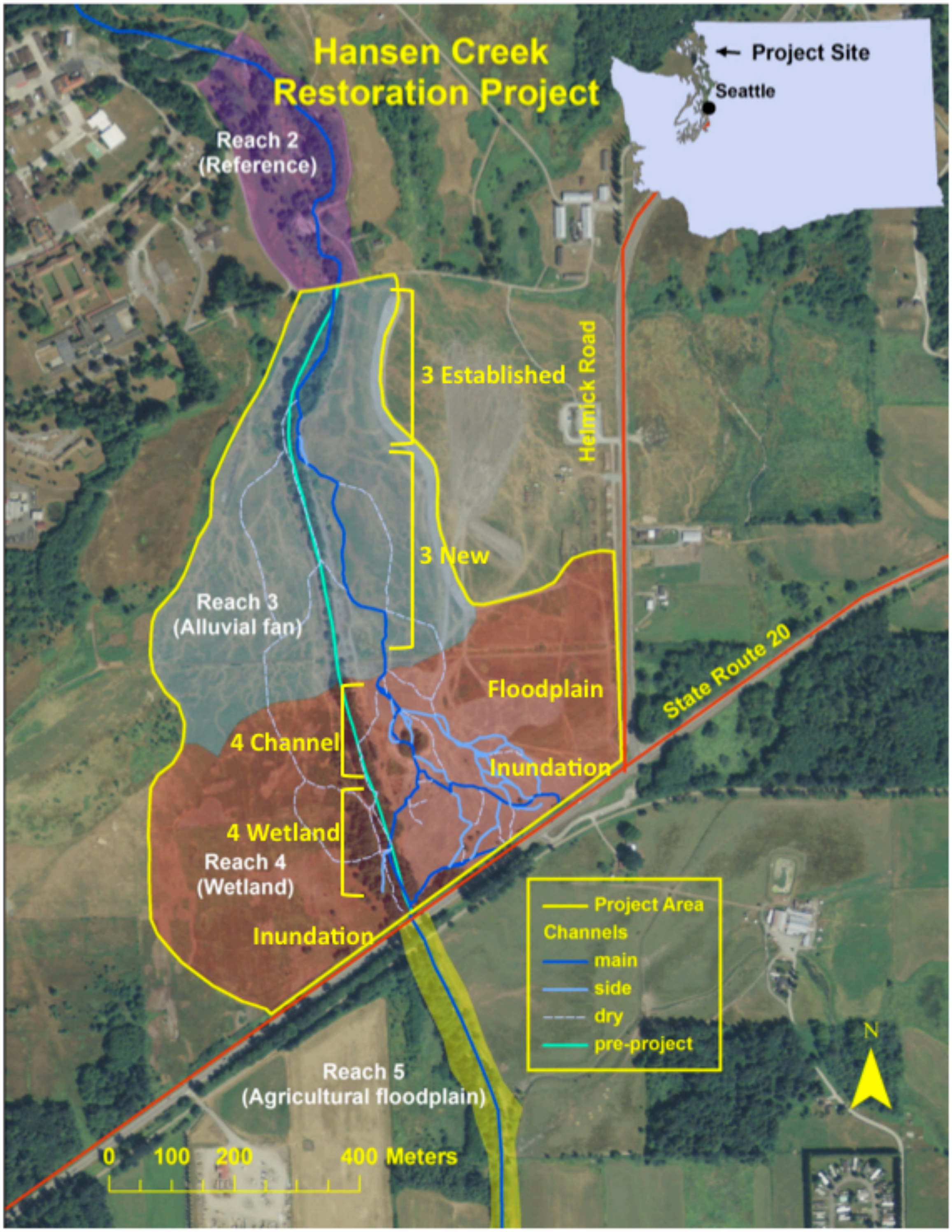


Figure 2. Hansen Creek alluvial fan site after restoration, showing sampling areas.

Table 1. Sampling locations and types of samples taken at each location.

Reach	2	3		4		
	2 Reference	3 Established	3 New	4 Channel	4 Wetland	Floodplain
Benthic index of Biotic Integrity	X	X		X		
Insect Fallout	X	X	X	X	X	X
Channel Neuston	X	X	X	X	X	
Snorkel	X	X		X	X	
Channel Fishing	X	X		X	X	

Table 2. Sampling conducted by date. Shaded cells indicate samples collected. A, unsuccessfully attempted, D, salmonid diets, C, salmonid catch data, N, neuston sampling.

	2010				2011								
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
IBI													
Insect Fallout													
Snorkel					A	A	A	A	A				
Channel Fishing		D				C,D	C,D	C,D	C,D	C,D,N	C,D	C,D	
Inundation Fishing					C,D	C		D,N	D				

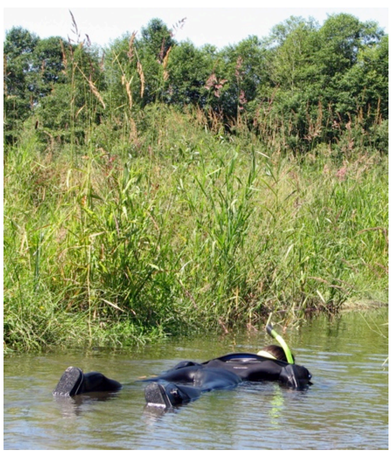
Monthly Channel Fishing

Fishing in main channel of Hansen Creek

Preliminary fishing for juvenile salmonids was conducted in October 2010, in order to test and standardize methods. At this time, several types of nets and snorkelers using a dip net were tested for collecting salmonids. Thereafter, fish sampling using nets occurred once-monthly February through August 2011 in main channel habitats at Reach 2 Reference, Reach 3, Reach 4 Channel and Reach 4 Wetland. At each site three areas were sampled, two by pole seine and one using a variable method based on habitat: in Reaches 2 and 3 fish were sampled by dip net around a log jam, in Reach 4 Channel by pole seining a side channel, and in Reach 4 Wetland by pole seining in the off-channel portion of the wetland. The efforts at each site were consistent in each month, except in July and August when the side channel in Reach 4 was not available, and in August when the effort at sites 4 Channel and 4 Wetland were reduced because numbers of fish caught were much higher than in prior months (effort was reduced to minimize stress on the fish

collected, and to stay within collection permit allowances). Pole seine sampling consisted of blocking the lower end of the channel to be sampled with a pole seine (1.2 x 9.1 m; 0.64-cm mesh) and sweeping down the reach with another pole seine. The block net retaining the fish was retrieved, and diets were collected from up to five salmonids of each of two size classes (approximately less than 55mm and 55mm and greater) and species present (see diet collection methods below). Lengths were recorded for up to 15 additional salmonids of each species, and the remainder were counted and released. In the field, trout over 80mm in length were identified to species, and those under 80mm were designated as "trout". It was assumed that the majority of the smaller fish were Steelhead trout, but there were also Cutthroat trout (*Oncorhynchus clarkii*) present in the system. In addition, in this study we did not differentiate between the two types of *Oncorhynchus mykiss*, i.e., resident Rainbow trout and anadromous Steelhead trout, and refer to all *O. mykiss* as "Steelhead trout".

Snorkel Surveys



Observing fish on snorkel transect.

During the October 2010 fish sampling, snorkel survey methods were also tested, but this was not a standard effort, so no snorkel data are presented from this month. After this, fish along two 25-m transects were counted at the Reach 2 Reference, Reach 3, Reach 4 Channel and Reach 4 Wetland sites. Transects were located in the same reaches fished by pole seine during the monthly channel fishing efforts. Observations started at the down stream end of the transect. Snorkel surveys were attempted January through May 2011, but high flows and turbidity resulted in low visibility, precluding surveys in those months. Visibility was measured using a secchi disk, and on any days with visibility less than 2 meters, surveys were not attempted. In June, July and August, the visibility was sufficient to allow snorkel surveys. Three channel widths were taken at each site and averaged to calculate transect surface area for each 25-m transect. Fish counts were converted to densities using these measurements.

Periodic Inundation Fishing

During inundation events in January, February, April and May 2011, salmonids were sampled by pole seine at three randomly selected wetland sites on the east side of the project area and three randomly selected wetland sites on the west side of the project area (except in January when only the east sites were sampled, and April when only two west sites were available). At each site pole seines were taken. Diets were collected from up to five salmonids of each size class (approximately less than 55mm and 55mm and greater) and species present. Additional salmonids collected were counted and released.

Pole seining during inundation.

Diets


Removal of juvenile salmon stomach contents using gastric lavage.

Diets collected during the monthly channel and periodic inundation fishing, were collected in one of two ways; those from salmonids greater than approximately 55mm were collected using non-lethal gastric lavage, and those from salmonids smaller than 55mm were collected by retaining and preserving whole fish. When catch numbers allowed, diets were collected from up to five salmonids of each size class and species present. Gastric lavage consists of flushing the contents from the stomach of a fish using a modified syringe or garden sprayer with a fitting of the correct size for the size of the fish. Salmonids were sedated by immersing them in a dilute MS-222 solution, and measured for fork length and weight. To collect the diet sample, the fish was held over a 106–µm sieve while the syringe fitting was inserted in the fish's mouth, and water flushed into stomach to remove its contents. Contents were washed into a 106–µm sieve and fixed in 10% buffered formaldehyde solution. Fish were immediately placed in a bucket of ambient water for recovery (approximately 2–3 minutes), and then released. Fish retained whole were killed using a concentrated solution of MS-222, preserved in a solution of 10% buffered formalin, and returned to the laboratory for dissection of the stomachs. Salmonid prey items were identified using a dissecting microscope. Most major prey items were identified to the order or family level. Each prey taxon was counted and weighed to the nearest 0.0001 g.

Neuston

We conducted exploratory sampling using neuston nets in order to determine whether or not they could be used in the future to supplement or replace prey resource data collected by insect fallout traps. Neuston samples were collected once in April 2011 on the Reach 4 wetland during an inundation event, and once in June 2011 at each of the in-channel sites. During the April inundation event, three replicate neuston samples were collected at each site sampled for fish, by towing a small neuston net (40 x 20 cm; 73 µm mesh) net for a distance of 10 m. In June, stationary neuston samples were collected by large neuston net (60 x 35 cm; 335 µm mesh) held in the channel for 5 min. Three replicates were collected at each in-channel site.

Small neuston net deployed during inundation.

Large neuston net deployed in channel.

Benthic Index of Biotic Integrity (B-IBI)

Invertebrate samples were collected in September 2010 and September 2011 to calculate the Benthic Index of Biotic Integrity (B-IBI) for Hansen Creek. The B-IBI score provides an overall view of the stream health and is useful for comparing among sites or at a single site through time, because it is sensitive to a broad range of disturbances. Between the two sample dates, Reach 3 changed course, leaving the area that had been sampled in 2010 dry. Therefore, in 2011 we sampled Reach 3 farther upstream where the creek had remained in the old channel, in a habitat similar to the area sampled in 2010. Three riffles were selected in each reach and a standard 1-square foot Surber sampler (mesh size 500 µm) was used to collect three samples from each riffle. The three replicates from each riffle were combined and organisms in the resulting sample were identified and counted. Family-species level identifications were made and 10 standard metrics were calculated and scored according to Puget Sound Lowlands ratings (Hayslip 2007). These metrics measured richness (total taxa, mayfly taxa, stonefly taxa, caddisfly taxa), population attributes (percent dominance of the top three taxa, number of "long-lived" taxa with fewer than one generation per year), tolerance to organic pollution (percent tolerant taxa, number of intolerant taxa), and behavior (percentage of predators, number of "clinger" taxa that are adapted to attaching to surfaces in riffles). We used tolerance values for the Pacific Northwest from the EPA Rapid Bioassesment Protocols (Barbour et. al 1999). Metric values were given a score of 1, 3, or 5 based on standards developed for Puget Sound lowland streams (Hayslip 2007) and the sum of these scores comprised the B-BIBI score.

B-IBI sampling with Surber Sampler.

Terrestrial Invertebrates

Insect Fallout Trap.

Terrestri
al insect and other invertebrate prey of salmonids were sampled once-monthly March-July 2011 with insect fallout traps. During each sampling effort, seven replicate traps were set randomly in each of the six habitats sampled. The fallout trap apparatus consists of a clear plastic tub (approximately 26.5L total capacity, 58.4 x 40.6 x 15.2cm), filled approximately 2 cm deep with sieved soapy water. These types of traps have been found to effectively sample terrestrial invertebrates, particularly insects, which are potentially available to salmonids foraging in the nearby aquatic habitat (Cordell et al. 1994; Gray et al. 2002; Lott 2004). Each trap was deployed for approximately 48 hours,

after which the sample was collected by sieving the water in the trap through a 106μm sieve, washing sieve contents into a sample jar with a garden sprayer and funnel, and was preserved in 70% isopropanol. In addition to the reference habitat (Reach 2), Reach 4 channel and wetland habitat, a floodplain site was also chosen. For fallout trap sampling, Reach 3 was further divided into "established" habitat that was within the original channel bank and had previously established riparian cover, and "new" habitat consisting of the new dynamic section of the channel.

Data Analysis

We used a non-parametric Friedman Rank Test to compare fish densities among sites and dates. Month was used as a block, such that the test compared the ranks of fish numbers between the sites with month used as a repeated measure. Unlike the case with parametric statistics (Analysis of Variance), there is not a standard post-hoc test available to use with the Friedman test to determine the sources of statistical differences. Instead, we applied a common technique, which is to use separate Wilcoxon signed-rank tests of each pairing (six in our case, i.e. Reach 2 vs 3, Reach 2 vs 4, etc.). We also used the Bonferroni adjustment for multiple tests, which is the designated alpha level divided by the number of tests (in this case 0.05/6, requiring $p < 0.0083$ for the result to be significant).

We used a parametric ANOVA test to compare Instantaneous Ration (weight of stomach contents/weight of fish) of fish diets among sites. Instantaneous ration is useful as a relative measurement of feeding rate. Since the number of diet samples at each site varied per month, we used a 1-way ANOVA on site separately for each month. When ANOVA identified significant differences, a post-hoc Tukey test was used to determine pairwise site differences.

We used a multivariate analysis to determine assemblage differences of diet and fallout trap data, using the PRIMER (Clarke and Gorley 2006) and PERMANOVA (Anderson et al. 2008) statistical programs. A PERMANOVA analysis was used to examine the entire assemblage of species and numbers, generating a p-value similar to that of a univariate ANOVA test ($p < 0.05$ indicates significant difference). PERMANOVA tests allow for 2-way analysis of site and month, with an interaction term when one factor varies with levels of another other factor. Post-hoc tests in the program identify the specific site pairs that are responsible for significant PERMANOVA results. Assemblage data was square-root transformed before analysis, and those taxa representing less than 3% of the numbers removed. For this analysis, we used only diet data that had complete replication across sites and months for a given size class/species (e.g., five individuals caught at all sites and sample dates)

Results

Fish Abundances and Sizes

Netting

Densities of juvenile salmonids were very low in winter (February, March) as compared to spring and summer (April through August) (Fig. 3). Reach 4 consistently had more Coho salmon in either the channel or the wetland or both, as compared to the other reaches. Coho fry first appeared in March; juvenile trout did not appear in the samples until July. Trout were less abundant than Coho on all sampling dates. Although most trout were too small to identify to species level, we observed larger individuals of both Steelhead and Cutthroat trout. Threespine sticklebacks were commonly caught in net samples, but were not quantified.

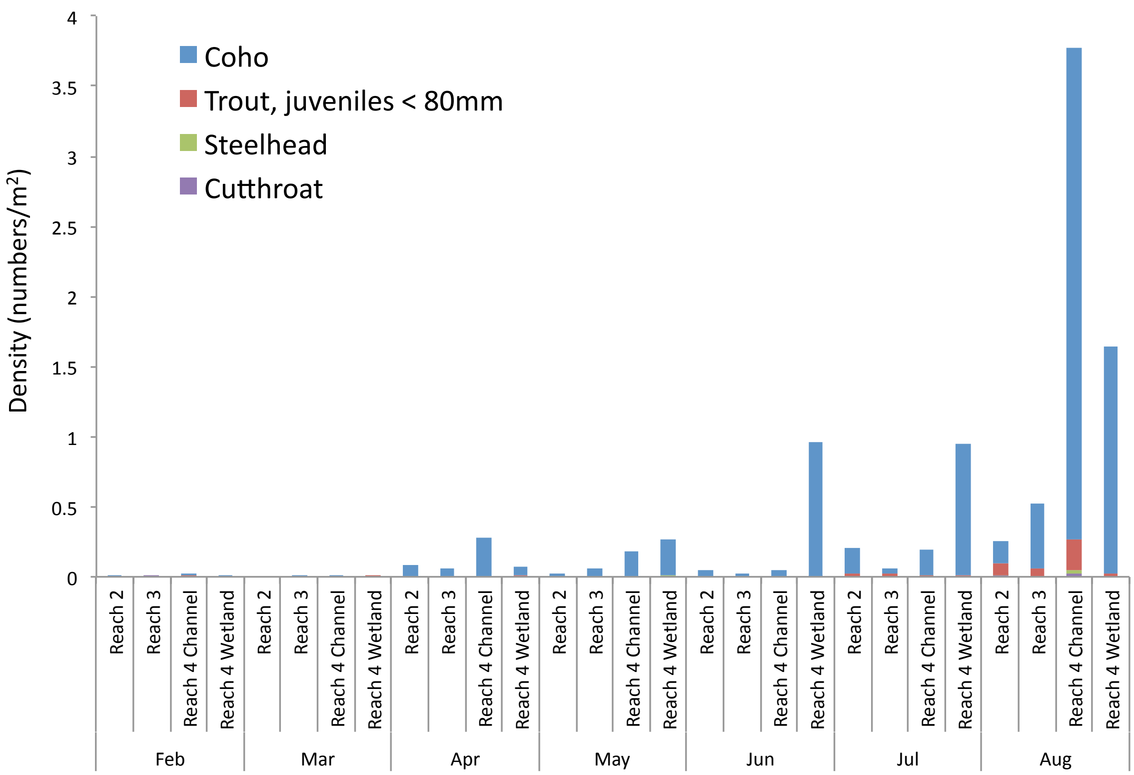


Figure 3. Density of salmonids captured by netting at main sites, February – August 2011.

Results of the Friedman Rank test indicated that overall densities of Coho salmon were different among reaches ($p = 0.0085$), but trout were not ($p = 0.68$). Wilcoxon Rank tests did not identify any particular sites that were responsible for the differences.

Juvenile Coho salmon were abundant in the inundated habitat during flooding in January, April, and May (Fig. 4). No fish were captured in February. One Cutthroat trout was captured in April, and this was the only trout caught in the inundated area. The only fish species found on the west side during inundations were Threespine stickleback, which were released.

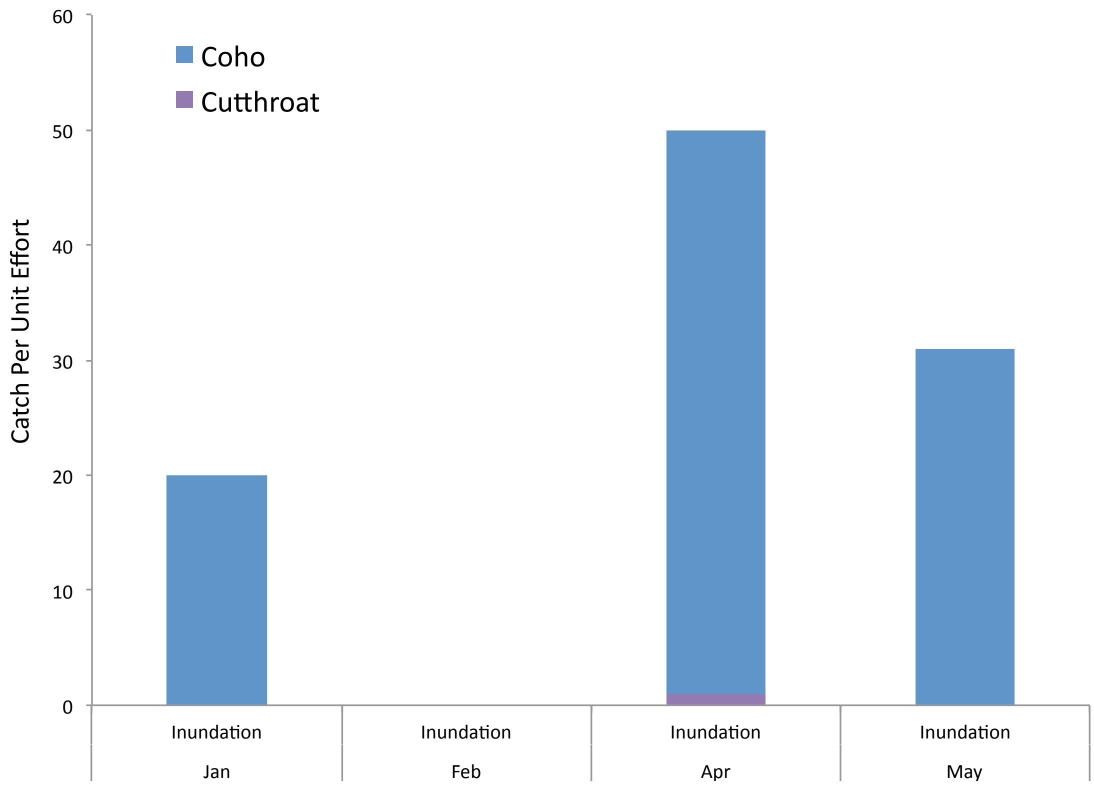


Figure 4. Catch per unit effort of salmonids captured by netting inundated habitat, January – May 2011.

Two Coho salmon size classes occurred in the spring (~40mm and ~80mm); the larger of these left the system by June (Fig. 5). There were also two size classes of trout that occurred in the summer when they were relatively abundant (~40m and ~100mm). Trout were the largest salmonids caught, ranging up to 147 mm fork length. We did not observe any Coho salmon over 100 mm fork length.

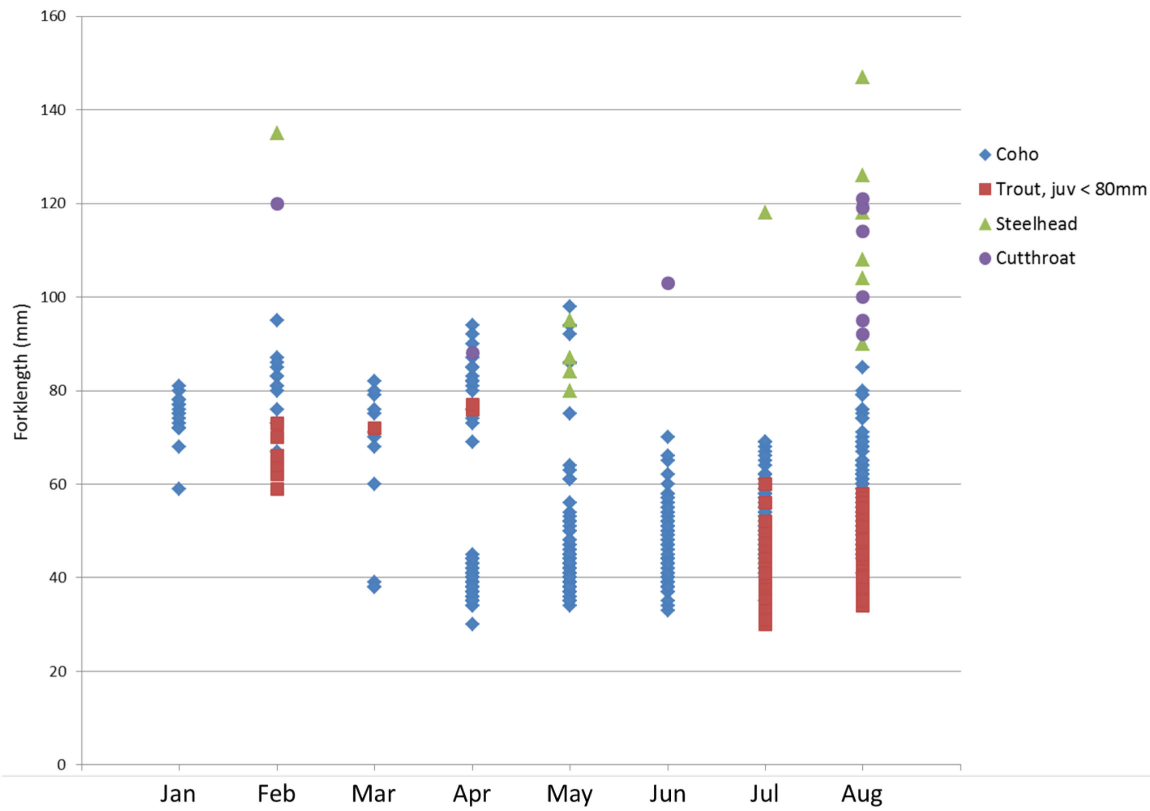


Figure 5. Fork length of salmonids captured by netting, January – August 2011.

Snorkeling

Overall density estimates obtained by snorkeling were comparable to those measured with nets during the June – August period, with most of the densities ranging between 0-1 fish per m^2 (Fig. 6). Density trends among the sites in June and July were similar to those from the net data, in that Reach 4 wetland had the highest numbers. In August, results from the snorkeling did not correspond to that from the netting: the netting data showed highest densities at Reach 4, and lowest at Reach 2, while snorkel data showed highest densities at Reach 2. In July relatively high numbers of trout were observed, while in the Reach 4 wetland site, none were observed. As with the netting data, trout were less abundant than Coho on all sampling dates, except for at the Reach 2 site in July.

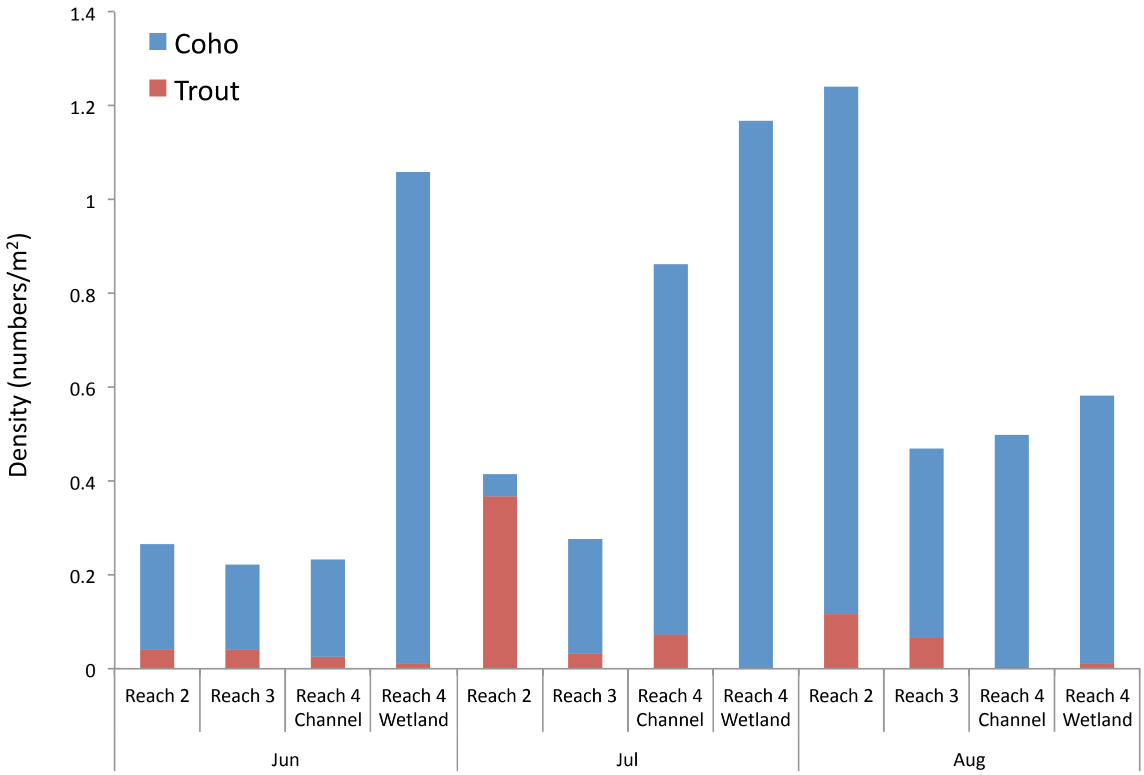


Figure 6. Densities of salmonids observed by snorkeling, June – August 2011.

Threespine sticklebacks were the only non-salmonid fish that were abundant in the snorkel observations (Fig. 7). They were most abundant in Reach 4.

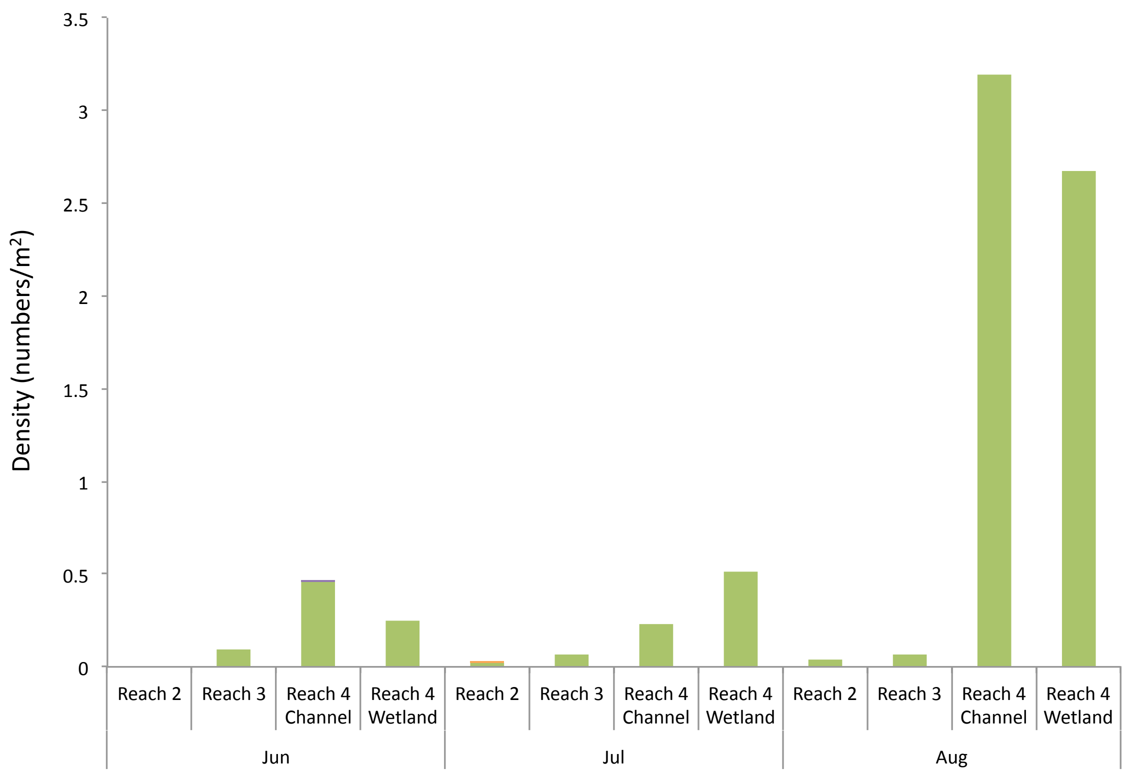


Figure 7. Density of Threespine Stickleback observed by snorkeling, June – August 2011.

The length ranges of salmonids observed in snorkel data (total lengths) were similar to those measured in the net samples (fork lengths) (Fig. 8). In June, Coho fry and larger trout co-occurred. As in the netting data, smaller trout appeared in July and August.

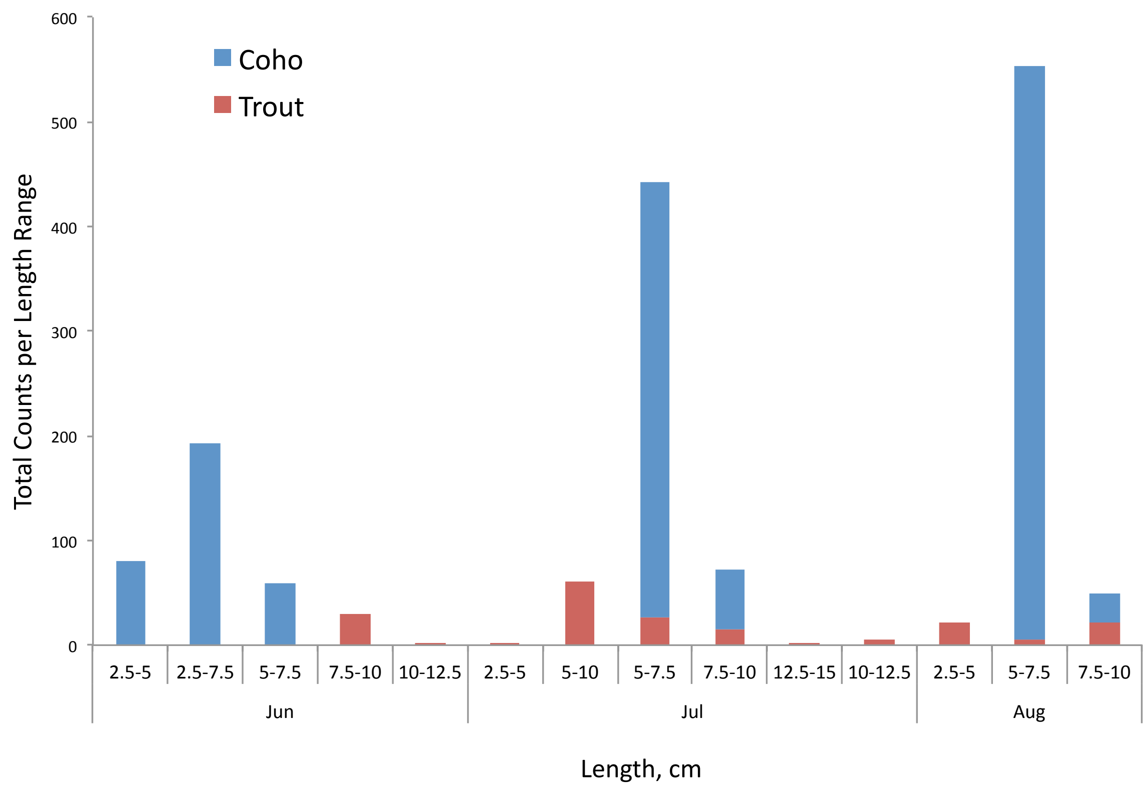


Figure 8. Length ranges of salmonids observed by snorkeling, all sites combined, June – August 2011.

Juvenile Salmonid Diets

Coho Salmon

Instantaneous Ration

On the April and May sampling dates when inundation of the floodplain occurred, small juvenile Coho salmon (i.e., those that had been preserved whole) had higher rations than did those from the other sites (Figure 9). These results were statistically significant: in April instantaneous rations from the inundated area were significantly higher than at all other reaches except Reach 2, and in May they were higher than those from Reach 4 (Table 3).

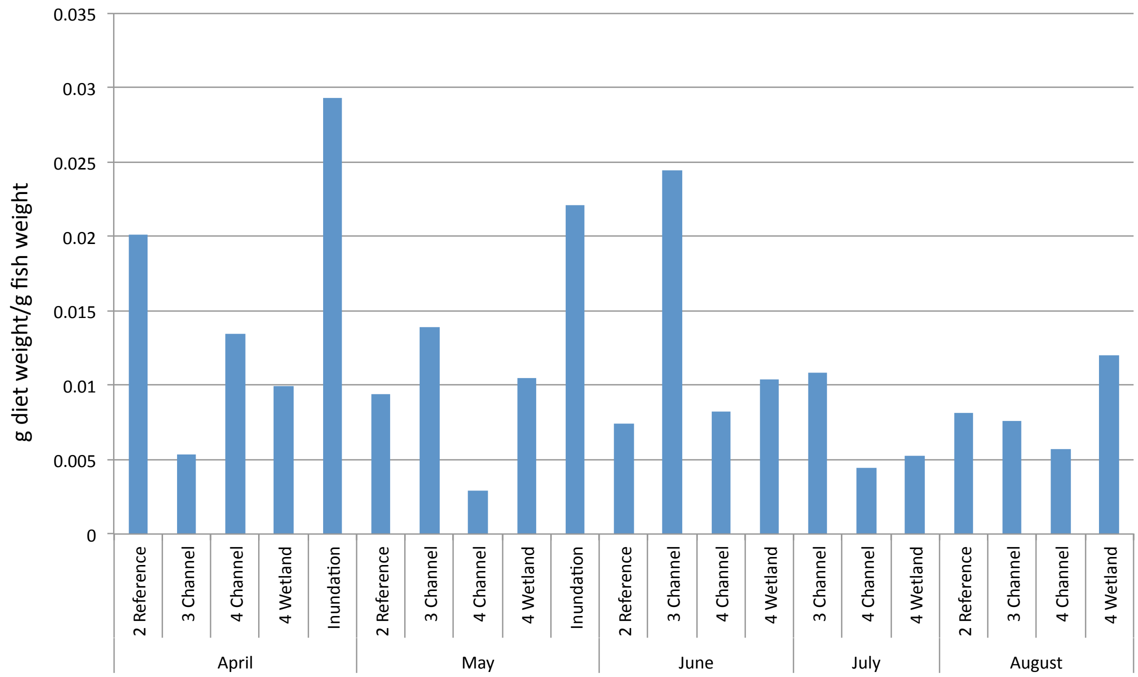


Figure 9. Average instantaneous rations from smaller juvenile Coho salmon (mean fork length 43 mm, range 34-57 mm) captured April-August 2011 that were retained whole.

Date	p-value	Results of post-hoc Tukey Test
April	**0.00001**	Inundation > Reach 3, Reach 4, and Reach 4 Wetland
May	**0.019**	Inundation > Reach 4
June	**0.032**	Reach 3 > Reach 2 and Reach 4
July	0.11	
August	**0.016**	Reach 4 Wetland > Reach 4

Table 3. ANOVA results from instantaneous ration of smaller juvenile Coho salmon (mean fork length 43 mm, range 34-57 mm) captured April-August 2011 that were retained whole. Significant results ($p<0.05$) are indicated in bold type.

In April, larger juvenile Coho salmon that had been sampled by gastric lavage also had significantly higher rations in the inundated area as compared to two other reaches (Fig. 10, Table 4).

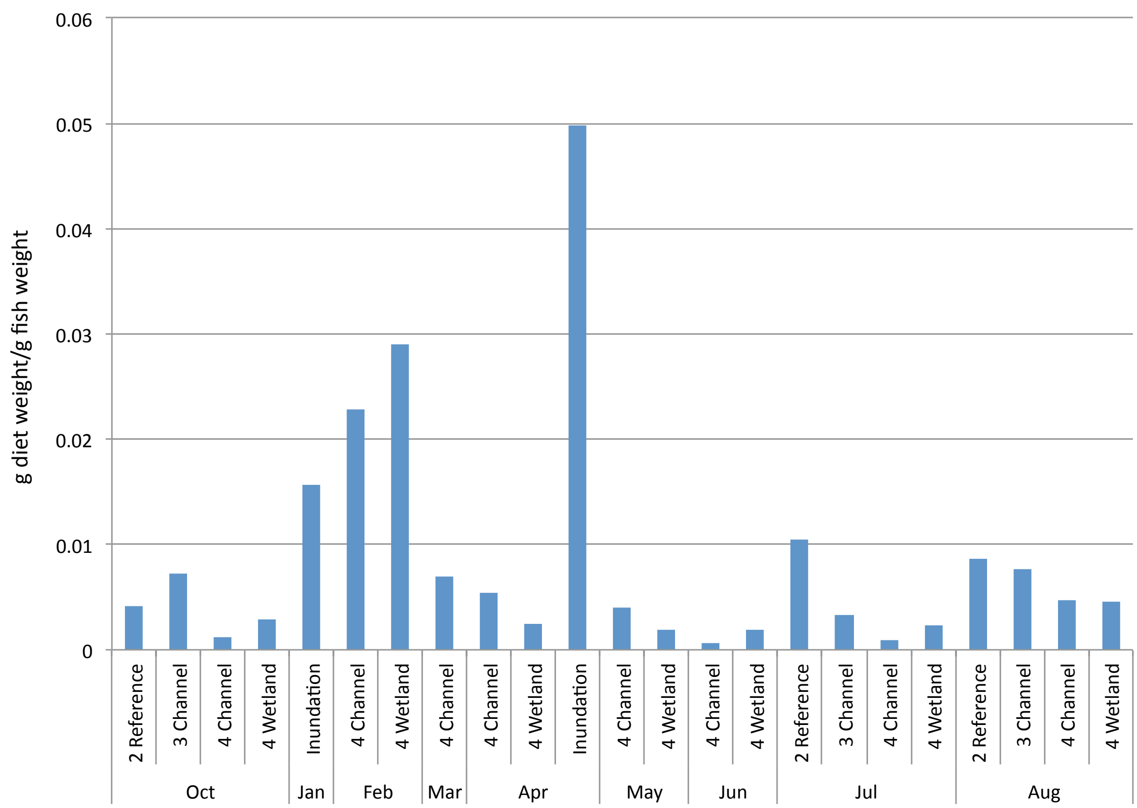


Figure 10. Average instantaneous rations from larger juvenile Coho salmon (mean fork length 72 mm, range 55-98 mm) captured October 2010-August 2011 that had been sampled by gastric lavage.

Date	p-value	Results of post-hoc Tukey Test
October	0.13	
February	0.66	
April	**0.0000001**	Inundation > Reach 4 and Reach 4 Wetland
May	0.58	
June	0.4	
July	0.08	
August	0.67	

Table 4. ANOVA results from instantaneous ration of larger juvenile Coho salmon (mean fork length 72 mm, range 55-98 mm) captured October 2010-August 2011 that had been sampled by gastric lavage. Significant results ($p<0.05$) are indicated in bold type.

Instantaneous rations of juvenile Steelhead trout were similar among the dates and sites sampled, with except at the Reach 3 channel site in July, where rations were higher than at the other sites and times (Fig. 11). However, ANOVA did not identify any statistically significant differences in instantaneous ration among the Steelhead trout samples.

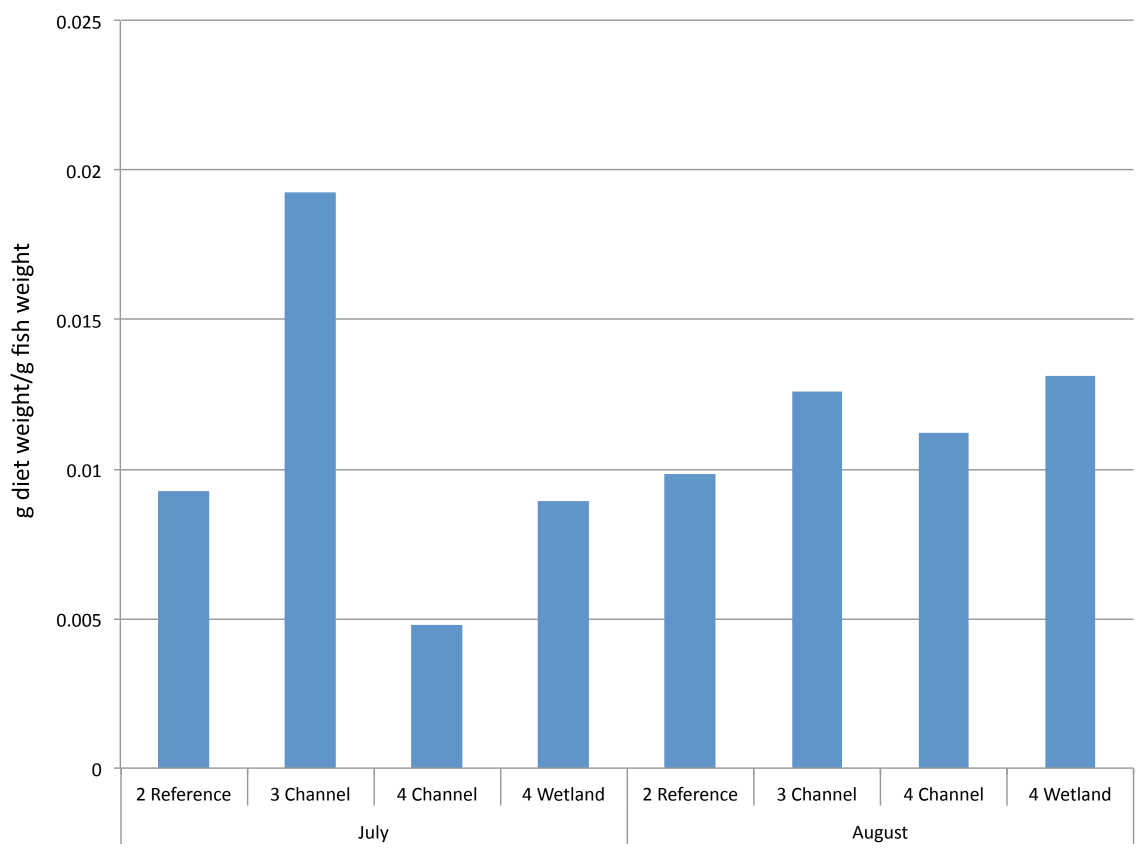


Figure 11. Average instantaneous rations from trout captured July-August 2011.

Diet Composition

Juvenile Coho salmon in the smaller size class preyed mainly on various larval and emergent adult insects (Fig. 12). However, the composition of main prey categories was quite variable among sites and times. Chironomids and other dipteran flies (green patterns in Figs. 12 and 13) were the only prey types that were consistently abundant in the diets, and they were particularly important to the smaller Coho salmon captured at the wetland area in Reach 4 and during the May inundation sampling. Larval aquatic insects mayflies (Ephemeroptera) and stoneflies (Plecoptera) (yellow patterns) were also prominent in April and May, but did not occur consistently among sites. Similarly, the larger size class of juvenile Coho salmon fed mainly on insects, and consistently on chironomids and other dipteran flies (Fig. 13). Also, as with the smaller fish, mayfly and

stonefly larvae were important diet items in April and May. In contrast to the smaller fish, the diets of the larger fish group tended to have more annelid worms and a variety of other kinds of insects.

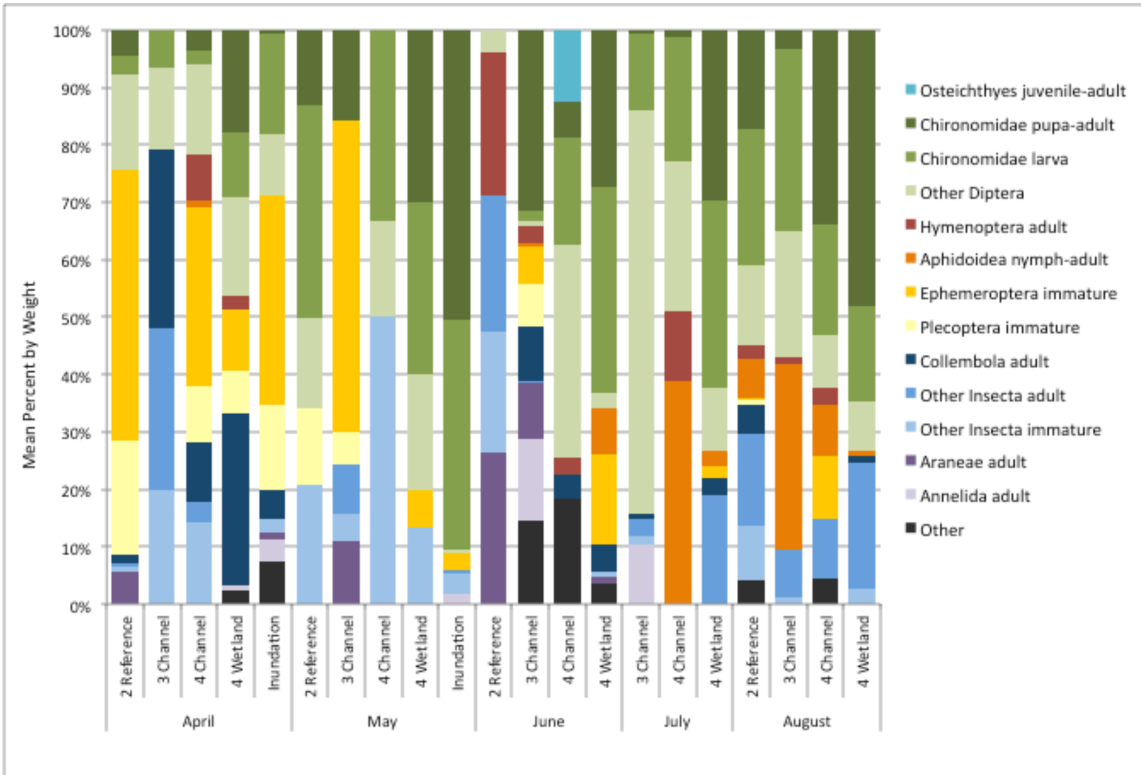


Figure 12. Percent composition of diets from smaller juvenile Coho salmon captured April-August 2011 that were retained whole (n=4–15 individuals per bar). Numbers before site names refer to reach.

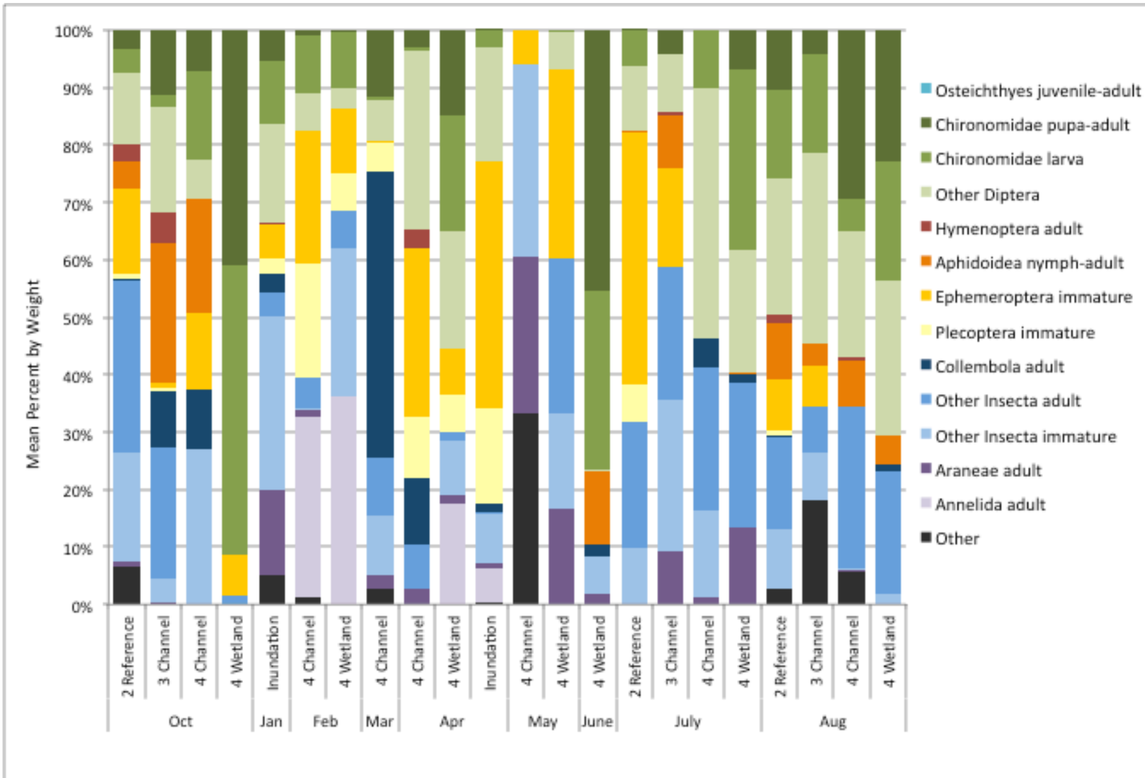


Figure 13. Percent composition of diets from larger juvenile Coho salmon captured October 2010-August 2011 that had been sampled by gastric lavage (n=3–10 individuals per bar). Numbers before site names refer to reach.

Prey items in trout diets were generally similar to those from Coho salmon diets, consisting mainly of chironomids and a variety of other insects (Fig. 14). Diets of the smaller trout that had been retained whole had diets that were dominated by chironomids and mayfly (Ephemeroptera) nymphs. In larger lavaged fish, diets tended to be more diverse, with prey distributed more evenly among several types of insects.

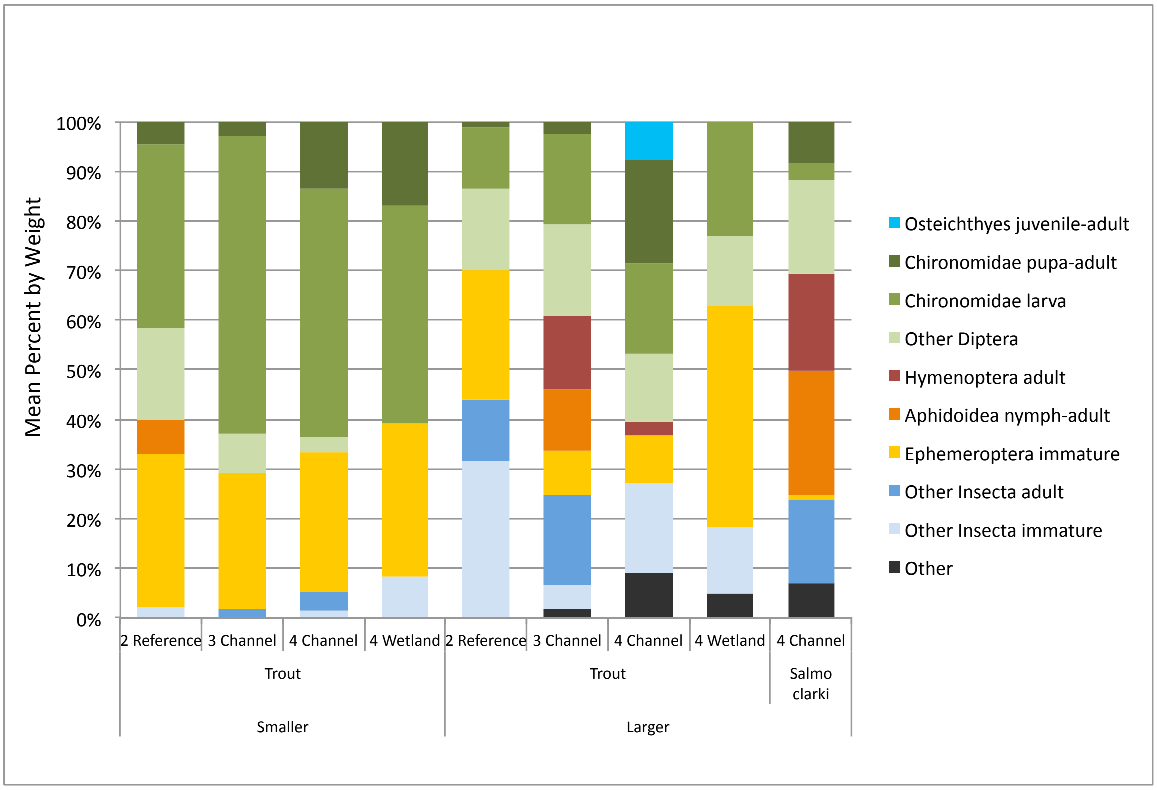


Figure 14. Percent composition of diets from trout (all dates combined, n=4–13 individuals per bar). The smaller size class of trout ranged from 50-56 mm fork length (mean 41.5 mm), and the larger size class ranged from 56-147mm fork length (mean 87.3 mm). Cutthroat trout ranged from 92-121mm fork length (mean 106.8 mm).

A PERMANOVA analysis conducted on the smaller size class of juvenile Coho salmon and also on trout diets indicated that there were no differences in diet composition based on sampling site. However, there were significant month differences for the small size class of Coho salmon (p=0.001). For the larger size class of juvenile Coho salmon, there were significant site, month and interaction differences. Although there was considerable variability in diets among sites and months (Fig. 13), PERMANOVA analysis indicated that the Reach 4 Wetland site was different from all other sites in October and July. In those two months, the larger size class of juvenile Coho salmon at the Reach 4 Wetland site had high percent composition of chironomids in their diets.

Fallout Traps

Densities of all fallout organisms combined across sampling dates were similar among the sites, except at the Floodplain site, where densities were approximately 3-4 times higher than at other sites (Fig. 15). Fallout organisms were more abundant July-September as compared to March-June (Fig. 16). They were particularly abundant in September. In terms of assemblage compositions of fallout organisms, Reaches 2 and 3 were very similar, consisting of about 40-50% chironomids and other dipteran flies, and the remainder consisting mainly of Acari (mites), Collembola (springtails), and a variety

of other insects (Fig. 17). At the Reach 4 Channel and Wetland sites, chironomid and other dipteran flies were more prominent, comprising more than 60% of the numbers. The Reach 4 sites also had smaller contributions from Collembola compared to the other sites. The floodplain site was different from the other sites in having higher proportions of mites and lower proportions of chironomids and other dipterans. When mites were removed from the analysis, densities of fallout organisms from the floodplain were similar to those from the other sites. (Fig. 18). However, the assemblage composition still differed from the other sites, in having a lower proportion of chironomids and other dipterans, and higher proportions of Hemiptera and Thysanoptera.

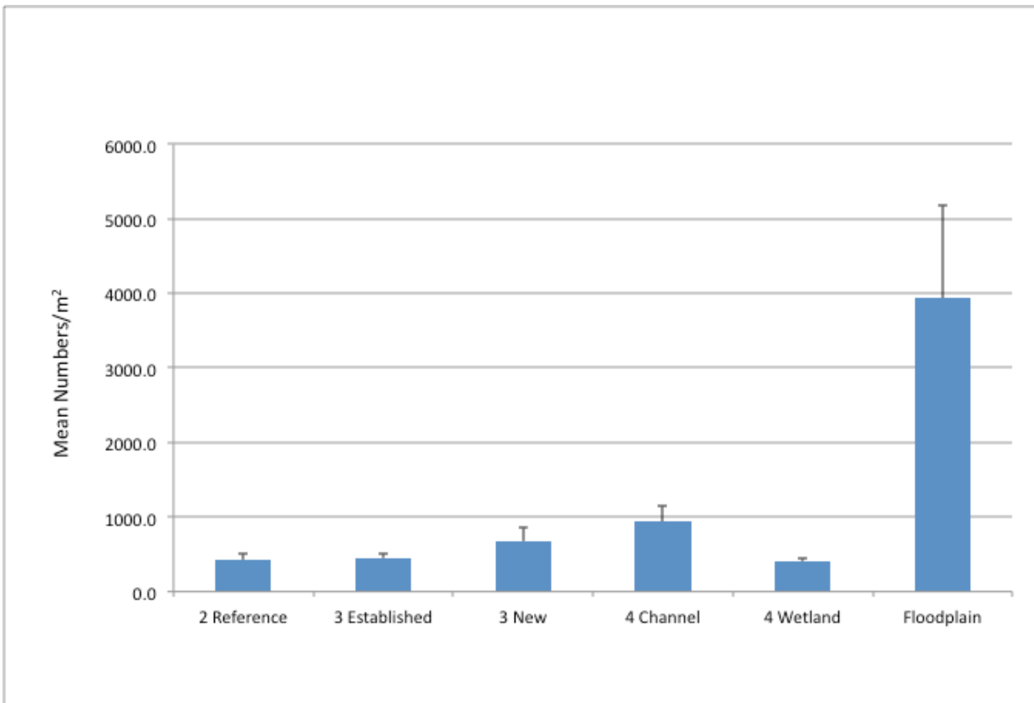


Figure 15. Densities of all organisms collected in fallout traps by site (sampling dates combined). Error bars represent standard error.

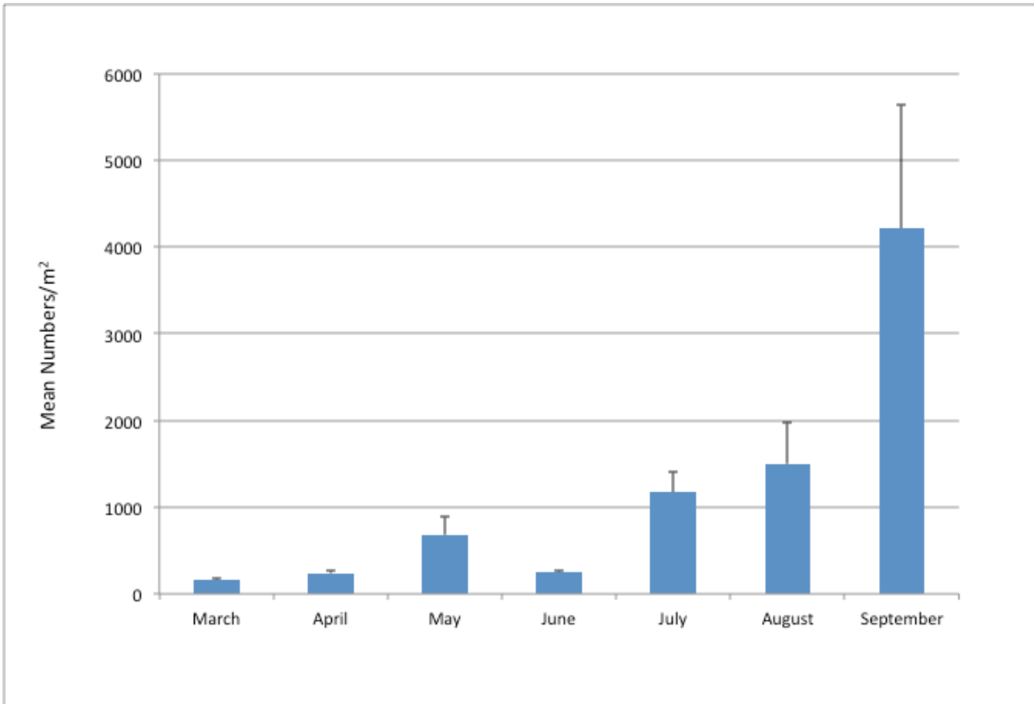


Figure 16. Densities of all organisms collected in fallout traps by date (sampling sites combined). Error bars represent standard error.

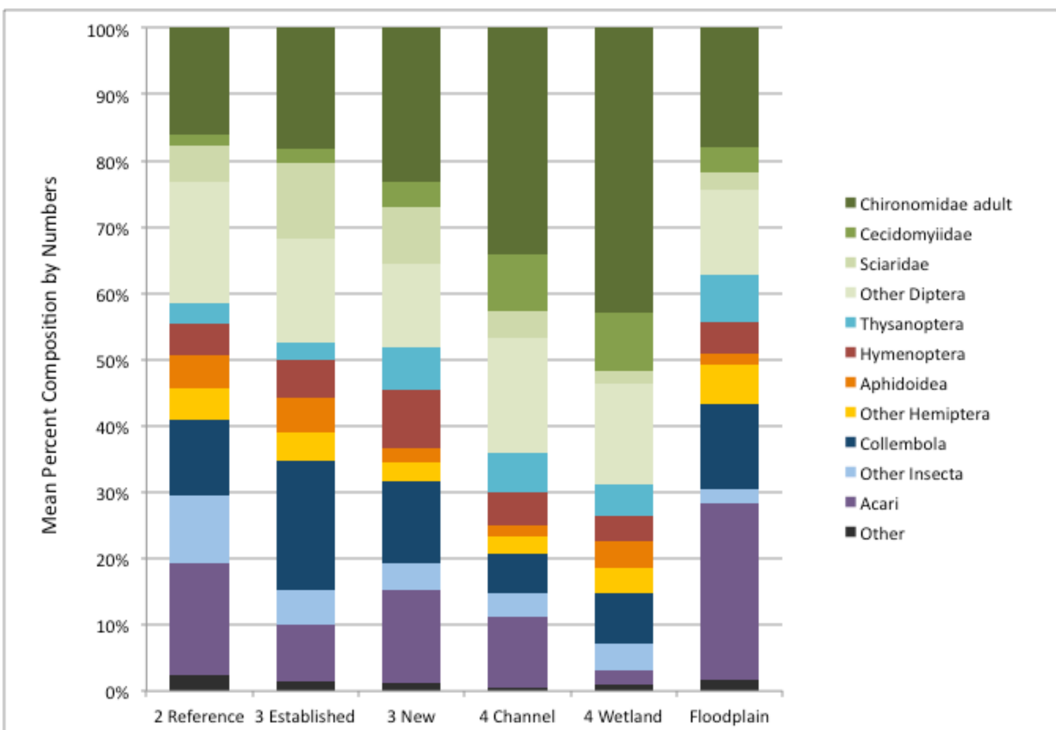


Figure 17. Percent composition of organisms from fallout traps by site (sampling dates combined).

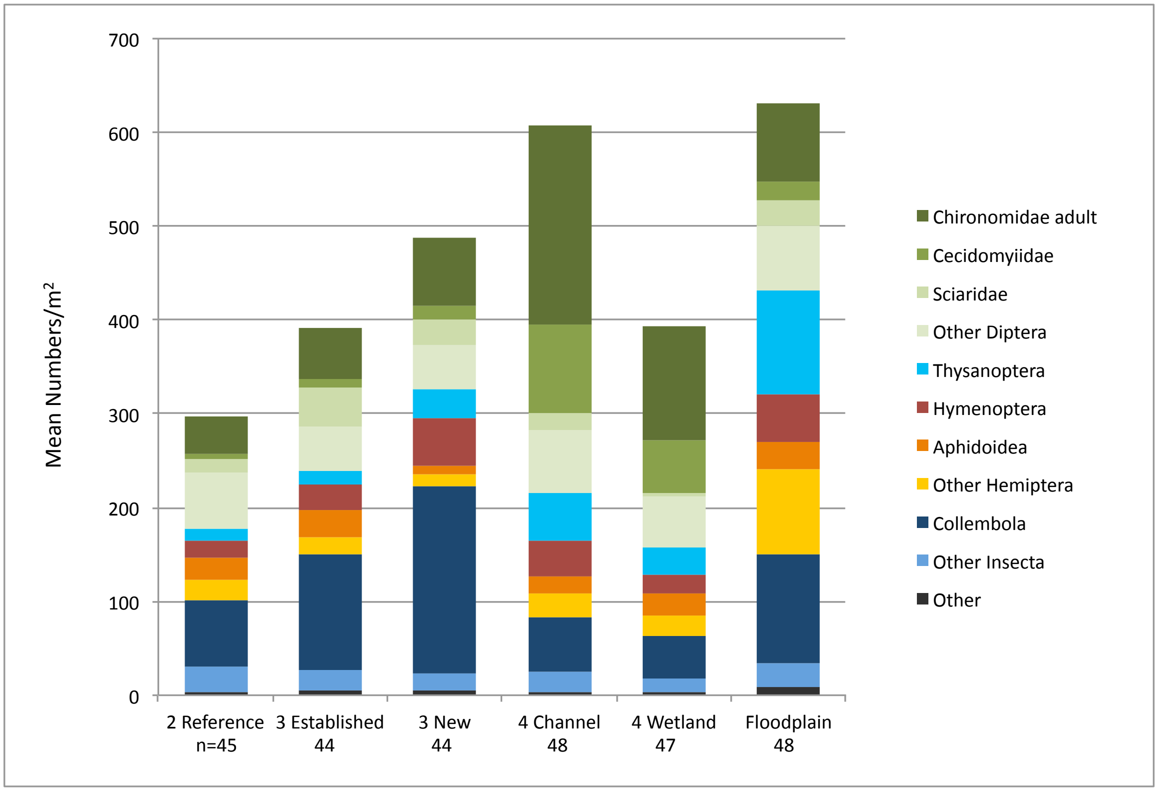


Figure 18. Densities and composition of organisms from fallout traps with Acari (mites) removed (sample dates combined).

Analysis of the fallout trap data using a 2-way crossed PERMANOVA on site x month with interactions indicated overall that site, month and site x month interaction were all significant (p=0.001). On a given sampling date, many of the sites were different from each other, but there were few consistent trends in the patterns of these differences (Table 5). The exceptions to this were at the Floodplain site, which always had significantly different fallout trap assemblages compared to the other sites, and at the two Reach 3 sites, which were the only adjacent pairs that were consistently different from each other every month.

Table 5. PERMANOVA results from fallout trap samples. Filled cells indicate that the two members of the site pair have significantly different communities ($p < 0.05$), X indicates no significant difference.

	Reach 2							Reach 3 (established)							Reach 3 (new)							Reach 4							Reach 4 Wetland						
	M	A	M	J	J	A	S	M	A	M	J	J	A	S	M	A	M	J	J	A	S	M	A	M	J	J	A	S	M	A	M	J	J	A	S
Reach 3 (established)	X	■	X	■	■	■	■																												
Reach 3 (new)	■	■	■	■	X	X	■	■	■	■	■	■	■	■																					
Reach 4 Channel	■	■	X	■	■	■	■	■	■	■	■	■	■	■	X	X	■	■	■	■	■														
Reach 4 Wetland	■	■	■	■	■	■	■	■	■	■	■	■	■	■	X	■	■	■	■	■	■	X	X	■	■	■	■	■							
Floodplain	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Neuston

Samples taken with the large neuston net in June in the main channel habitats were dominated by chironomid pupae and larvae (Fig. 19). Most of the remainder consisted of other types of insects.

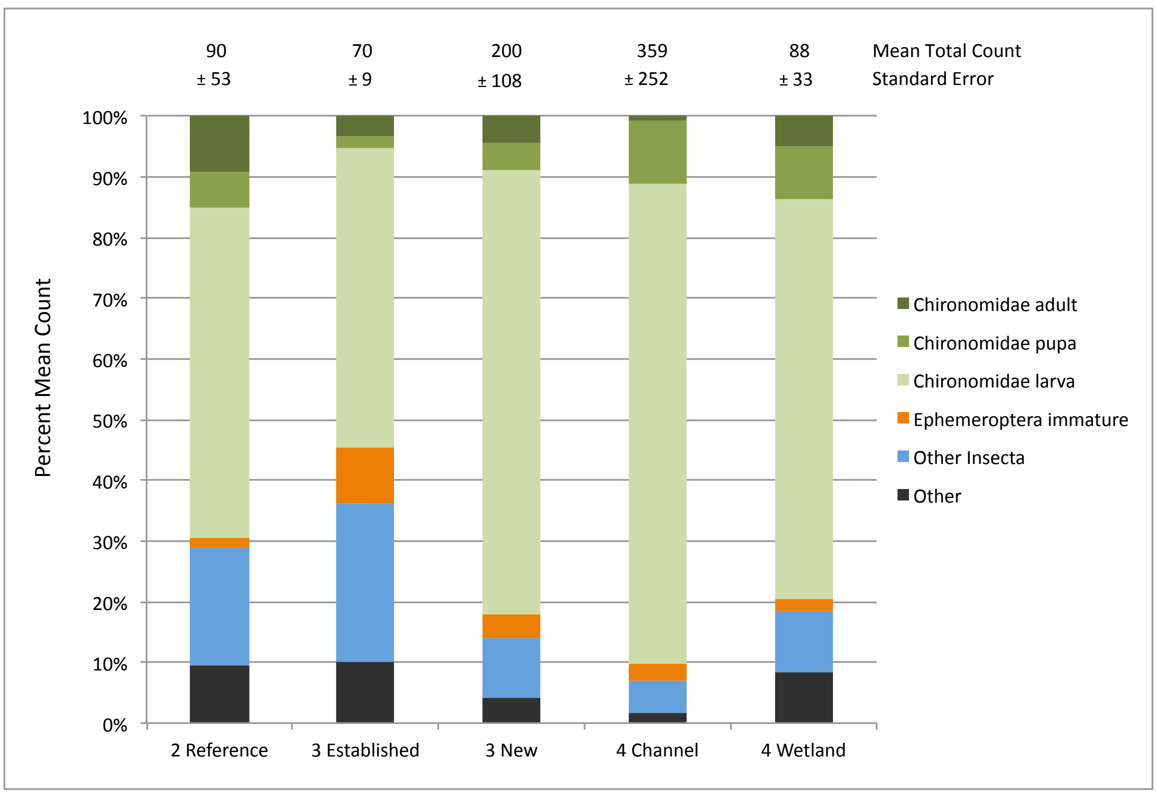
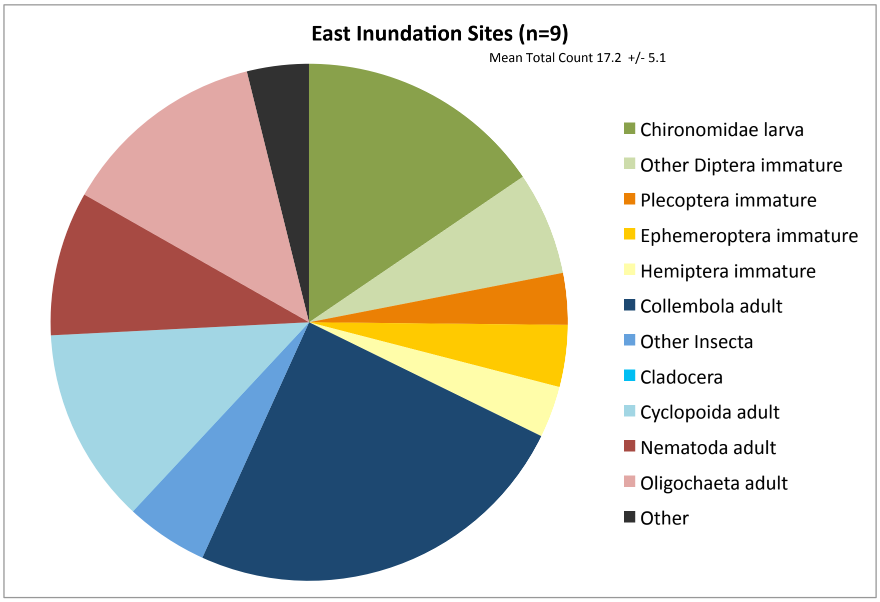


Figure 19. Percent composition of invertebrates from large neuston net samples taken in June 2011 in channel habitats.

Organisms collected with the small neuston net during inundation of the Reach 4 area in April differed greatly between the west and east sides of the restoration site (Fig 20). On

the west side, planktonic cyclopoid copepods dominated the samples, with only minor contributions by insects. In contrast, on the east side the assemblage composition was distributed more evenly through variety of categories, including chironomids, other insects, and oligochaete and nematode worms. Also, neuston organisms were much more abundant on the west side as compared to the east side.



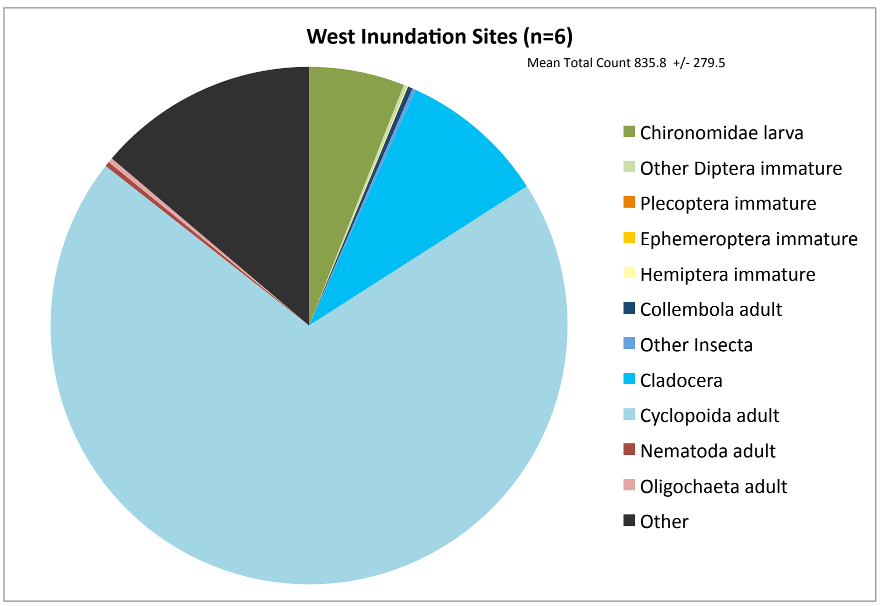


Figure 20. Percent composition by numbers of invertebrates from small neuston net samples taken in April 2011 in inundated habitats.

Benthic Index of Biotic Integrity

The three reaches sampled all scored in the fair range in both 2010 and 2011, except for Reach 3, which scored in the good range in 2010 (Table 6). However, the score for Reach 3 dropped from 38 (good) to 28 (fair) in 2011.

Table 6. Summary of B-IBI metric values and scores from Hansen Creek restoration site, 2010 and 2011.

	Reach 2				Reach 3*				Reach 4			
	2010		2011		2010		2011		2010		2011	
Metric	**value**	**score**	**value**	**score**	**value**	**score**	**value**	**score**	**value**	**score**	**value**	**score**
Total taxa richness	27	3	28	3	33	5	19	3	31	5	30	5
Mayfly taxa richness	6	3	6	3	6	3	4	1	6	3	5	3
Stonefly taxa richness	4	3	4	3	4	3	4	3	5	3	3	1
Caddisfly taxa richness	3	1	6	3	5	1	4	1	3	1	8	3
% Dominant (top 3)	66.8	3	65	3	56.5	5	64	3	84.4	1	72.4	3
"long-lived" taxa	2.7	3	2.3	3	3.3	3	1	1	2.7	3	2.7	3
# Intolerant taxa	8	5	6	5	8	5	6	5	9	5	7	5
% Tolerant individuals	0	5	0	5	0	5	0	5	0	5	4.7	5
"clinger" taxa richness	9	3	8	1	10	3	4	1	9	3	9	3
% Predators	21.3	5	19.3	3	29.7	5	33	5	28.8	5	26	5
IBI score		**34**		**32**		**38**		**28**		**34**		**36**
Biological Condition		**fair**		**fair**		**good**		**fair**		**fair**		**fair**

* The creek changed course between 2010 and 2011 so a different area within Reach 3 was sampled in 2011.

Discussion

Fish Abundances and Patterns

Highest abundances of juvenile Coho salmon consistently occurred in samples taken from the restored floodplain area in Reach 4. However, while statistical tests identified an overall difference in abundances among the sites, associated post-hoc tests could not identify any paired site differences. This may have been due to relatively small and variable sample sizes obtained. It may thus be beneficial in future sampling for fish at Hansen Creek to conduct more intensive fishing effort on fewer sampling dates. For example, sampling dates could be concentrated in the summer and fall period when juvenile Coho salmon and trout are relatively abundant, along with adding more replication within each reach to reduce variance in the catch results.

Winter catches (February, March) of juvenile salmonids were much lower than those in the spring and summer (April through August). This may have been due in part to our netting methods working less efficiently during high flows. However, it is likely that many of the juvenile Coho salmon left the channel habitat (where most of the winter fish sampling was conducted) and occupied other habitats during the winter. It has been demonstrated elsewhere in a variety of creeks and rivers that as channel flow increases in the fall, juvenile Coho salmon move from the main channel into off-channel habitats (Cederholm and Scarlett, 1982; Peterson 1982; Brown and Hartman 1988; McMahon and Hartman, 1989; Swales and Levings, 1989; Nickelson *et al*., 1992a). Even relatively small increases in water discharge cause many individuals to move downstream and relocate into sheltered habitats well before high flows and turbidity occur (Tschaplinski and Hartman, 1983, Giannico and Healey, 1998). Although we were unable to generate density estimates for the juvenile Coho salmon that we caught during inundations of the restored Hansen Creek floodplain habitat, we did catch fish there in January, and in April over 50 juvenile Coho salmon were caught there when abundances were low in the other habitats. This suggests that the salmon can make at least temporary use of the restored habitat when it floods. This function may increase in the future as vegetation planted at the site matures and adds complexity to the habitat. For example, channels or pools that hold water for longer periods may form in low areas around willows and other plants that create higher ground.

Juvenile trout were less abundant than Coho salmon in the net samples and snorkel observations, and were rare in the samples until July. Only one Cutthroat trout was captured during inundation sampling. Thus, it appears that trout do not have the opportunity to extensively use the inundated areas of the restoration site. In addition, even if they were present during inundation events, based on other studies in the region it seems unlikely that juvenile trout would use the off-channel areas to the extent that the Coho salmon would. For example, in the Coldwater and Keogh rivers, British Columbia, it was found that juvenile Coho salmon were much more abundant in off-channel habitats, while trout were more abundant in the main channels (Swales et al. 1987, Swales and Levings 1989). Similarly, in Carnation Creek, British Columbia, juvenile Steelhead trout

were usually found closer to the bottom in deeper water than Coho salmon fry, and were almost never associated with side pools or bay areas as many of the Coho salmon were (Bustard and Narver 1975). These studies also found that cover and coarse substrates appeared to be important to juvenile Steelhead trout. Such findings suggest that at the Hansen Creek restoration site the shallow water habitats in Reach 4 (wetlands, inundated areas) were more beneficial for juvenile Coho salmon, while the channel habitats and associated cover (e.g. placement of large woody debris) at all of the reaches within the site were more important for juvenile Steelhead trout.

Juvenile Salmonid Diets

The instantaneous rations found in juvenile Coho salmon and trout at the Hansen Creek sites were comparable to or higher than those found in for juvenile salmon in restored and natural habitats elsewhere in the region (Gray 2005, Spilseth 2008, Cordell et al. 2010). Juvenile Coho salmon sampled on the inundated floodplain habitat had higher instantaneous rations than at the other sites. It is interesting that in particular, rations were significantly higher at the inundated areas compared to adjacent habitats in Reach 4. At these times their diets were similar to those from the other sites, consisting of a variety of aquatic and emergent insects. This suggests that the inundated area had prey types that were similar to the other sites but that the prey was more abundant and/or more accessible there. This could have resulted from either higher production of prey within the inundated areas or from concentration of prey that was being transported into the inundated floodplain from other areas. We do not know if increased rations in the floodplain area would lead to higher growth or survival of Coho salmon feeding there. However, results from other streams suggest that juvenile Coho salmon using similar restored habitat experience increased growth and survival (e.g. the Chehalis River, Washington—Henning et al. 2006).

An alternate explanation for higher rations in the inundated areas compared to other areas is that fish there may have been less concentrated when they were there. We note that Coho salmon from Reach 4 often had significantly lower instantaneous rations compared to other sites (4 out of the 5 months), and Reach 4 also typically had higher fish numbers. Thus, it is possible that there was more competition for food when the fish occurred in high densities in the channel, and less competition when they were spread out on the inundated wetland. Because our fishing method in the inundated area did not allow us to generate densities per unit area, we cannot say whether or not lower densities there could have contributed to the higher rations.

Chironomids and other dipteran fly larvae, pupae, and emergent adults were abundant in the prey of all of the salmonids. Mayfly nymphs were also prominent prey items for both size classes of juvenile Coho salmon, and also for the small size class of trout. They were abundant in the Coho salmon diets in April at most of the sites, particularly in diets from inundated floodplain habitats. Certain species of mayfly nymphs are known to migrate into flooded habitats to complete their life cycles, and also can be transported into flooded areas either passively or by actively moving there (Smock 1999, Galatowitsch and Batzer 2011). Similarly, some chironomid species can exploit temporary water sources with several different life history strategies such as rapid colonization by ovipositing females (Clement et al., 1977) and emergence from sediments within the

flooded areas (Benigno and Sommer 2007). We do not known whether or not the mayfly and chironomid species that the fish fed on in the channel habitats were different than those in the inundated floodplain, but in future studies of the site, it may be beneficial to attempt identification to a lower taxonomic levels in order to understand the sources of the prey.

Neuston

Organisms sampled in the inundated wetland areas of Reach 4 in April were remarkably different between the east and west sides of Hansen Creek. On the west side, densities were much higher, and the samples were dominated by planktonic cyclopoid copepods and cladocerans. On the east side, densities were an order of magnitude lower than on the west side, and the composition was not dominated by any one taxon. Planktonic species were present on the east side, but were a relatively low proportion of the total. We identified the dominant cyclopoid copepod in west side samples as *Acanthocyclops robustus*, a common copepod of lakes and reservoirs in the region. The populations of *A. robustus* could have either come into the floodplain area from upstream ponds, or been produced within the wetland habitat on site. It is most likely that the planktonic organisms were produced on site, because if they had been transported into the system from upstream, they would have been abundant at both east and west sides. The habitat on the west side of the creek is much less dynamic than that on the east side, and in addition to the planktonic species found in the neuston samples there, while fish sampling we also noted other taxa characteristic of standing waters, such as tadpoles, dragonfly larvae, and giant water beetle larvae. We caught no salmonids in the west side habitat, so availability of invertebrate prey produced on that side is probably limited. We did see some evidence of planktonic prey in Coho salmon diets on the east side of the creek. For example, in Coho salmon collected on the inundated east side floodplain on 4 April 2011, cyclopoid copepods made up 11% of the prey by numbers. These and other prey taxa are probably not exported from the west to east sides during flooding because the connection between the two sides is at the downstream end of the site, and any flow from the west to the east side would be carried downstream during flood events.

Neuston organisms collected in the main channel habitats were different than those found in the inundated habitats. The main difference was that chironomid larvae were the dominant organism in the channel samples and made up much smaller proportions in the inundation samples. While this may be due to the fact that channel and inundation samples were taken in different months, it is more likely due to the habitat and location of the samples. The channel samples were taken in flowing water such that organisms in the samples were those that were being transported downstream. Presumably the chironomid larvae in the channel samples were being displaced from benthic habitats and being entrained in the stream flow. Because chironomid larvae and pupae were common and sometimes dominant prey items for juvenile Coho salmon and for small trout caught in the channels, the channel neuston sampling may be an effective way to measure available prey for these fish.

Fallout Traps

Fallout traps provide a measure of adult flying insects, and various life history stages of insects that are associated with terrestrial and emergent vegetation. They are meant to

provide an estimate of the amount of potential drift organisms being provided to the aquatic habitat from the surroundings. In the salmonid diets, these were represented by common prey items such as Hymenoptera (ants, wasps, etc.), aphids, collembolans, and spiders. The most notable finding from our fallout trap sampling was that the floodplain samples that were taken at higher elevations than are reached by most inundations were both qualitatively and quantitatively different than all of the other sites. Samples from this site had much higher abundances than at the other sites, and the PERMANOVA analysis indicated that it was always different from the other sites in assemblage composition. These differences were mainly due to high numbers of mites in the floodplain samples, and when they were removed from the analysis, the total numbers of organisms from floodplain samples were similar to those from other sites. However, the floodplain assemblages without mites were still different than those at other sites, having relatively more terrestrial insects such as Hemiptera and Thysanoptera and fewer insects with aquatic life history stages such as chironomids and other dipterans. Because mites were not an important component of salmonid diets, this method of analysis may be a better way to examine fallout trap data from Hansen Creek.

The juvenile salmonids that we collected at Hansen Creek fed on a wide variety of prey types, including adult insects likely to be sampled with the fallout traps. The larger size class of juvenile Coho salmon was particularly prone to feed on these types of insects. The terrestrial and riparian vegetation that was planted and is developing at the Hansen Creek restoration site is expected to change greatly as the site matures. This is especially likely in Reach 4, where the dynamics of the channel are still changing. When the vegetation communities change and mature, it is likely that the associated insect fauna will change as well. If the site is monitored in the future, fallout trap sampling will remain a useful tool to document this and to provide for comparisons between the insect communities and salmonid diets.

Benthic Index of Biotic Integrity

The three reaches sampled all scored in the fair range in both 2010 and 2011, except for Reach 3, which scored in the good range in 2010. However, the score for Reach 3 dropped from 38 (good) to 28 (fair) in 2011. This may be due to the fact that the 2011 samples were taken in an area farther upstream than those taken in 2010 due to a change in the channel position, and that might account for the decline. The B-IBI scores were consistently excellent for metrics measuring tolerance to organic pollution. In 2010 there were no pollution tolerant species and in 2011 there was only one (*Physa* sp.). The relatively low B-IBI scores were the result of there being few long-lived taxa, i.e. those that require more than one year to complete their development. It is possible that disturbance and continued restructuring of the benthic habitat in the new Hansen Creek habitats may limit the numbers of these types of organisms. This may also account for the relatively low scores for most measures of taxa richness.

In 2008, prior to restoration, Aquatic Biology Associates, Inc. did a B-IBI on Hansen Creek. The sampling locations were comparable to our Reaches 3 and 4 samples and the calculated score was 36 for both reaches, very similar to our results. In general these values are consistent with other IBI studies in the rural parts of the Puget Sound Lowlands ecoregion (http://pugetsoundstreambenthos.org). Carpenter Creek and Willard

Creek, the two streams closest to Hansen Creek for which data is available, both scored 22, which fall in the poor category.

Conclusions and Future Sampling

The main goal of this study was to provide an evaluation of the biological attributes of the Hansen Creek floodplain restoration site in its early stages of development. In order to do so we sampled insect assemblages that are potential juvenile salmon prey, biotic integrity (B-IBI), and juvenile salmonid densities and diets. We sampled these attributes in different seasons and hydrological conditions, and compared the different reaches within the site. We also sampled the restored floodplain during inundation events to document juvenile salmon presence and diets in the newly available habitat. The sampling that we conducted at the restoration site provides a baseline of biological data to compare to future conditions at the site. It also provides a picture of the site in its earliest stages of development. It is evident from our results that juvenile Coho salmon and trout occupy the site and obtain relatively high food rations there, especially during inundation events. Thus, the restored floodplain habitat appears to be productive and beneficial to juvenile salmonids even in its early stages of development.

A second goal of the study was to try different methods of sampling fish abundances and diets and invertebrates at Hansen Creek in order to learn which techniques might work best in future sampling at the site. In the following sections of the report, we discuss the methods that we used, and explore others that may work well under the conditions we experienced, and also in conditions that may develop as the site changes over time.

It is expected that the Hansen Creek floodplain restoration site will change drastically as planted and naturally recruited vegetation becomes established and as the creek channel in the floodplain becomes less dynamic. In addition, this study took place over a single year, and interannual variation in rainfall amount and duration, temperatures, and fish populations could affect the biota at the site. To account for these factors in understanding the developing restoration site, the final section of this report recommends strategies for future sampling.

Fish Sampling

The methods we used for catching salmonids were arrived at after trying several methods early in the study. In October 2010 during low-flow conditions, we successfully collected salmonids using a dip net while snorkeling around logjams and in undercut bank areas. However, increased flows and turbidity later in the season precluded this visual method. In order to obtain enough fish for diet analyses and also generate density estimates, we settled on a "hybrid" effort in which one targeted dip net or side channel sampling was combined with two block-and-sweep net samplings in each reach. These methods were probably not completely effective at capturing larger more evasive salmonids or at quantifying salmonids in especially complex habitats such as log jams or dense overhanging vegetation. For example, we noted in trial sampling using a dip net while snorkeling that larger trout were much quicker and much more difficult to catch than smaller Coho salmon. Also, snorkeling transect observations revealed that many juvenile salmonids occurred in dense schools below undercut banks where they may have avoided

our netting techniques. In the future, a better method would be multiple-pass depletion electrofishing paired with visual snorkel surveys when visibility allows, such as the Basin-wide Visual Estimation Technique (BVET) (Hankin and Reeves 1988, Dollof et al. 1993). In this method, available habitat for the fish is first inventoried, and a stratified subsample of habitat units is selected. Paired snorkeling and depletion electrofishing estimates are conducted in selected habitat units. This method would allow for not only accurate fish density estimates, but would also allow for diet collections, and identification of microhabitat associations of different size classes and species of salmonids. Although we could not conduct snorkel surveys during much of the year because of high turbidity, as the system matures and sediments stabilize visibility may improve and allow visual surveys during higher flow periods. Conducting electrofishing would require the application and approval of the necessary fish permits, which can take up to one year for capture of salmonids listed under the Endangered Species Act.

Pole seining in the inundated areas was effective for obtaining juvenile salmonids for diets. However, we were not able to generate densities using this method. In addition fishing with pole seines in the floodplain area will likely become more difficult as the vegetation community matures and becomes denser. If this becomes the case, additional fishing methods such as fyke nets or traps could be used. In a similar situation in which floodplain lakes with large amounts of coarse woody debris were sampled, Clark et al. (2007) found that fyke nets collected more fish and produced greater species richness and diversity measures than did seining. Fyke nets could also give an estimate of fish emigration and immigration in chosen habitats because they can be fished in multiple directions for varying lengths of time.

Our study identified periods in which juvenile Coho salmon and trout are abundant in the restored Hansen Creek habitats. Using this information, it will be possible to conduct more intensive fishing effort on fewer sampling dates, focusing on the summer and fall period when the fish are relatively abundant, along with adding more replication within each reach to reduce variance in the catch results. Although we did not find juvenile salmonids on the west side of the project area, we only conducted limited sampling there in the winter. Because it is well known that juvenile Coho salmon extensively overwinter in similar still water habitats, we recommend that future sampling include all inundated areas and that it be conducted in the winter as well as in other seasons.

Invertebrate Sampling

In this study we used two standard invertebrate assessment methods, fallout traps and B-IBI sampling. The former method samples insects entering the aquatic systems from surrounding terrestrial and riparian habitats, while the latter provides a measure of ecosystem health. In addition, we conducted trial sampling using two kinds of neuston nets that sampled organisms in surface waters during inundations, and channel organisms being carried downstream in the current. The intent was to determine if this type of sampling could provide information about some types of juvenile salmonid prey that is not effectively sampled by fallout traps (e.g. larvae of chironomids and mayflies). We did find these prey organisms in the neuston net samples, in addition to others such as planktonic cyclopoid copepods. Thus, addition of neuston sampling to future studies at the site would be useful. Identification of the dominant prey items of juvenile Coho

salmon, such as chironomid larvae and mayfly nymphs to higher taxonomic levels in diet and invertebrate samples, may also be useful in clarifying where some of the dominant salmonid prey is being produced. Stationary neuston nets may also be a good way to sample import and export of invertebrate prey taxa among habitats. This method has been successfully used to measure mayfly nymphs moving between river channels and floodplain wetlands (Galatowitsch and Batzer 2011).

Fallout traps are useful in characterizing an important component of available prey for salmonids, and they can also be useful in establishing habitat-prey associations. As the vegetation communities at the Hansen creek site continue to mature, using insect fallout traps to characterize habitat complexes might provide information on how the associated invertebrate communities change with the maturation of the site.

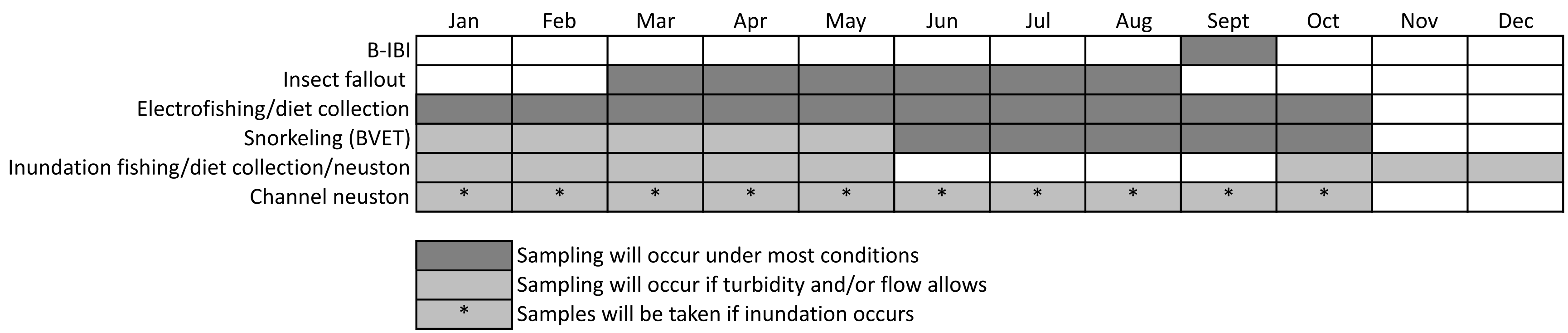
Scale of Future Sampling

The span over which restoration monitoring should be conducted depends on the processes being evaluated and the types of habitats restored. Suggested time frames published in the literature range from three to fifty years depending on the objective of the restoration project (Thayer et al. 2003). Clewell and Lea (1990) suggested that wetland restoration monitoring should be done for at least five years following the completion of the project. However, in a study of a tidal fresh water restored site in the Puyallup River, Simenstad and Thom (1996) found that a much longer time frame was probably needed to understand the ultimate functions at the site. Thus, longer-term sampling should be a part of any comprehensive monitoring plan for the Hansen Creek restoration site. Also, sampling in multiple years should be considered for several reasons. First, it will provide information about specific habitats within the site and their impact on biota as they change over time. The Hansen Creek site will change greatly as vegetation matures and channels stabilize, and some characteristics of the habitats will be ephemeral. Second, multiple-year sampling will document the effects of interannual variation in physical processes such as temperature and rainfall. Third, sampling in multiple years will identify sources and effects of biological variation such as interannual differences in fish abundances and the effect of juvenile Pink salmon (*Oncorhyncus gorbuscha*) that are present in alternate years.

In addition to having an adequate temporal timeframe, a broad spatial scale of analysis is also important to gauging restoration success. In this report we detail monitoring within the Hansen Creek system separate from that of the main stem of the Skagit River and other nearby creeks that flow into the Skagit River. Future monitoring work at the site could benefit from placing the Hansen Creek system into context with its surroundings. For example, sampling several watersheds would allow a comparison of biological and physical data from Hansen Creek with that from other creeks, providing insight into how developing restored habitats compare to more established habitats. Sampling source fish populations in the main stem of the Skagit River would allow us to compare the timing, assemblage structure, and ecology of fish populations there with those in Hansen Creek. This would allow an assessment of unique functions of the Hansen Creek system that are not available in the main stem of the Skagit River.

We recommend that sampling occur again in 2013 in order to allow time to acquire electrofishing permits, but soon enough to document changing conditions as the site develops. If Pink salmon and non-Pink salmon outmigration years are to be compared sampling would occur again in 2014. We would then recommend sampling on a three-year periodicity with evaluation of the results guiding revisions of sampling periodicity thereafter. For example, if results from year nine sampling indicate that the site has stabilized and that sources of interannual variation have been captured adequately, then it may be recommended that continued sampling be based on longer intervals. The suggested yearly sampling scenario presented in Table 7 focuses on methodologies and time periods based on what we learned during the initial studies we conducted at the Hansen Creek restoration site. Inclusion of a broader scale of analysis in adjacent creeks and the main stem of the Skagit River could be included as funding allows.

Table 7. Example yearly sampling plan for Hansen Creek alluvial floodplain restoration site. An inventory of fish habitats should be completed prior to the first BVET sampling.



<u>Sampling Sites</u>

Reach 2 Reference
Reach 3 Established
Reach 3 Unestablished
Reach 4 Channel
Reach 4 Wetland
Reach Floodplain West
Reach Floodplain East (fallout traps only)

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References

Anderson, M.J., R.N. Gorley, and K.R. Clarke. 2008. PERMANOVA+ for PRIMER: Guide to Software and Statistical Methods. PRIMER-E, Plymouth, UK.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Brown, T. G., and G. F. Hartman. 1988. Contribution of seasonally flooded lands and minor tributaries to the production of coho salmon in Carnation Creek, British Columbia. Transactions of the American Fisheries Society 117:546–551.

Bryant, M. D., R. T. Edwards, and R. D. Woodsmith. 2005. An approach to effectiveness monitoring of floodplain channel aquatic habitat: salmonid relationships. Landscape and Urban Planning 72:157–176.

Bustard, D. R., and D. W. Narver. 1975. Aspects of the winter ecology of juvenile Coho salmon (*Oncorhynchus kisutch*) and Steelhead trout (*Salmo gairdneri)*. Journal of the Fisheries Research Board of Canada 32:667–680.

Castello, L. 2008b. Nesting habitat of pirarucu *Arapaima gigas* in floodplains of the Amazon. Journal of Fish Biology 72: 1520–1528.

Cederholm, C. J., and W. J. Scarlett. 1982. Seasonal immigration of juvenile salmonids into four small tributaries of the Clearwater River, Washington, 1977–1981. In Salmon and Trout Migratory Behavior Symposium, Brannon E. L., and E. O. Salmon (eds). University of Washington: Seattle; 98–110.

Clement, S. L., A. A. Grigarick, and M. O. Way. 1977. The colonization of California rice paddies by chironomid midges. Journal of Applied Ecology 14: 379–389.

Dolloff, C.A., D.G.Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. Gen. Tech. Rep. SE-GTR-83. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 25 p.

Cordell, J. R., L. M. Tear, C. A. Simenstad, S. M. Wenger, and W. G. Hood. 1994. Duwamish River Coastal America restoration and reference sites: results and Recommendations from year-one pilot and monitoring studies. FRI-UW-9416, Fisheries Research Institute, University of Washington, Seattle.

Cordell, J. R., J. T. Toft, A. Gray, G. T. Ruggerone, and M. Cooksey. 2011. Functions of restored wetlands for juvenile salmon in an industrialized estuary. Ecol. Engr. 37:343–353.

Clark, S. J., Jackson, J. R., and Lochmann, S. E. 2007. A comparison of shoreline seines with fyke nets for sampling littoral fish communities in floodplain lakes. North American Journal of Fisheries Management 27:676–680.

Clarke, K. R., and R. N. Gorley. 2006. Primer v6: User Manual/Tutorial. Plymouth, UK: PRIMER-E.

Eberle, L. C., and J. A. Stanford. 2010. Importance and seasonal availability of terrestrial invertebrates as prey for juvenile salmonids in floodplain spring brooks of the Kol River (Kamchatka, Russian Federation). River Research and Applications 26:682–694.

Giannico, G. R., and M. C. Healey. 1998a. Effects of flow and food on winter movements of juvenile coho salmon. Transactions of the American Fisheries Society 127:645–651.

Giannico, G. R., and S. G. Hinch. 2007. Juvenile coho salmon responses to salmon carcasses and instream wood manipulations during winter and spring. Canadian Journal of Fisheries and Aquatic Sciences 64:324–335.

Gray, A., C. A. Simenstad, D. L. Bottom, and T. J. Cornwell. 2002. Contrasting functional performance of juvenile salmon habitat in recovering wetlands of the Salmon River estuary, Oregon, USA. Restoration Ecology 10:514–526.

Gray, A. 2005. The Salmon river estuary: restoring tidal inundation and tracking ecosystem response. PhD dissertation, University of Washington.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences. 45: 834–844.

Hayslip, Gretchen, editor. 2007. Methods for the Collection and Analysis of Benthic Macroinvertebrate assemblages in Wadeable Streams of the Pacific Northwest. Pacific Northwest Aquatic Monitoring Partnership, Cook, Washington.

Henning, J. A., R. E. Gresswell, and I. A. Fleming. 2006. Juvenile salmonid use of freshwater emergent wetlands in the floodplain and its implications for conservation management. North American Journal of Fisheries Management 26:367–376.

Henning, J. A., R. E. Gresswell, and I. A. Fleming. 2007. Use of seasonal freshwater wetlands by fishes in a temperate river floodplain. Journal of Fish Biology 71:476–492.

Herrera Environmental Consultants. 2007. Conceptual Restoration Report for the Hansen Creek Alluvial Fan and Adjacent Wetland Restoration Project. Prepared for Upper Skagit Indian Tribe.

Junk, W. J., P. B. Bayley, and R. E. Sparks. 1989. The flood pulse concept in river–floodplain systems. Canadian Special Publication of Fisheries and Aquatic Sciences. 106:110–127.

Limm, M. P., and M. P. Marchetti. 2009. Juvenile Chinook salmon (*Oncorhynchus tshawytscha*) growth in off-channel and main-channel habitats on the Sacramento River, CA using otolith increment widths. Environmental Biology of Fishes 85:141-151.

Lott, M. A. 2004. Habitat-Specific Feeding Ecology of Ocean-Type Juvenile Chinook Salmon in the Lower Columbia River Estuary. M.S. Thesis, University of Washington.

McMahon, T. E., and G. F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 46: 1551–1557

Miller Consulting and Watershed Professionals Network. 2002. Hansen Creek Watershed Management Plan. Prepared for the Skagit County Public Works Department by Miller Consulting and Watershed Professionals Network.

Morley, S. A., P. S. Garcia, T. R. Bennett, and P. Roni. 2005. Juvenile salmonid use of constructed and natural side channels in Pacific Northwest rivers. Canadian Journal of Fisheries and Aquatic Sciences 62:2811–2821.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992a. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783–789.

Nickelson, T. E., M. F. Solazzi, S. L. Johnson, and J. D. Rodgers. 1992b. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:790–794.

Pess, G. R., S. A. Morley, J. L. Hall, and R. K. Timm. 2005. Monitoring floodplain restoration. Pages 122–166 in P. Roni, editors. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland.

Peterson, N. P. 1982. Immigration of juvenile coho salmon (*Oncorhynchus kisutch*) into riverine ponds. Canadian Journal of Fisheries and Aquatic Sciences 39:1308–1310.

Roni, P., C. Dietrich, D. King, S. Morley, and P. Garcia. 2006. Coho smolt production from constructed and natural floodplain habitats. Transactions of the American Fisheries Society 135:1398–1408.

Roni, P., G. Pess, T. Beechie, and S. Morley. 2010. Changes in Coho salmon and steelhead abundance from watershed restoration: how much restoration is needed to

measurably increase smolt production? North American Journal of Fisheries Management 30:1469–1484.

Simenstad, C. A. and R. M. Thom. 1996. Functional equivalency trajectories of the restored Gog-Le-Hi-Te estuarine wetland. Ecological Applications 6: 38–56

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batha, and W. J. Kimmerer (2001) Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58:325–333.

Sommer, T. R., W. C. Harrell, and M. L. Nobriga. 2005. Habitat use and stranding risk of juvenile Chinook salmon on a seasonal floodplain. North American Journal of Fisheries Management 25:1493–1504.

Spilseth, S. A. 2008. Short-term competition between juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and threespine stickleback (*Gasterosteus aculeatus*) in tidal channels. MS Theses, University of Washington.

Benigno, G. M., and T. R. Sommer. 2007. Just add water: sources of chironomid drift in a large river floodplain. Hydrobiologia 600: 297–305.

Swales, S., F. Caron, J. R. Irvine, and C. D. Levings. 1988. Overwintering habitats of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Keogh River system, British Columbia. Canadian Journal of Zoology 66:254–261.

Swales, S., and C. D. Levings. 1989. Role of off-channel ponds in the life cycle of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Coldwater River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 46:232–242.

Thayer G. W., T. A. McTigue, R. J. Bellmer, et al. (eds). 2005. Science-based restoration monitoring of coastal habitats, vol 1: a framework for monitoring plans under the estuaries and Clean Waters Act of 2000 (Public Law 160-457). NOAA Coastal Ocean Program Decision Analysis Series No.23. NOAA National Centers for Coastal Ocean Science, Silver Spring, Md.

Tschaplinski P. J., and G. F. Hartman. 1983. Winter distribution of juvenile coho salmon (*Oncorhynchus kisutch*) before and after logging in Carnation Creek, British Columbia, and some implications for overwintering survival. Canadian Journal of Fisheries and Aquatic Sciences 40: 452–461.