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An Evaluation of Fish and Amphibian Use of Restored and Natural Floodplain Wetlands

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Washington Department of Fish and Wildlife

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CHAPTER 1: INTRODUCTION

Palustrine wetlands are prominent habitats of Pacific Northwest coastal floodplains. The importance of these flooded wetlands (e.g. marshes, beaver ponds, remnant oxbows) to fish has not been well documented historically. The seasonal influence of the hydrological regimen across the floodplain is critical (Bayley 1995; Poff et al. 1997; Michener and Haeuber 1998) and maintains biological and physical diversity. Based on observations in relatively undisturbed river-floodplains, bigger floods inundate larger areas and make greater quantities of food and shelter available for fish and other aquatic and semi-aquatic organisms as floodwaters flow over riverbanks (Welcomme 1979). This flood process maintains high production due to the decomposition of organic matter and nutrients, which can result in high yields of fish (Bayley 1991; 1995).

The river-floodplain connection has been greatly reduced in most temperate systems because humans have substantially modified the rivers' peak flows. In addition, many river channels and associated floodplains have been isolated from one another (Junk et al. 1989). Examples of actions that have affected the hydrologic pattern include: channelizing and armoring river segments, dredging, forest clearing, diking, and ditching and draining wetlands. Awareness of the value of wetland habitats has gradually increased and wetland creation, restoration, and functional enhancement have become important tools for compensating wetland acreage and functional losses (Ratti et al. 2001). However, fish are rarely the focus of these wetland projects.

Wetland restoration and enhancement activities have become an integral component of nation-wide conservation efforts under such federal authorities as Natural Resources Conservation Service (NRCS) Wetland Reserve Program and U.S. Fish and Wildlife Services North American Wetland Conservation Act. These federal agency programs have restored and created over 1.5 million acres of wetlands in the United States since the initiation of the 1990 Farm Bill (NRCS 2004).

In floodplains, restoration projects with water control structures are often intended to conserve and restore wetland habitat characteristics including floodplain function, hydrologic connectivity, and critical habitat for migratory wildlife and threatened and endangered semi-aquatic and aquatic wildlife and plant species. Wetland restoration projects often include a mechanism to retard the rate of water drainage. This is often accomplished by blocking drainage ditches or installing water control structures to retain water within the wetland floodplain area. Also, decreasing the rate of drainage can facilitate longer connectivity between the river and floodplain. A water control structure can be manipulated to vary water depths in the wetland throughout the year. In some cases, the structure includes a culvert connected to a half round riser where boards are placed to control the wetland hydrology (Figure 2). Water control structures can increase wetland water storage and return water to the river more slowly, long after water levels recede in the river channel. Moreover, if properly constructed and operated such outlets can maintain connectivity between the wetland and river. In this study, wetlands that contain water control structures are referred to as regulated wetlands and non-regulated sites are those wetlands without water control structures.

Many wetland research studies have focused on the importance of wetland habitat for invertebrates, waterfowl, and amphibian populations (Kaminski and Prince 1981; Murkin et al. 1982; Safran et al. 1997). Most wetland restoration and enhancement projects are wildlife oriented and are rarely designed specifically to benefit fish populations. In fact, many wetland projects could be detrimental to fish (i.e. entrapment, predation, and water quality limiting). However, in a floodplain environment a wide variety of fish species, including salmonids, have the potential of accessing and benefiting from seasonal wetlands. Floodplain wetlands may serve directly as important rearing habitat (i.e. feeding, refuge) and indirectly as a source of primary and secondary production for the main river channel. Significant information gaps remain in our understanding of the use of floodplain wetlands by fishes, particularly salmonids, in temperate systems. This is related to the uncertainties of river-floodplain relationships, the diversity of wetland habitats in floodplains, and the sampling problems associated with seasonal habitats, which can have extreme environmental variability (Sommer et al. 2001).

In the Pacific Northwest, the degree to which floodplains support fish remains poorly understood. Numerous studies have shown the significance of off-channel habitat and beaver ponds to juvenile coho salmon *Oncorhychus kisutch* (Bustard and Narver 1975; Brown and Hartman 1988; Swales and Levings 1989). Off-channel habitats are channels that have formed by the channeling of runoff through swales created by the migration of the mainstem stream (Peterson and Reid 1984). These channels and associated ponds are productive habitat for overwintering fish and contain a hydrologic connection to the river during the winter (Peterson and Reid 1984). In Carnation Creek watershed (a drainage in Vancouver, B.C.), a floodplain area of about 50 hectares in a given location, 15-25% of the total smolt yield were captured in off-channel sites, and most of those fish spent the winter in off-channels devoid of standing water during summer (Brown and Hartman 1988). However, these studies may not be as applicable when inferred to large river-floodplain habitats because most of these studies were done in headwater areas of small watersheds (10-300 km^2 river drainage) that contain narrow floodplains, low discharges, and spring fed ponds. The Chehalis River floodplain has seasonal wetlands that have infrequent surface water connections to the river, are temporarily flooded for brief periods, and are primarily rain-fed.

Federal listings of threatened and endangered fish stocks, specifically Pacific salmon, underscore the need to understand the effects of regulated wetlands on such populations. Specific questions pertaining to how salmon respond to regulated wetlands include identifying the degree of utilization, growth, survival and outmigration. These responses have major management implications for the successful creation and restoration of wetland habitats to benefit and/or to avoid detrimental effects to fish. The continued development of such wetland projects is dependent on new information about the overall consequences of these restoration projects on salmonid growth and survival.

The goal of this study was to broaden our understanding of the role of regulated floodplain wetlands in the Pacific Northwest as rearing (i.e. feeding, refugia) habitat for fishes. This was accomplished by comparing six wetlands in the Chehalis River (Washington State) floodplain (Figure 1). Two wetlands are regulated and four are non-regulated. Two non-regulated wetlands, N1 and N2, were selected based on their proximity and similarity to pre-impoundment conditions of the regulated sites (R1 and R2). The other two non-regulated sites, alternative sites A1 and A2, are a seasonal off-channel and a remnant oxbow permanent pond with a beaver dam (Table 1). The alternative sites were added to compare with existing fish habitat literature. Detailed descriptions of each study site are in chapter 2. Given the potential that fish are accessing floodplain wetlands, specific objectives of the study were:

1. Compare relative fish abundance, especially salmon, between regulated, non-regulated, and alternative wetland sites.

2. Determine fish community characteristics such as species richness, diversity, and ratio of native to non-native fishes in regulated and non-regulated wetlands and examine fish population metrics (condition index and fork length) over the duration of the study.

3. Examine the duration of fish access in and out of sampled wetlands.

4. Characterize physical parameters (e.g. water temperature and dissolved oxygen concentration) of regulated, non-regulated, and alternative wetlands and associate characteristics with juvenile salmon populations.

5. Compare relative amphibian abundances between regulated, non-regulated, and alternative wetlands.

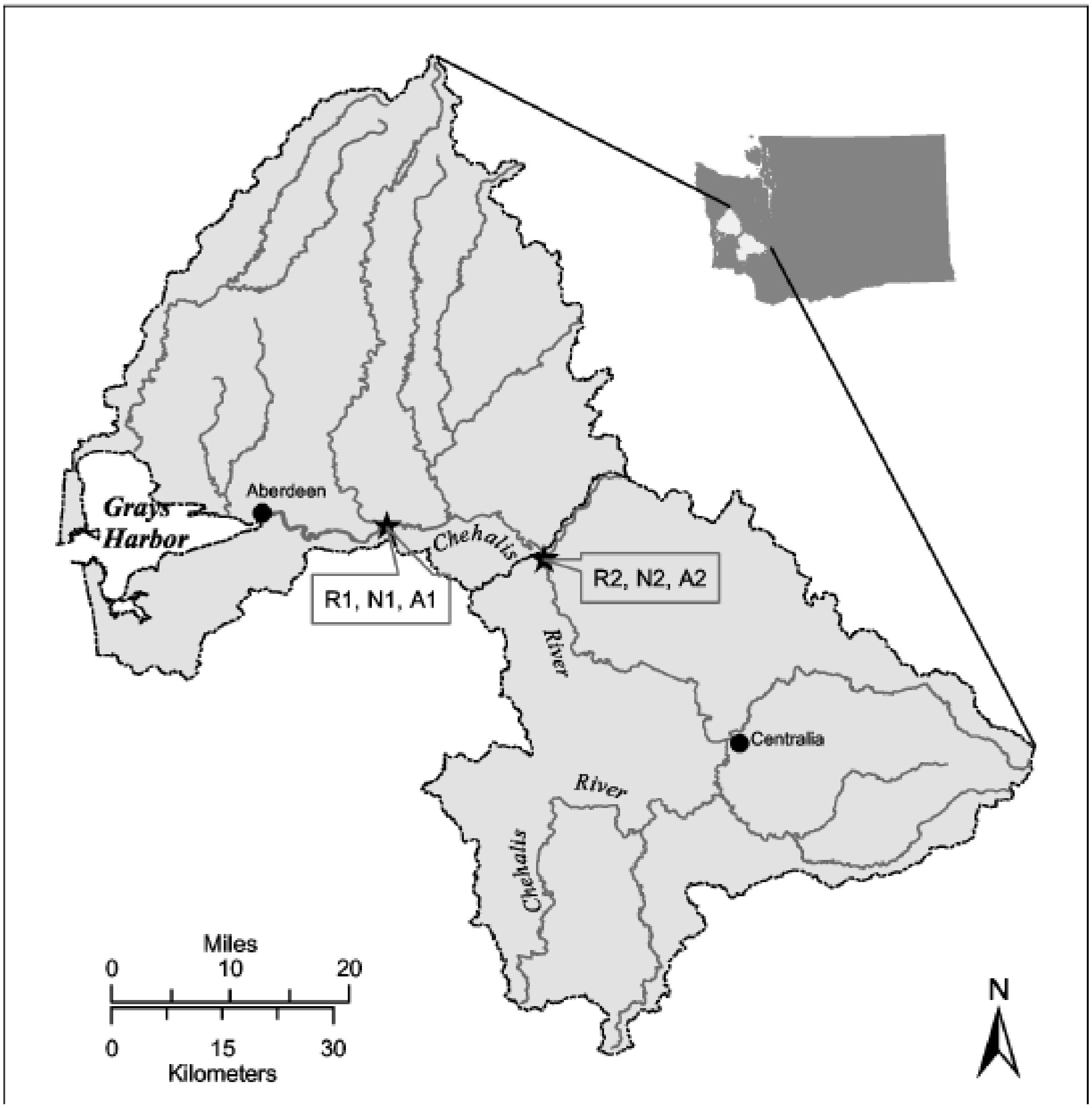

Figure 1. General location of study sites evaluating fish use of wetland habitats in the Chehalis River Basin, Washington. Regulated wetlands are represented as R1 and R2, non-regulated wetlands are represented as N1 and N2, and alternative sites are represented as A1 and A2.

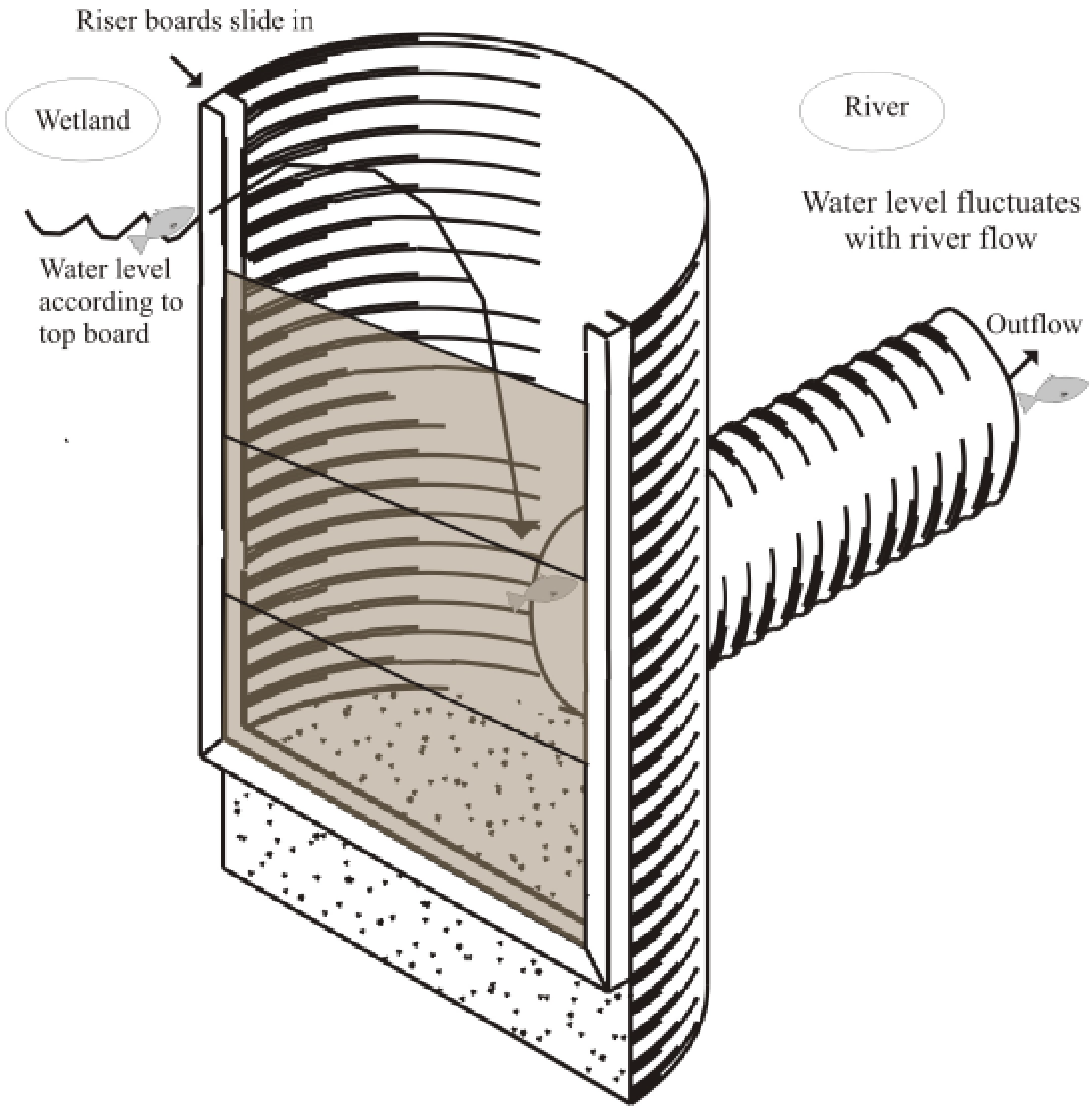

Figure 2. A diagram of a half-round riser water control structure. This is placed in many regulated wetlands to enhance wetland hydrology. Diagram courtesy of Cyndi Baker, Ducks Unlimited, Inc.

CHAPTER 2: BACKGROUND

Basin description

The Chehalis River Basin is the third largest river basin in the State of Washington behind the Columbia River and Skagit River Basins. The total drainage area of the Chehalis Basin is 6,889 km^2 of which approximately 85% is forestlands and 9.7% is agriculture (67,177 hectares). The basin is bounded on the west by the Pacific Ocean, on the north by the Cascade Mountains, and on the south by the Willapa Hills and Cowlitz Basin (Chehalis River Basin Action Plan 1992; Figure 1). The Chehalis River system is largely rain-fed with precipitation levels that range from 114 centimeters per year in Chehalis/Centralia to over 559 centimeters per year in the Olympic Mountains. The study sites range in precipitation from 152-203 centimeters annually. Average temperatures over much of the region range from 3.3ºC to 4.4ºC during January and from 15ºC to 17.8ºC during July. Snowmelt is relatively minor component of the Chehalis flows in the spring compared to the precipitation.

The lower Chehalis Basin, where the study sites are located, is characterized as a broad flat valley floor, where the river is unconstrained to move and wind through the floodplain. The river's movement through the floodplain has created a mosaic of habitats. Oxbows, off-channel areas, sloughs, seasonally flooded wetlands, and permanent ponds are examples of the diversity of habitats occurring in the Chehalis floodplain. These habitats are relatively intact and minimally degraded compared to other watersheds. There has been minimal dikes, rip-rap, and other flow control measures in the Chehalis Basin. The primary source for floodplain degradation in the Chehalis River Valley is ditching and draining for conversion to cropland or pasture.

Winter rains cause floodplain wetlands to fill and the Chehalis River to overflow, reconnecting the mainstem to the associated floodplain (Figure 3). Movement of water from the river onto the floodplain, provides opportunity for fish and other aquatic species to access flooded wetland habitats. Also, flooding allows food recruitment from the floodplain to the river. In the Chehalis River, flooding frequently occurs in late winter and early spring. As a result, the seasonal wetlands are not per se over winter habitat unless the river floods in late fall and fish have access to the floodplain during winter months.

Presence of salmon that may use floodplain habitats in the Chehalis River include chum salmon (*Oncorhynchus keta*), coho salmon (*O. kisutch*), and spring and fall Chinook salmon (*O. tshawytscha*). These stocks are reported healthy and are not federally listed (WDF et al. 1993). The study sites are located in the lower section of the Chehalis River at river kilometer 27 and 50 (Figure 1).

Figure 3. The lower Chehalis Valley during a winter flood. Fish can access most floodplain wetlands during high water events. Chehalis River floodplain, Washington, 2003.

CHAPTER 3: STUDY SITES

Regulated wetlands

Regulated site 1 (R1) is a NRCS Wetland Reserve easement that has been restored and permanently protected (Figure 4). Before restoration, rennie and salzer clays (USDA 1986) were drained as part of a drainage district project to facilitate farming. In 1998, the restoration involved blocking drainage capabilities and constructing a water control structure and levee to reestablish wetland hydrology that provided conditions for a diversity of emergent vegetation. R1 is approximately 14.5 hectares and located at river kilometer 27. The wetland is connected to the river by a no-name tributary that flows into Metcalf slough. Hydrology at R1 is dependent on precipitation and river floods. Riverine aquatic species have access to the wetland during high river flows that cause Metcalf slough to flood and connect the creek to the floodplain. Also during high river flows, R1 can be tidally influenced. The tidal influence coupled with high river flows increase the frequency of water connection between the river and wetland. In the winter, standing water in the wetland is 0-1.5m (except in the borrow ditch which is 2-2.5m deep). Much of the wetland is parched during summer months but does contain a 1-hectare permanent pond near the southern edge of the wetland. Prior to restoration the site was dominated by dense, monotypic stands of invasive reed canarygrass (*Phalaris arundinacea*). After restoration the dominate vegetation assemblage includes: reed canarygrass, narrow leaf burreed (*Sparganium emersum*), mild waterpepper (*Polygonum hydropiperoides*), water-purslane (*Ludwigia palustris*), mannagrass (*Glyceria* sp.), and yellow pond lily (*Nuphar luteum*). During late winter and early spring, the ratio of open water to vegetation is approximately 50:50. Land use adjacent to R1 consists of row crops and grazing, and wetlands dominated by reed canarygrass.

The second regulated wetland, R2, is managed regularly and contains a water control structure (Figure 5). Before restoration, the wetland was drained to facilitate farming. In 1997, the restoration involved blocking a drainage ditch and installing a water control structure to reestablish wetland hydrology. The 17-hectare site, at river kilometer 58, is connected to the river by a ditch that connects to a slough off the main river. Hydrology sources at R2 are precipitation, surface inflow from an adjacent seasonal creek, and river floods. Riverine species enter the site during flood events via sheetwater. The outlet structure is managed to allow fish outmigration but impounds water to provide hydrology conditions for emergent vegetation. Much of R2 wetland is parched in the summer months but does contain a 0.5-hectare permanent pond near the southern edge of the wetland. During winter months, the permanent pond water depths are 3-4m while standing water in the main wetland is 0-2m. The wetland is primarily open water in winter months with vegetation around the perimeter. Dominant vegetation consists of reed canarygrass, ladysthumb (*Polygonum persicaria*), narrowleaf burreed, marsh cudweed (*Gnaphalium uliginosum*), slough sedge (*Carex obnupta*), and bentgrass (*Agrostis* sp.). Land use prior to restoration consisted of row crops and haying. Adjacent land management consists of haying and mowing.

Figure 4. Regulated wetland, R1, in early summer 2003 (partially drawndown), Chehalis floodplain (Rkm 27.4), Washington.

Figure 5. Regulated wetland, R2, in March 2003 with water flowing through the water control structure, Chehalis floodplain (Rkm 57.9), Washington.

Non-regulated wetlands

Non-regulated wetland, N1, is 3.2-hectares and has no water control structure (Figure 6). It is approximately 400m from R1 and connected to the same water body as R1. Hydrology inputs are precipitation and river flows. Riverine aquatic species have access to enter the wetland during high river flows that cause Metcalf slough to flood and connect the creek to the floodplain. Also during high river flows, N1 can be tidally influenced. The tidal influence coupled with high river flows increases the frequency of water connection between the river and wetland. There is no surface water outlet as water levels recede. Wetland water depths range from 0-1m and desiccation occurs in late spring. The wetland is dominated by reed canarygrass and surrounded by row crops (harvested corn). The site was chosen because of its proximity and similarity to R1 prior to restoration.

Non-regulated site, N2, is adjacent to R2 and connected to the same water body as R2 (Figure 7). This 7-hectare site has no water control structure. The hydrology is dependent on precipitation, adjacent surface water, and river floods. N2 wetland is connected to R2 during high water but has no outlet as water levels recede. Riverine species access this wetland during high water through R2. Wetland water depths range from 0-2m. In the winter and early spring the wetland is primarily open water containing reed canarygrass around the perimeter. Wetland water levels evaporate by early summer and emergent vegetation colonizes the open water areas. Vegetation consists of reed canarygrass, creeping spikerush (*Eleocharis palustris*), narrowleaf bureed, sedge (*Carex* sp.), and water-purslane. Surrounding land use consists of haying and a reed canarygrass wetland.

Figure 6. A fyke net deployed at a non-regulated wetland, N1, Chehalis floodplain (Rkm 27.4), Washington, 2003.

Figure 7. Non-regulated wetland, N2, in March 2003, Chehalis floodplain (Rkm 59.5), Washington, 2003

Alternative sites

The alternative site A1 is a remnant oxbow channel with permanent water (Figure 8). It connects to a no-name creek that flows into Metcalf slough. A1 is in the same creek drainage but upstream of N1 and R1. It is permanently connected to the creek by spring inputs and a beaver dam that retains water. This 3.8-hectare pond is 1-6m deep and contains woody vegetation. The dominant vegetation is yellow pond-lily (*Nuphar luteum*) and largeleaf pondweed (*Potamogeton amplifolius*). The perimeter of the oxbow contains reed canarygrass, willow (S*alix* sp.), spruce (*Picea sitchensis*), and Himalayan blackberry (*Rubus procerus*).

Alternative site A2 is a 3-hectare seasonal off-channel oxbow (Figures 9 and 10). It is at river kilometer 30 and near sites R2 and N2 (Figure 1). A2 contains a hydrologic connection to the river through the winter and spring months. The hydrology sources are river flows, precipitation, and surface water runoff from adjacent lands. Water depth is 2-4m and dependent on river water surface height. During winter and early spring there is water current in this channel. By late spring, A2 is parched and reed canarygrass dominates the previous open water areas. Surrounding land use is haying, and a reed canarygrass wetland.

Table 1. Physical characteristics of the six study sites in the lower Chehalis River, Washington, 2003.

Study site	River km	Winter area (ha)	Mean winter depth (m)	Wetland edge dominant vegetation	Seasonal wetland	Water source in order of dominance
R1	27.4	14.5	<2	reed canarygrass	Yes	rain,river
N1	27.4	3.2	<1	reed canarygrass	Yes	rain, river
R2	57.9	7.3	<3	reed canarygrass	Yes	rain, runoff, river
N2	59.5	1.2	<2.5	reed canarygrass	Yes	rain, runoff, river
A1	53.1	3	<2	reed canarygrass	Yes	river, rain, runoff
A2	30.6	3.8	<4	woody species	No	Spring, rain, river

Figure 8. Alternative wetland, A1, checking the out-migrant trap, April 2003, Chehalis floodplain (Rkm 53.1), Washington, 2003.

Figure 9. Alternative wetland, A2, in March 2003, during a flood event, Chehalis floodplain (Rkm 30.6), Washington.

Figure 10. Alternative wetland, A2, in April 2003, as water levels recede, Chehalis River floodplain (Rkm 30.6), Washington, 2003.

CHAPTER 4: METHODS

To address the objectives of the study (see Chapter 1, p.4), six wetlands were sampled: two regulated wetlands, two non-regulated wetlands, and two alternative wetlands. Fieldwork was conducted between January 2003 and June 2003 to encompass the peak outmigration of juvenile salmon and the occurrence of winter floods that provide wetland access for riverine fishes.

<u>Relative fish abundance</u>

Fish were sampled in the wetlands from January-May 2003 with the most intense sampling occurring in March and April, which directly proceeded flood events. Relative fish abundance was obtained using fyke nets and compared between the six study sites. Two types of fyke nets were used in the study sites: hoop nets and box traps. The five-ringed steel hoop net with two trapping throats was 4.5m long, 1.2m wide, and contained 4.76mm mesh. The box trap had a PVC frame that was 1.2m long, 0.6m wide, and contained 3.17mm mesh. Attached to fyke nets (hoop and box nets) was a 1.2m x 15m lead line to guide fish into the fyke net. The nets were set perpendicular to the shoreline, around the wetland perimeter, and each set was approximately 24-hours. Fish were counted and identified taxonomically using the criteria in Pollard et al. (1997) and Wydoski and Whitney (1979).

The number of fish captured in a fyke net set over 24-hours was defined as a catch per unit effort (CPUE). The CPUE estimates were averaged per month for each study site and compared between wetlands. A one-way analysis of variance (ANOV) was used to compare the relative fish abundance between wetland sites (Zar 1974). Data was log transformed ($\log_{10}$) to meet the normality assumptions of ANOV and to standardize the variances. Student-Newman-Keuls test (SNK) was calculated to determine where differences in fish abundance occurred between wetlands for each month sampled (Zar 1974, Ramsey and Schafer 2002). This multiple range test accommodated unequal sample sizes. Data was stratified by month and an $\propto$ value of 0.05 was used for statistical significance on all tests.

Fish migrating out of the wetlands were monitored at sites that contained a defined outlet. One-way out-migrant traps were installed downstream of study sites: R1, R2, A1, and A2 to capture out-migrating fish. The traps were in operation from 3/04/03 to 6/05/03 and checked daily. The out-migrant trap consisted of a 0.6m x 1.2m holding box that attached to wing nets. The wing nets blocked the channel and funneled fish into the box. Fish captured in the out-migrant traps were identified to species, measured, and juvenile coho salmon yearlings were weighed (Figures 11 and 12). Subsequently, fish were released downstream of the wetland to migrate to the river. Fish totals and salmon abundances were compared between regulated and alternative wetlands.

Figure 11. Measuring the fork length of a juvenile coho salmon, Chehalis River floodplain, Washington, 2003.

Fish community characteristics (richness, diversity) and selected population metrics (fork length, condition index)

Results from fish abundance sampling (fyke nets) were used to calculate species richness, species diversity, and the ratio of native to non-native fishes for each wetland. Species richness (S) was the total number of species captured for each wetland site. Two species diversity indices were calculated for each sampled site. The Shannon-Wiener and Simpson's indices combined the abundance and evenness of species in a community (Krebs 1989). A Shannon-Wiener index measures the amount of uncertainty in predicting the species of the next individual collected. It is sensitive to changes in rare species and defined as:

$$H' = \sum (P_i)(\log_2 P_i)$$

Where, H' is the log of the number of species of equal abundance. As the Shannon-Wiener measure increases, there is higher uncertainty and greater diversity. It usually ranges between 1.0 and 4.0 depending the number of species (Margalef 1972, Magurran 1988). The Simpson's index, more sensitive to changes in abundant species in a community, was calculated and defined as:

$$1- D = 1- \sum [n_i(n_i-1)/N(N-1)]$$

Where 1-D is the probability of picking two organisms at random that are the same species (Krebs 1989). Simpson's index ranges from 0 (low diversity) to about 1(1-1/s).

A Fulton condition factor (KFL) was calculated for coho salmon yearlings to compare the condition of coho salmon through the duration of the study and between wetlands (Murphy and Willis 1996). The KFL is useful for comparing length and weight in different individual fish of the same species. The heavier a fish is at a given length, the larger the factor and (by implication) the better the condition of the fish (Ricker 1975). It was calculated from the length and weight measurements using the formula:

$$KFL = (\text{weight x fork length}^{-3}) \times 10^5$$

The condition factor was used to compare the condition of coho salmon between sites and between months within the same wetland. A condition factor was not calculated for Olympic mudminnow (*Novumbra hubbsi*). The small size made it difficult to obtain an accurate weight measurement. Therefore, average fork length (FL) for this species was compared between study sites. Fork length (FL) was measured from the tip of the snout to the fork of the tail (Figure 12).

Figure 12. Measuring the fork length of Olympic mudminnow, Chehalis River floodplain, Washington, 2003.

Fish access in and out of wetlands

Surface water connectivity between seasonal wetlands and riverine habitat is essential if fishes are to access and utilize wetlands for rearing. The surface water connection between wetland and riverine habitats were separated into two categories: the duration riverine fish had access to wetlands and duration fish had to exit wetlands. Fish access into wetlands was during flood events when the river and floodplain were connected by surface water (i.e. sheetwater). Fish accessing the wetlands could not be sampled effectively due to the large flooded surface area. Instead, the frequency of time that fish had opportunity to access wetlands was estimated by determining the lowest point that water could enter the wetlands from a nearby channel and analyzing gage height records to predict the river height at which water could enter the wetlands. River gage height was determined from U.S. Geological Survey (USGS) instantaneous gage records (U.S. Department of the Interior 2004). Two USGS gages were used to obtain data in the vicinity of the study sites: Porter (12031000) and the Montesano (12035100) gage stations in the Chehalis River. The estimated frequency of surface water values was based on daily gage height values recorded every fifteen minutes from the Porter and Montesano gage stations. Field observations verified the time period and river gage height when the river and wetland habitats were hydrologically connected. Wetland elevations with recorded gage heights determined the frequency that fish could enter the wetland. Frequency of habitat access was determined from October 2002 to June 2003 when fish would likely access the wetlands for rearing.

Fish migrating out of the wetlands were monitored using one-way out-migrant traps. These traps were installed on study sites that contained a defined outlet: R1, R2, A1, and A2. Refer to methods section 1 - Relative fish abundance (p.16) for one-way out-migrant trap details.

Physical parameters

Wetland water temperature and dissolved oxygen concentrations were measured to evaluate the suitability of wetland water quality for fishes. Water temperature (°C) and dissolved oxygen (mg/l) concentrations were measured a minimum of once a week at each study site using a YSI 85 probe. This was a handheld measurement taken approximately 0.5 meters below the water surface.

Relative amphibian abundance and community characteristics (richness, diversity)

Presence and relative abundance of amphibians was determined using fyke nets and one-way out-migrant traps. The same study design used to collect fish abundance data was used to collect amphibian abundances. Amphibians captured were counted and identified taxonomically using the criteria in Leonard et al. (1993) and Corkran and Thoms (1996).

Relative amphibian abundance was calculated using catch per unit effort estimates that were averaged to obtain the mean abundance per month for each study site. Results from amphibian abundance sampling (fyke nets) were used to calculate species richness and species diversity indices. Refer to methods section 3 – Fish community characteristics (p.18) for diversity indices details.

As an alternate trapping method Gee's crayfish traps with funnel entries at both ends were used to catch adult frogs and salamanders. Traps were deployed in March and the beginning of April 2003 at each wetland for three days. Fifteen traps were set approximately 40m apart on the wetland perimeter with 60% to 70% of the trap submerged. Traps were checked every 24-hours.

CHAPTER 5: RESULTS

Relative fish abundance

Eighteen species representing ten families were captured from January-May 2003, a period when water levels were generally receding (Table 3). A total of 142,814 individual fish species were captured in the fyke net and out-migrant traps. The average catch per unit effort (CPUE) for each month of sampling was compared between six wetlands (Table 2). A one-way analysis of variance (ANOV) showed significant differences among wetlands in sampled months (Table 2). Subsequently, a Student Newman-Keuls test (SNK) was run to determine where those differences occurred between wetlands and showed no significant differences in January and March. In January, regulated sites (R1 & R2) had greater overall CPUE of fishes when compared to the other sites; however, high variance resulted in no significant difference. In March, regulated sites (R1 & R2) and a non-regulated site (N2) had a higher number of fishes compared to N1, A1, and A2; however, not significantly different. Three-spine stickleback (*Gasterosteus aculeatus*) and Olympic mudminnow were higher in abundance in these wetlands (R1, R2, and N2) compared to the other sites. In April, the SNK test showed significant differences in relative fish abundance between R1 and N1, R1 and A2, R1 and A1, and R1 and R2. Additionally, in April R1 and N2 had the highest abundance of Olympic mudminnow compared to the other sampled wetlands. There were significant differences in fish abundance between wetland pairs in May (Table 2). Regulated wetland, R1, had the highest abundance in May because of the spawned population of Olympic mudminnow and three-spine stickleback. Discrepancies in the results between statistical tests were related to the power of those analyzes to detect differences. The analysis of variance detected differences between means that the SNK test failed to detect in January and March. This indicates that the analysis of variance is a more powerful test than the multiple range comparison test (Zar 1974).

Table 2. Total fish species per trap night (CPUE) at two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington, 2003. ANOVA was completed for relative fish abundance between wetlands.

	January		March		April		May	
Site	mean	SE	mean	SE	mean	SE	mean	SE
R1	62.6	22.6	167.7	44.4	531	176.1	2409	620.9
R2	222	109.6	59.6	19.2	71.5	25.9	112.5	40.7
N1	34	17.8	13.6	7.3	16.5	13.5		
N2	29	25.4	61.8	22.9	317.8	128.3	340.7	34.6
A1	4.2	0.8	6.4	2	61.8	40.7	32.5	9.6
A2	2.5	2.2	3.6	1.4	33.6	14.8	307	86
ANOVA	F=3.7		F=5.03		F=2.96		F=25.23	
	p<0.025		P<0.0001		p<0.025		p<0.001	

Four species of salmonids were captured including coho salmon, Chinook salmon, chum salmon, and cutthroat trout (*Oncorhynchus clarki*; Table 4). Coho salmon young-of-the-year (YOY) and yearlings dominated the catch of salmonids at all sites. There was a significant difference in coho salmon yearlings between regulated and non-regulated wetlands (Table 5). No coho salmon yearlings were captured in non-regulated wetlands in any of the sampled months (Table 5). Coho salmon YOY were captured at all sites in April or May with fyke net traps (Table 5). At A2 wetland, salmon dominated the species composition in April and May (Table 7). Alternatively, few salmon were captured at A1 over all sampled months compared to the other sites (Tables 5 and 7).

Table 3. Summary of fish and amphibian species captured in the fyke nets combining all sampled months at two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington, 2003.

Species	R1	R2	N1	N2	A1	A2
bluegill	2	17	1	3	0	4
brown bullhead	2	31	0	0	4	0
Chinook salmon YOY	0	0	0	0	0	155
coho salmon yearling	105	13	0	0	4	165
coho salmon YOY	2	5	22	5	5	474
chum salmon YOY	0	0	9	0	0	1
unidentified sculpin	1	5	0	0	7	0
cutthrout trout	0	7	0	2	0	6
largescale sucker	6	21	0	7	7	2
Northern pikeminnow	1	142	0	33	10	1
Olympic mudminnow	10,413	116	9	964	22	2
Pacific lamprey	0	1	12	0	1	1
prickly sculpin	2	0	0	0	11	2
rock bass	0	0	0	0	0	1
redside shiner	1	5	0	0	2	1
reticulate sculpin	7	26	1	0	4	0
speckled dace	0	0	0	0	0	2
three-spine stickleback	6,299	2,968	297	2,525	606	3
yellow perch	1	1	0	0	2	1
warmouth	0	0	0	1	0	0
Northern red-legged frog	30	17	4	10	0	2
N. red-legged frog tadpole	1,115	1,437	0	5,446	0	1
long-toed salamander	7	2	17	10	0	7
Bullfrog	1	29	0	0	1	0
Bullfrog tadpole	1	88	0	0	0	0
rough-skinned newt	1,911	20	93	93	14	9
Northwestern salamander	122	13	45	45	0	2
treefrog	0	0	10	10	0	1

YOY- represents young-of-the-year

Table 4. One-way out-migrant trap data for March-June 2003 in regulated and alternative wetlands in the Chehalis River floodplain, Washington.

Site	R1	R2	A1	A2
# trap nights	68	68	63	31
total fish	102,513	12,094	401	1,798
coho yearlings	619	487	19	179
coho YOY	1,802	3,685	51	1,416
chum YOY	276	0	0	6
cutthroat	1	9	0	1
chinook YOY	1	14	0	111
amphibian	1,983	2,360	6	3

Table 5. CPUE of coho salmon yearlings and YOY captured in fyke nets at two regulated wetlands, two non-regulated wetlands, and two alternative wetlands, Chehalis River floodplain, Washington, 2003.

	January		March		April		May	
Site	yearling	YOY	yearling	YOY	yearling	YOY	yearling	YOY
R1	8	0	0.25	0	0.52	0.15	0	0
R2	0	0	0.47	0	0.85	0.31	0.5	0.25
N1	0	0	0	0.67	0	9	0	0
N2	0	0	0	0	0	0.5	0	0
A1	0	0	0	0	0	0	1	1.25
A2	2.25	0	0.5	0	12.22	3.78	17	61

Table 6. Total fish in the one-way out-migrant trap stratified by month from March-June 2003 in regulated and alternative wetlands, Chehalis River, Washington.

	R1	R2	A1	A2
March	7,495(14)	3,423(13)	47(9)	--
April	6,727(23)	2,303(23)	157(21)	736(18)
May	80,331(30)	4,648(30)	184(30)	1,062(13)
June	8,323(3)	1,720(3)	13(3)	--

() refers to number of effective sampling days. – refers to no data

One-way out-migrant traps were used to assess the abundance and timing of fish exiting wetlands that contained an outlet (R and A-sites). Abundances of fishes exiting wetlands were highest in the regulated areas averaging 1,507 fish/night at R1 and 175.3 fish/night at R2 wetland (Table 4). Overall, fish outmigration was highest in May compared to the other sampled months (Table 6). At the regulated sites, this was related to the emergence of YOY three-spine stickleback and YOY Olympic mudminnow. Relative to the number of trapping days, out-migrating salmon were highest in R2 (60.38 salmon/day) compared to A2 (55.26 salmon/day) and R1 (39.7 salmon/day; Table 7). Regulated wetland, R2, had the highest abundance of out-migrating salmon but a lower salmon density than A2. This was because R2 is more than twice the hectares of A2.

The fish assemblage at A2 differed from the other sites with juvenile coho and Chinook salmon dominating the catch (Table 3). Even though A2 had more salmon, the site had lower fish abundance and few three-spine stickleback and Olympic mudminnow.

None of the salmonids captured in the study sites had hatchery marks and were thus presumed to be wild. The hatchery-released fish in the Chehalis River are adipose clipped and juvenile coho salmon are released ca. 15 April each year. Hatchery fish do not usually have access to floodplain habitats at this time because high river flows that permit access usually occur earlier in the year.

Table 7. Total salmon captured in one-way out-migrant traps per month at two regulated wetlands and two alternative wetlands in the Chehalis River floodplain, Washington, 2003. The number in parenthesis is the percentage of salmon captured from the total fish catch.

	R1	R2	A1	A2
March	1,132 (15.1%)	186 (5.43%)	0	--
April	1,362 (20.2%)	1,374 (59.6%	14 (8.9%)	712 (96.7%)
May	205 (0.25%)	2,608 (56.11%)	10 (5.4%)	1,001 (94.3%)
Total	2,699	4,166	24	1,713
catch/day	39.7	60.38	0.38	55.26

<u>Fish community characteristics (richness, diversity) and selected fish population metrics (fork length, condition index)</u>

Olympic mudminnow and three-spine stickleback were the most abundant fishes at sampled sites with the exception of A2 (Figure 13). These taxa were particularly dominant in April and May when YOY emerged. Salmonids dominated the catch at A2 wetland (Figure 13). When comparing species richness (S) between wetland sites, A2 had the greatest species richness (S=15) compared to the other wetlands (Table 3 and Figure 14). Regulated wetlands had greater species richness (S=13&14) compared to non-regulated wetlands (S=7&8). Non-native species were greater in R1 and R2 (S=3&4) compared to N1 and N2 (S=1&2). Also, regulated wetlands had a higher ratio of native to non-native species per trap night (0.372 fish/trap, 0.5 fish/trap) compared to non-regulated wetlands (0.17 fish/trap, 0.33 fish/trap) and alternative sites (0.25 fish/trap, 0.25 fish/trap; Figure 14).

The Shannon-Wiener and Simpson's diversity indices were highest in March at N2, A1, and A2 wetlands (Table 8 and Figure 15). In wetlands R2 and N1, diversity indices increased through the sampled months while fish diversity at R1 decreased though the sampled months (Figure 15).

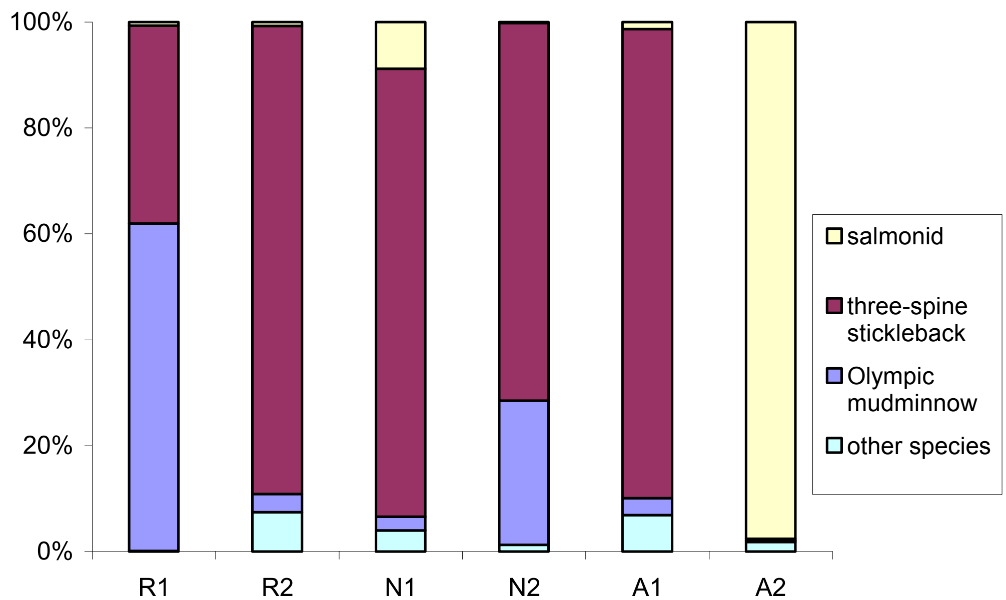

Figure 13. Proportional abundance of fishes for all months of fyke net sampling in two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington, 2003.

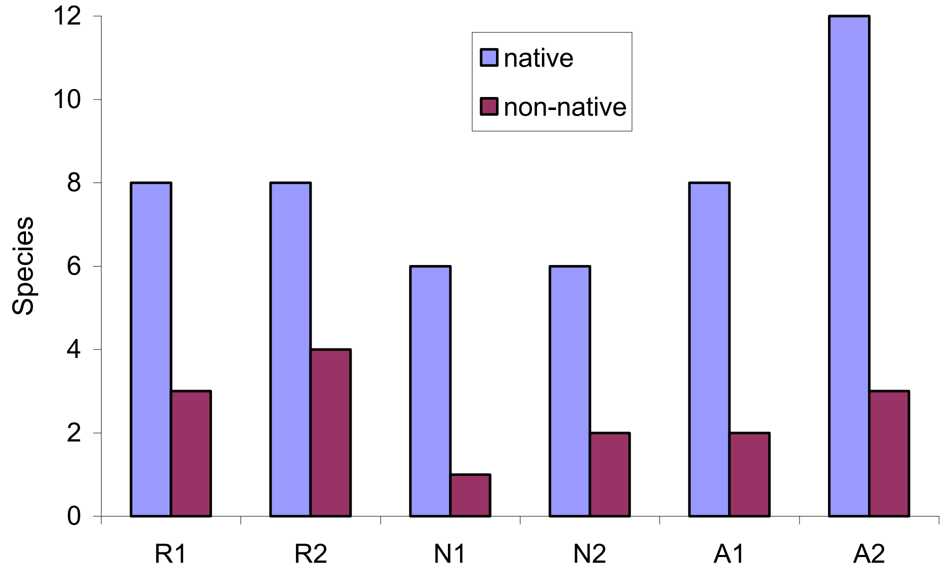

Figure 14. Native fish species compared to non-native fish species in two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington, 2003.

Table 8. Fish community characteristics including species richness, Shannon-Wiener index, and Simpson's index on two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington, 2003.

	January			March		
	Richness	Shannon	Simpson	Richness	Shannon	Simpson
R1	5	1.37	0.217	4	1.134	0.518
R2	6	0.233	0.0541	9	0.739	0.214
N1	3	0.411	0.137	5	0.713	0.214
N2	2	1	0.504	3	1.58	0.67
A1	5	1.61	0.581	5	1.842	0.66
A2	2	0.469	0.2	3	1.52	0.8
	April			May		
	Richness	Shannon	Simpson	Richness	Shannon	Simpson
R1	9	1.04	0.486	4	0.912	0.439
R2	11	0.921	0.241	9	1.33	0.434
N1	6	1.26	0.417			
N2	7	0.751	0.287	5	1.12	0.516
A1	9	0.695	0.181	6	0.554	0.148
A2	10	1.37	0.471	6	0.794	0.317

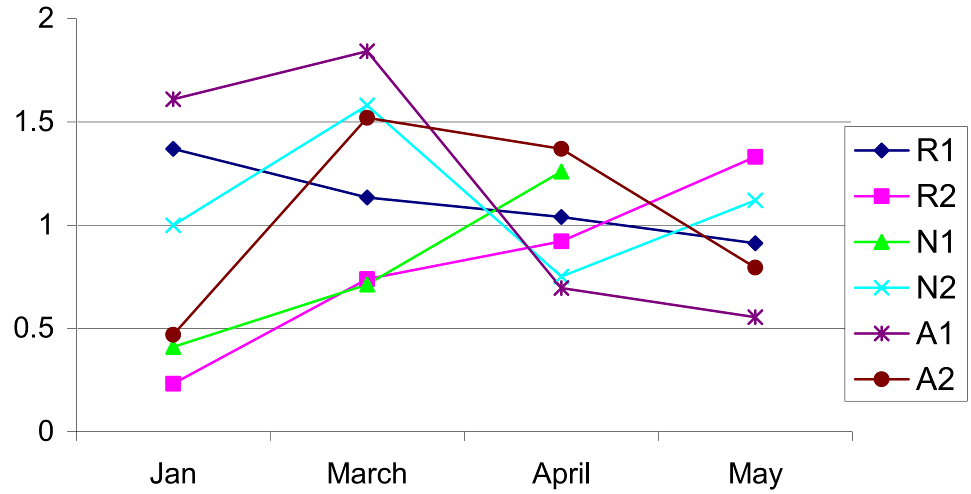

Figure 15. The Shannon-Wiener index for fish diversity at two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington, 2003.

The condition factor of coho salmon yearlings was calculated each month at R1, R2, and A2 (Figure 16). At A1, condition factor could not be calculated because few salmon were captured. The highest condition factor for coho salmon yearlings was observed at A2 in January, while the lowest condition factors were observed in May at A2 and R1 (Figure 16). In May, R2 wetland contained the highest condition factor compared to the other sampled sites. Olympic mudminnow average FL increased throughout the sampled months at R1, R2, and N2 wetlands. Also, these sites contained the highest abundances of Olympic mudminnow compared to the other sampled wetlands (Figure 17).

Fish species that utilized the regulated wetlands for spawning included: Olympic mudminnow, three-spine stickleback, redside shiner (*Richarsonius balteatus*), and Northern pikeminnow (*Esox lucius*). There was no evidence of these fish species spawning at N1, A1, or A2 sites.

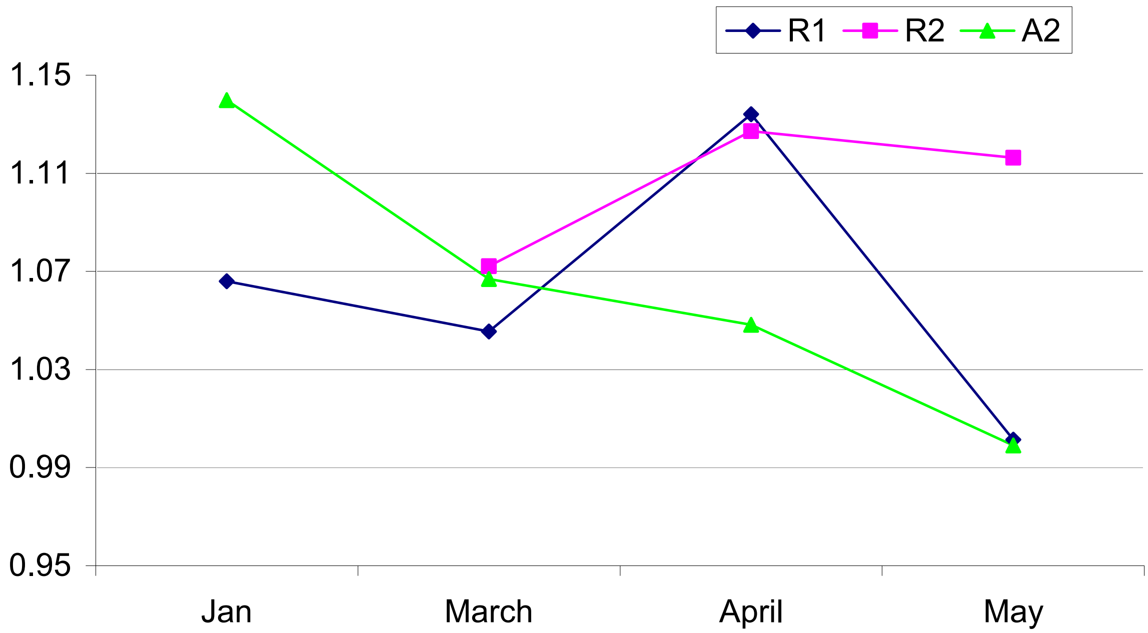

Figure 16. Fulton condition index for coho salmon yearlings each month at regulated wetland R1, regulated wetland R2, and alternative wetland A2, Chehalis River, Washington, 2003.

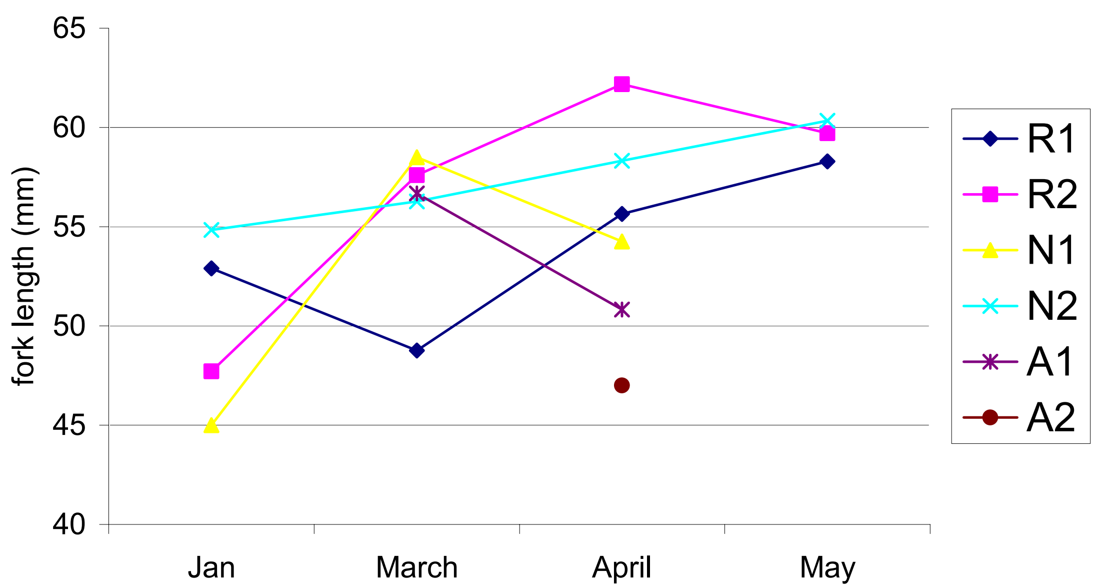

Figure 17. Average fork length of Olympic mudminnow at regulated wetlands, non-regulated wetlands, and alternative wetlands for each sampled month, Chehalis River, Washington, 2003.

<u>Fish access in and out of the wetland</u>

Connectivity of the floodplain with the river is essential if fish are to have access to seasonally flooded wetlands for rearing and refugia. The estimated frequency that riverine fishes could access wetlands was highest in the alternative sites. Fish had opportunity to access A1 100% of the sampling season while fish had opportunity to access A2 24% of the sampling season (65.5 days) between October and June 2003 (Figure 18). The frequency of water entering R1 and N1 from the slough was greater than the frequency of water entering R2 and N2. Fish could access R1 4.1 % of the time (~11 days) between October and June 2003 (Figure 19). During that same time period fish could access N1 1.1% of the time (~3 days; Figure 19) and R2 3.3% of the time (~9 days; Figure 18). In 2003, fish could not directly access N2 via the river but instead had to swim through R2 to access N2. The frequency of riverine fish access to N2 was while R2 was connected to the river (~9 days).

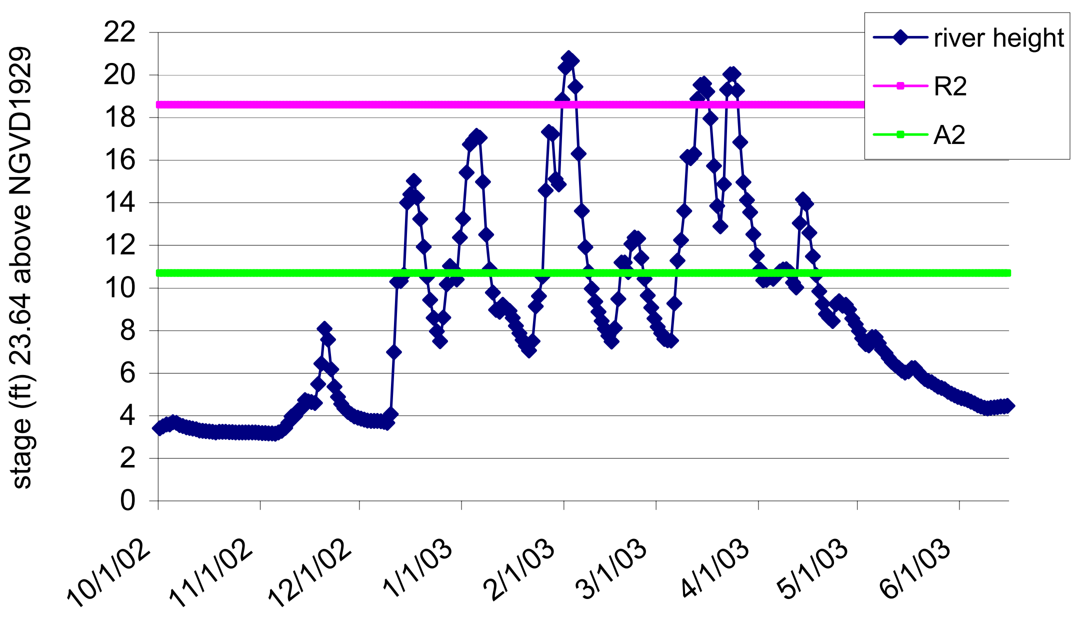

Figure 18. Maximum peak stage for the Chehalis River at Porter gage station, 1 October 2002 to 15 June 2003. R2 and A2 connect with the river at water surface elevation 18.6 and 10.7 NGVD1929.

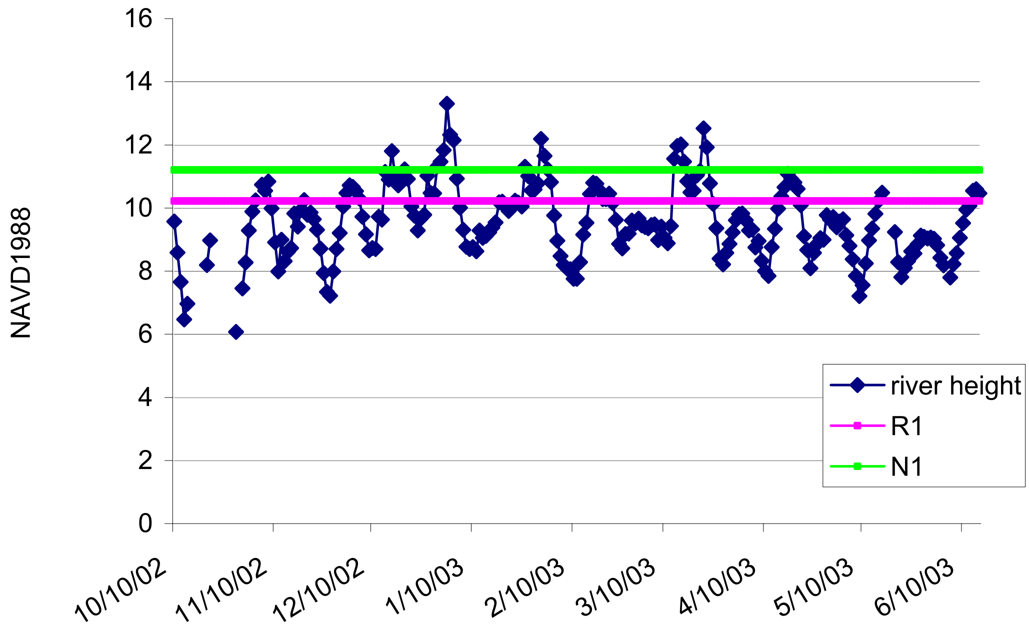

Figure 19. Maximum peak stage for the Chehalis River at Montesano gage station, 1 October 2002 to 15 June 2003. R1 and N1 connect with the river at water surface elevation 10.22 and 11.2 NAVD1988.

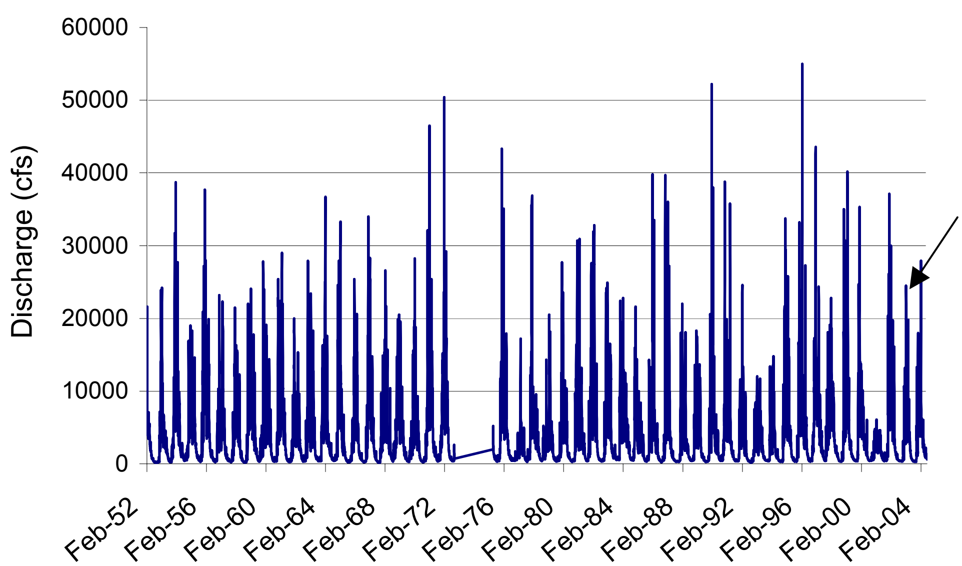

Figure 20. Average daily discharge (cubic feet per second) in the Chehalis River at Porter (gage 12031000) from February 1952 to June 2004. The arrow represents the discharge during the 2003 sampling period.

The 2003 river flows were compared with the historical average daily discharge from 1952 to 2003 for the Chehalis River at the Porter gage station (Figure 20). The 2003 sampling year had relatively average river flows compared to other years (Figure 20). Thus, the frequency of the river-floodplain connection during the sampling year was not unusual compared to previous years.

Frequency of wetland access for fish immigration and outmigration were similar in wetlands that did not have a water control structure. Alternatively, fish outmigration in regulated wetlands was longer in duration than fish immigration due to the water control structure. Salmon out-migrated at R2 until 9 June, while the last salmon out-migrated R1 on 18 May and at A2 on 13 May. Even though salmon outmigration declined in May at R1, there was continuous fish outmigration into June.

Outmigration timing varied between wetlands and age classes of coho salmon. Yearling coho salmon outmigration peaked earlier than YOY coho salmon at both regulated and alternative wetlands (Figures 21 and 22). At A2, coho salmon yearlings peaked on 28 April while YOY coho salmon peaked about two weeks later (Figure 27). At R2, yearling numbers were highest in March while YOY fish were captured starting the first week of April and numbers increased until the 27 May (Figure 26). At R1, many yearlings migrated out in early March compared to the YOY, which were not captured until the beginning of April (Figure 25).

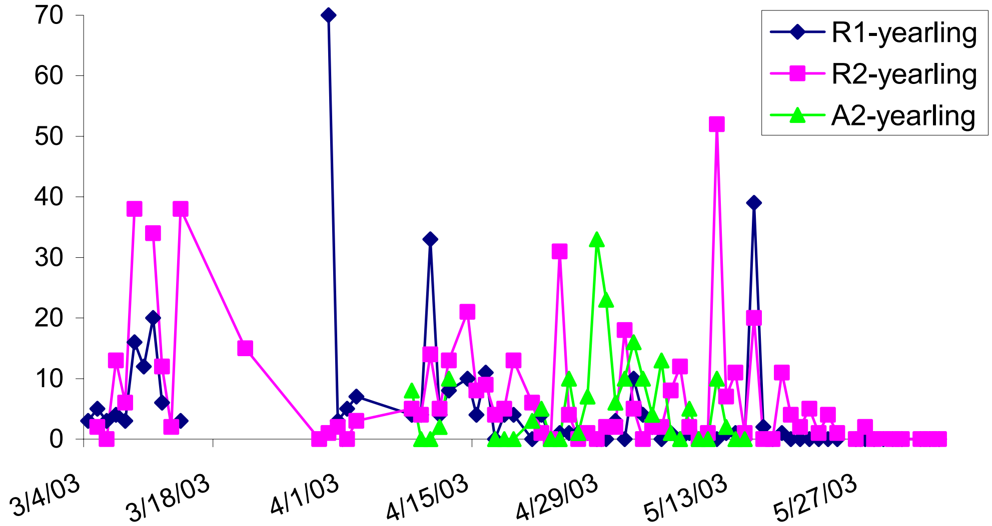

Figure 21. Outmigration timing of coho salmon yearlings in regulated wetland R1 and R2 and alternative wetland A2 from 03/04/03 through 6/04/03, Chehalis River, Washington. Note that A1 had nine coho salmon yearlings out-migrate over 2 days.

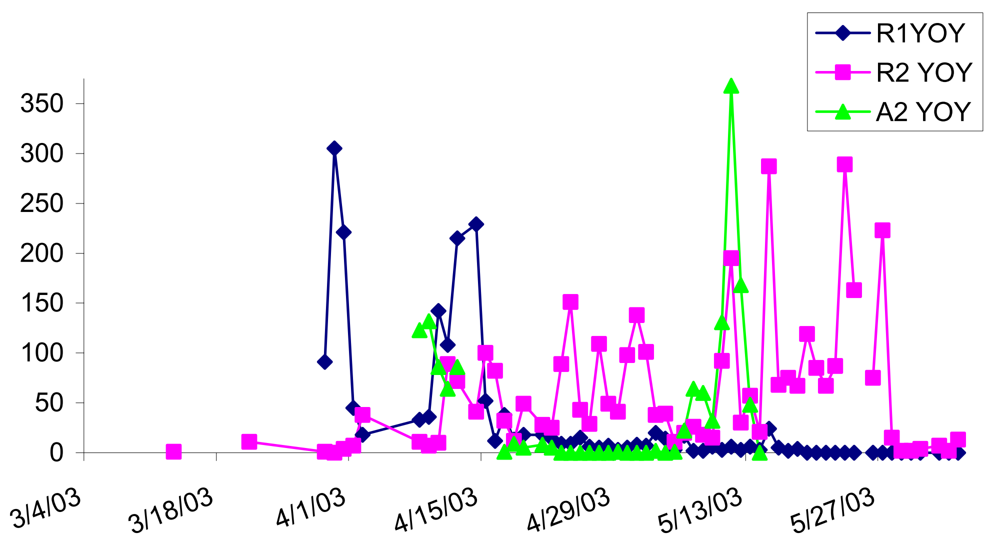

Figure 22. Outmigration timing of coho salmon YOY in regulated wetland R1 and R2 and alternative wetland A2 from 03/04/03 through 6/04/03, Chehalis River, Washington. Note: A1 had 40 YOY coho salmon out-migrate over six days but otherwise, had few salmon out-migrate.

Physical parameters

Water quality parameters were suitable for fishes until wetland water temperatures increased, dissolved oxygen concentrations decreased, and/or wetland water levels became low. Water temperatures ranged from 7ºC to 11ºC in March, 9-13ºC in April, and 10-22ºC in May (Figure 23). Dissolved oxygen concentrations (DO) ranged from 0-10mg/l and decreased throughout the sampled months (Figure 24). DO levels decreased prior to increased water temperature. The DO decreased earlier in the R and N-sites compared to the A-sites (Figure 24). R1 and N1 DO levels became low by the beginning of May. Wetland A1 had water quality suitable for fishes throughout the season.

The outmigration of coho salmon was related to DO levels at the regulated sites (Figures 25 and 26). At R1 in April, there was a decrease in DO levels from 6mg/l to <1mg/l. While DO levels decreased at R1, numbers of YOY and yearling coho salmon continued to out-migrate until 18 May (Figure 25). At R2, YOY coho salmon increased until 2 June when DO concentrations became low (Figure 26). Wetland outmigration of YOY and yearlings decreased as DO concentrations approached 2mg/l. Also, salmon outmigration numbers declined after a large negative change in DO levels. At R1, dissolved oxygen concentrations decreased by 3.33 mg/l in seven days to 2mg/l. Dissolved oxygen levels at R2 had a similar pattern decreasing by 4.11mg/l in 8 days to 1.34mg/l. Few salmon out-migrated after large declines in DO levels that coincided with DO concentrations below 2 mg/l.

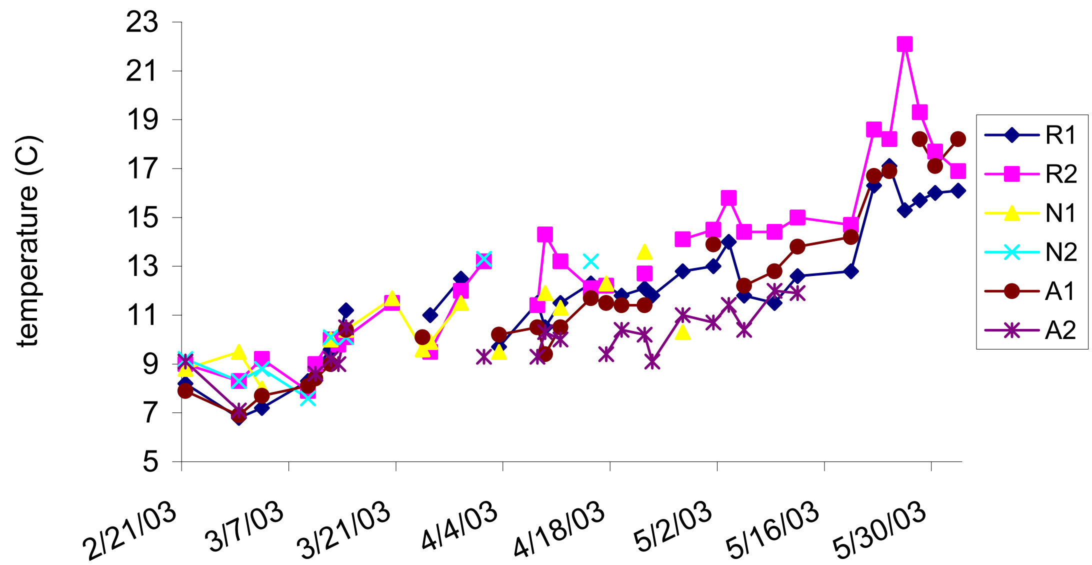

Figure 23. Water temperature (ºC) of two regulated wetlands, two non-regulated wetlands, and two alternative wetlands from 21 February 2003 through 2 June 2003, Chehalis River floodplain, Washington. Note that N1 and A2 were desiccated on May 2nd and May 15th, respectively.

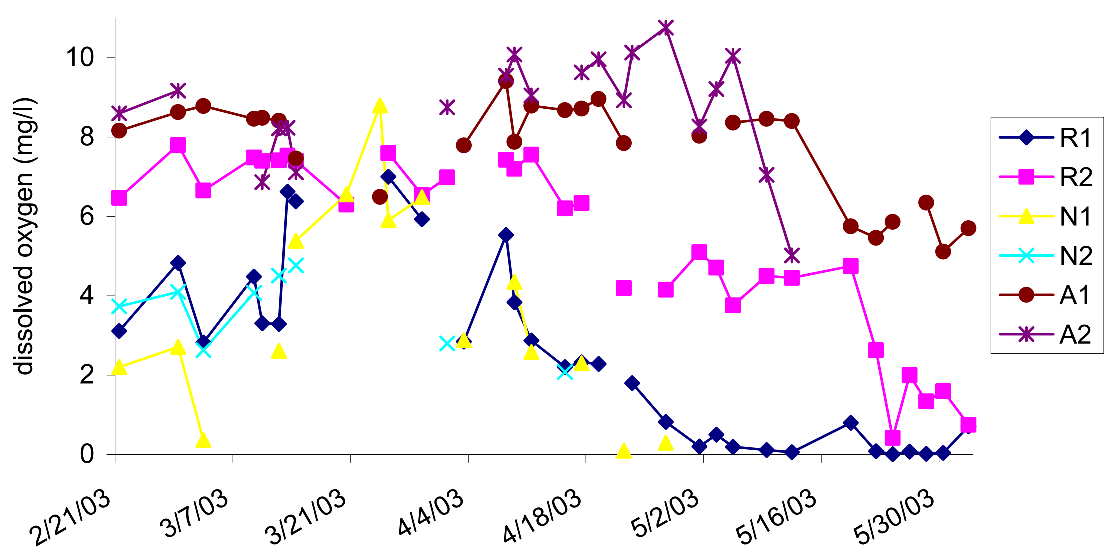

Figure 24. Dissolved oxygen concentrations (mg/l) of two regulated wetlands, two non-regulated wetlands, and two alternative wetlands from 21 February 2003 through 2 June 2003, Chehalis River floodplain, Washington. Note that N1 and A2 were desiccated on May 2nd and May 15th, respectively.

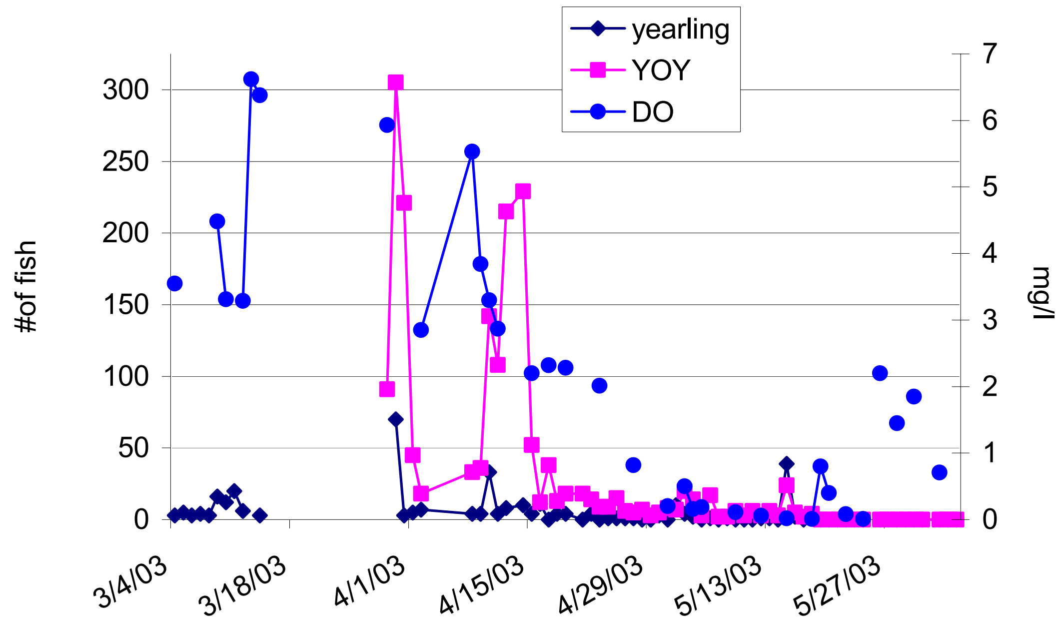

Figure 25. At the R1 wetland, the outmigration timing of coho salmon yearling and YOY are graphed with wetland dissolved oxygen concentrations between 4 March 2003 and 4 June 2003, Chehalis River floodplain, Washington.

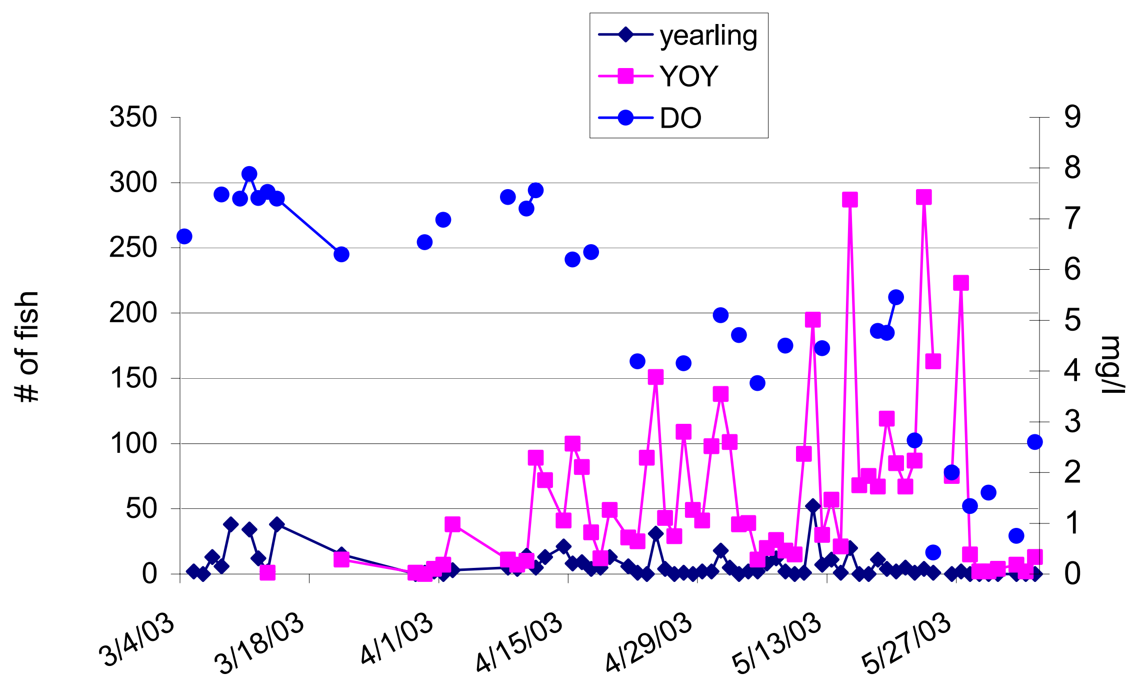

Figure 26. At the R2 wetland, the outmigration timing of coho salmon yearling and YOY are graphed with wetland dissolved oxygen concentrations between 4 March 2003 and 4 June 2003, Chehalis floodplain, Washington.

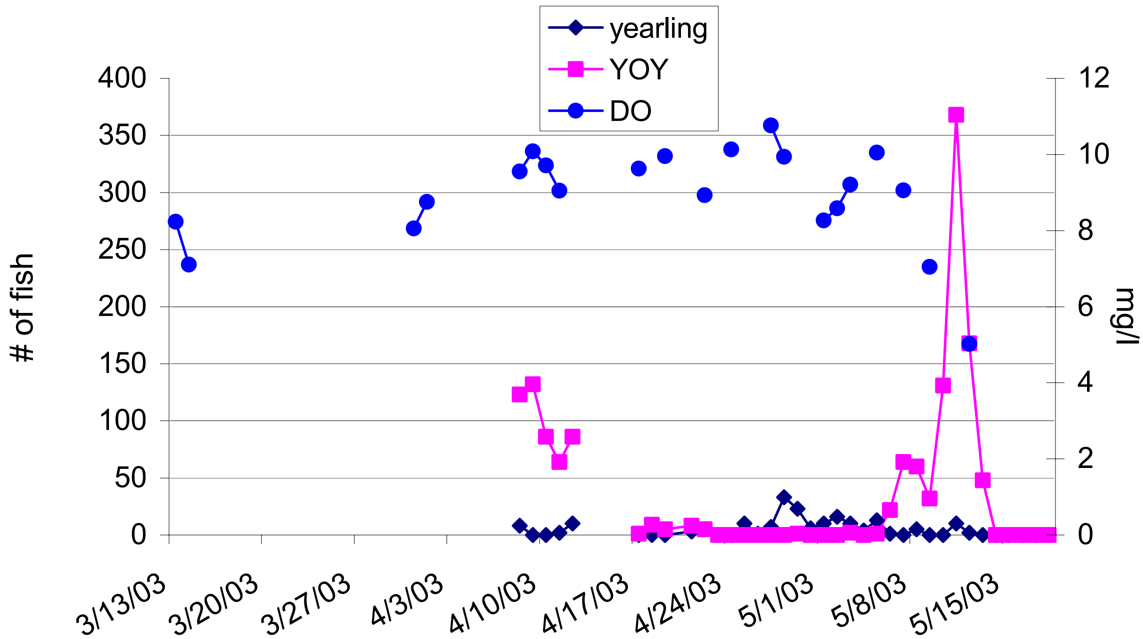

Figure 27. At the A2 wetland, the outmigration timing of coho salmon yearling and YOY are graphed with wetland dissolved oxygen concentrations between 13 March 2003 and 18 May 2003, Chehalis floodplain, Washington.

<u>Relative amphibian abundance and community characteristics (richness, diversity)</u>

Four amphibian families representing three salamanders species and three frog species were captured from January-May 2003 (Table 3). Adult Northern red-legged frog (*Rana aurora*) dominated the catch in January while Northern red-legged frog tadpoles dominated the catch in April and May (Figures 29, 31, and 32). In March, dominant species were rough-skinned newt (*Taricha granulosa*) and Northwestern salamander (*Ambystoma gracile*; Figure 30). Except for N1, Northwestern salamander was captured at all sampled sites. In May, wetlands R1, R2, and N2 had high abundances of Northern red-legged frog tadpoles (CPUE of up to 1,389 tadpoles; Figure 32). Also, R2 had the highest abundance of non-native bullfrog (*Rana catesbeiana*; adult and tadpole) compared to the other wetlands. There were few amphibians captured in the alternative sites and Northern red-legged frog breeding was negligible (Figure 28). Out-migrant data had similar results as the fyke nets sampling with regulated wetlands having significantly more amphibians than alternative sites ($p<0.0005$; Figure 28). Gee's crayfish traps had relatively low amphibian capture rate and were not used in the data analysis (Table 9).

Species richness was low (never > 4 native species) in all wetlands. The Shannon-Wiener diversity index was highest in the regulated and non-regulated wetlands compared to the alternative sites (Figure 33).

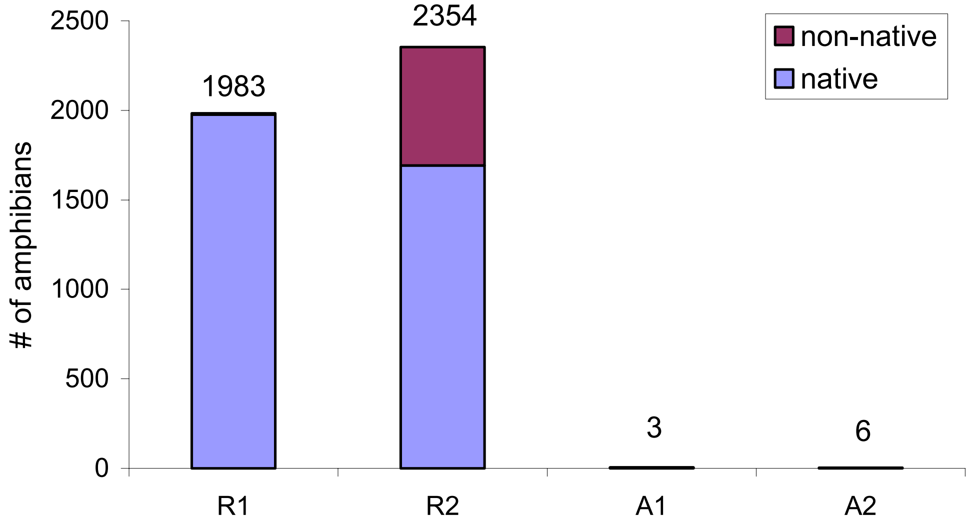

Figure 28. Total number of native and non-native amphibians captured in one-way out-migrant traps from March-May 2003 in two regulated wetlands and two alternative wetlands, Chehalis floodplain, Washington. Numbers above each bar represent the total amphibians captured at each site.

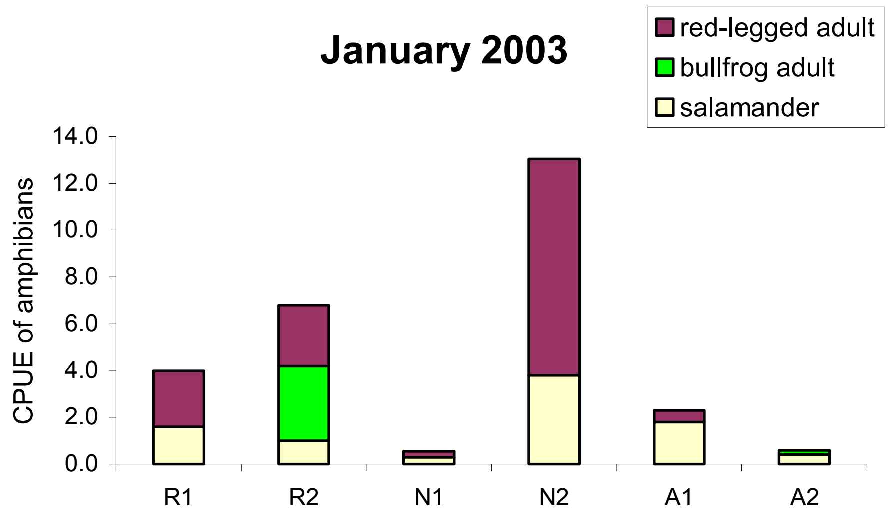

Figure 29. CPUE of amphibians using fyke net traps in January 2003 at two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington.

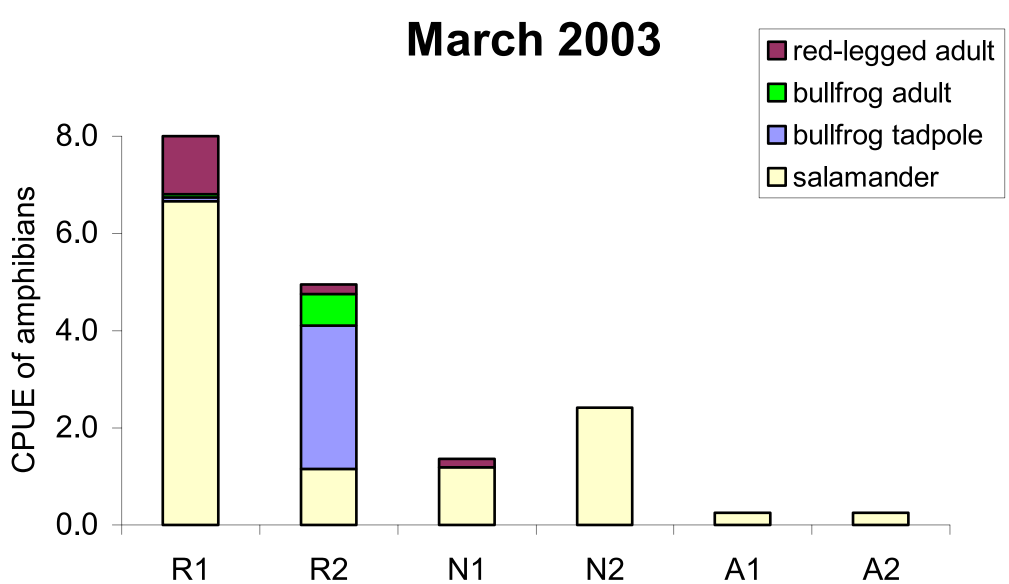

Figure 30. CPUE of amphibians using fyke net traps in March 2003 at two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington.

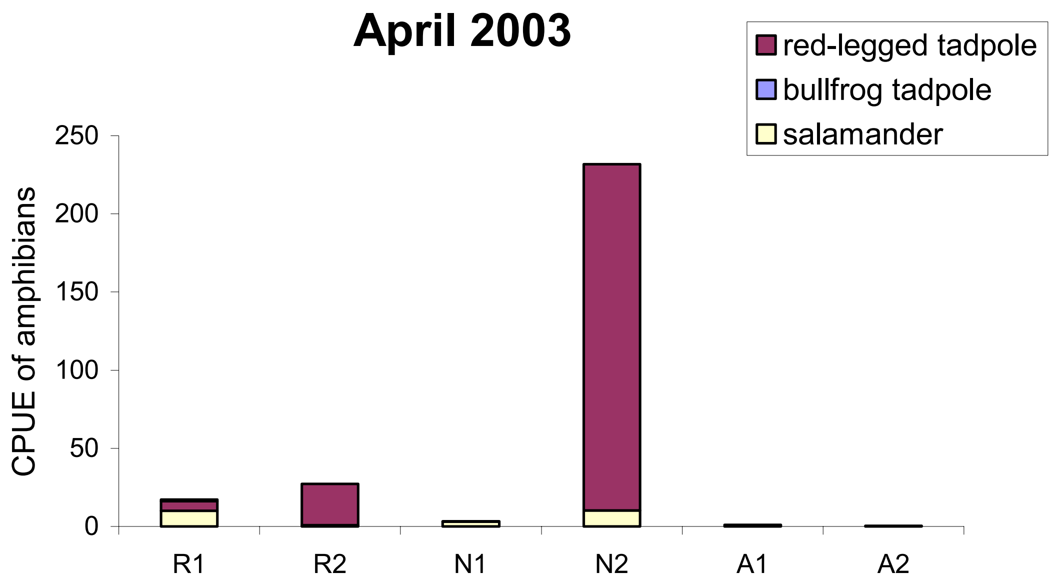

Figure 31. CPUE of amphibians using fyke net traps in April 2003 at two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington.

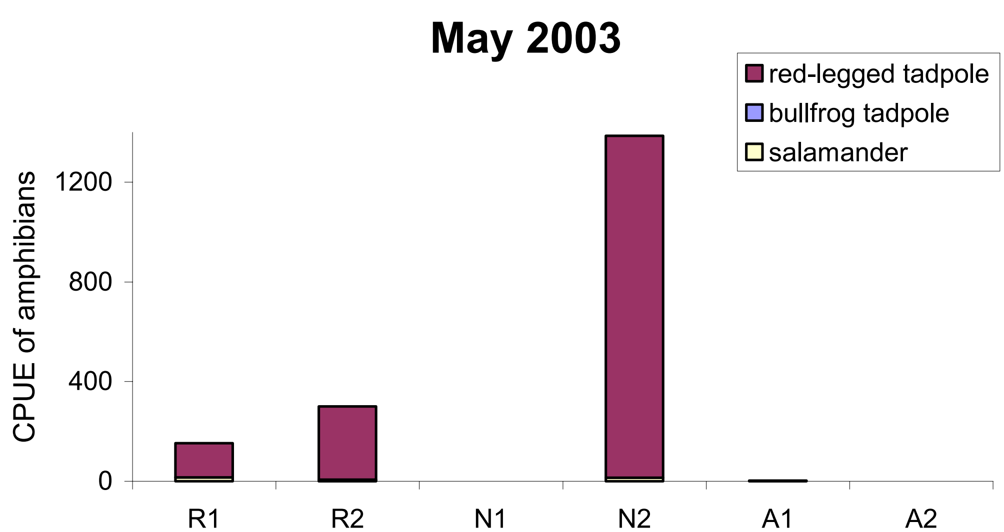

Figure 32. CPUE of amphibians using fyke net traps in May 2003 at two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington.

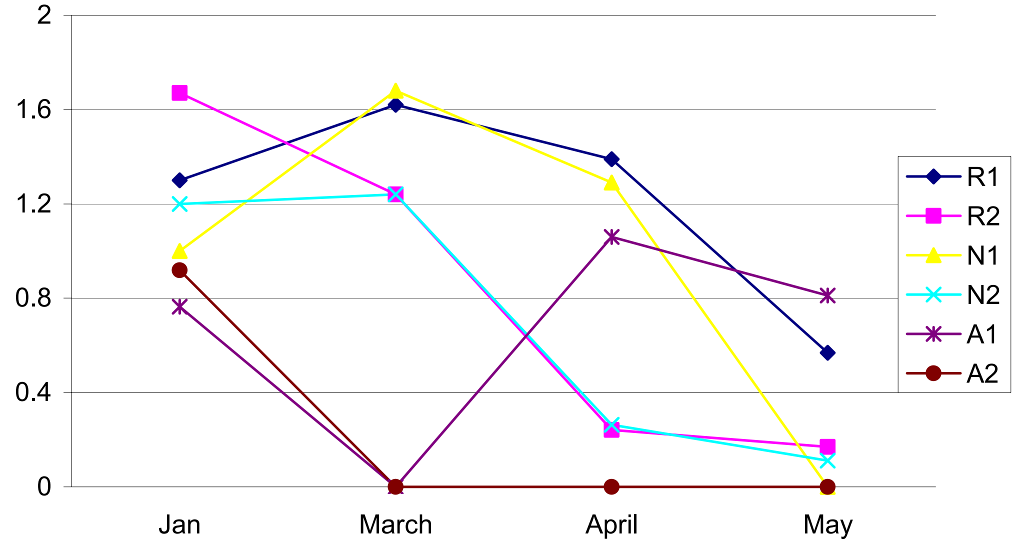

Figure 33. The Shannon-Wiener index for amphibian diversity in two regulated wetlands, two non-regulated wetlands, and two alternative wetlands in the Chehalis River floodplain, Washington, 2003.

Table 9. Total amphibians captured per day using Gee's crayfish traps for regulated, non-regulated, and alternative wetlands in the Chehalis River floodplain, Washington, 2003.

Site	date	#traps	#of amphibians
A1	2-Apr	12	1
A1	3-Apr	12	1
A1	4-Apr	12	1
A2	11-Mar	13	0
A2	12-Mar	15	1
A2	13-Mar	3	0
A2	1-Apr	10	0
N1	25-Mar	15	0
N1	26-Mar	15	0
N1	27-Mar	15	0
N1	4-Apr	12	1
N2	31-Mar	15	1
R1	9-Mar	15	1
R1	10-Mar	15	0
R1	28-Mar	15	0
R2	20-Mar	15	1
R2	21-Mar	15	3
R2	22-Mar	15	2

CHAPTER 6: DISCUSSION

The degree to which fish utilize seasonally flooded wetland habitats is not well understood and has been challenging to address in the Pacific Northwest and in other temperate river systems. This is due to the difficulty in sampling shallow vegetated areas, duration of hydroperiod (total days a pond is flooded annually), and the spatial and temporal variability of these dynamic floodplain habitats.

Fish abundance

The results of this study suggest high fish utilization in seasonally flooded habitats in the Chehalis River. Fish CPUE in regulated wetlands were more than 200 times the CPUE of juvenile salmon in off-channel ponds (Swales and Levings 1989). Overall fish use, including non-salmonid species, of off-channel areas has not been well documented. In late spring (April and May), floodplain wetlands appear to support higher abundances of fishes compared to winter months. This is related to the emergence of YOY fishes (i.e. three-spine stickleback and Olympic mudminnow), fish access to wetlands determined by flood timing and wetland elevation, and reduced water surface area caused by evaporation and outflow drainage, which concentrates the fishes. Less surface water created the appearance of increased fish abundance. In winter months, fish abundance was not significantly different between wetlands. This was related to variable fish abundances between fyke net catches. High variability between fish catches suggests fish are not evenly distributed in wetlands. Regulated wetlands, which are restored wetlands with water control structures are providing habitat for a diversity of fish and wildlife species. Fish diversity in the Chehalis wetlands may be greater than in overwintering habitats described by Scarlett and Cederholm (1984), Swales and Levings (1989), and Peterson and Reid (1984). These off-channel habitats, located in small tributaries of headwater streams, are dominated by juvenile coho salmon with few non-salmonid species documented. The results of this study suggest that restored wetlands are preferred habitat for some native non-game species such as Olympic mudminnow, three-spine stickleback, and many amphibians. Restored wetlands are supporting higher abundances of juvenile coho salmon than natural wetlands (non-regulated wetlands without water control structures).

Salmon are using restored areas but in lower numbers compared to off-channel habitats, such as A2. High densities of salmon rearing in off-channel sites have been documented throughout the fisheries literature (Bustard and Narver 1975; Brown and Hartman 1988; Swales and Levings 1989). These observations are probably due to duration fish have access to the habitat, water quality conditions (temperature and dissolved oxygen), water flow velocities, and hydroperiod. At the off-channel site A2, water depth and current were related to river flows. Also, due to the connectivity of the habitat to the river during winter months, the habitat had water quality similar to water quality conditions of the river. Even though the off-channel site had higher abundances of salmon compared to the other sampled wetlands, it had low abundances of non-game fish species such as Olympic mudminnow and three-spine stickleback. Few Olympic mudminnow were captured in the off-channel habitat, which probably related to the species low tolerance to water currents (Meldrim 1968).

The beaver pond, A1, had the appearance of sufficient salmon rearing habitat, however few salmon were captured. This was unexpected because the site had deep water, was connected to the creek annually, contained woody debris and a woody riparian, and had adequate water quality conditions. Also, this finding is inconsistent with other studies that reported the importance of beaver pond habitat for juvenile coho salmon (Sanner 1987; Leidholt-Bruner et al. 1992; Nickelson et al. 1992). These studies suggest that beaver ponds are important overwintering habitat for juvenile coho salmon. The discrepancies between the results of this study and what was predicted from the literature may be in the differences between beaver ponds, such as how they function and where they are located in a stream system. Most of the studies on coho salmon use of beaver ponds are located on small creeks and tributaries where dams are built in the stream channel. These dams maintain in-river pool depth, which has been shown to correlate with density of juvenile coho salmon (Nickelson et al. 1992). Also, these dams are frequently destroyed by high winter flows and re-built each summer (Leidholt-Bruner et al. 1992). In the Chehalis system, beaver dams are imbedded in the floodplain in relatively stable environments such as agricultural ditches and remnant oxbows. Dams are more permanent and usually damaged from beaver abandonment rather than high flows. Caution should be used in extrapolating the beaver pond literature results to larger river systems without understanding the context of the study. At A1, the causes for low salmon abundance is unknown, however, high predation and low food availability could be explanations. Largemouth bass (*Micropterus salmoides*) and brown bullhead (*Ameiurus nebulosus*) use the beaver pond and can prey on juvenile salmon. Also, minimal emergent vegetation is present, due to steep side slopes, thus failing to provide conditions suitable for invertebrate production. Invertebrates are more abundant in vegetated areas than non-vegetated areas and usually increase proportionately with plant biomass (Eldridge 1990). Also, invertebrate composition is dependent on vegetation structure and hydrologic regime of a wetland (Murkin et al. 1992). Lastly, few Olympic mudminnow were present in the beaver pond. Beecher and Fernau (1982) found that Olympic mudminnow were absent where non-native species were present in the Chehalis River Basin. They suggest that mudminnows may be excluded from the Chehalis drainage oxbows by non-native species. The present study results suggest that Olympic mudminnow prefer shallow emergent wetlands with muddy substrate, dense vegetation, and no visible current such as habitat characteristics in restored wetlands. Olympic mudminnow presence may be related to habitat preference rather than an affect of competitive exclusion.

<u>Physical parameters and fish community characteristics</u>

Survival of fish utilizing seasonal wetlands is dependent on movement to the river before water quality decreased and/or the wetland became isolated and stranding and desiccation occurred. Natural wetlands (non-regulated) became isolated earlier in the year (beginning of April) before water quality conditions declined. Fish captured in April and May in natural wetlands were stranded. By contrast, in restored wetlands water quality decreased (e.g. 0mg/l D.O. in June) before the wetlands became isolated. A rapid rise and fall of the river hydrograph may have little direct benefit to aquatic biota (Bayley 1991). Sudden drops in the hydrograph can leave fish stranded in isolated pools in the floodplain (King et al. 2003). In the present study, numbers of fishes, mostly three-spine stickleback and Olympic mudminnow were left stranded in natural wetlands. Restored wetlands, because they contain a defined outlet (i.e. water control structure) allow water levels to fall relatively slowly, increasing the flood land during a greater part of the year. This may be more advantageous for fishes to use the floodplain for spawning and rearing. Welcomme (1985) suggests that a larger flooded area integrated through the year may produce more fish.

In restored wetlands, fish survival was related to out-migrating from wetlands before water temperature and dissolved oxygen levels became limiting. Water temperatures did not reach lethal limits of 25ºC (Brett 1952) during the study in any sampled wetland. However, wetlands did exceed preferred coho salmon rearing water temperatures of 12-14ºC (Brett 1952). Dissolved oxygen concentrations, which were at lethal fish levels in June, became more of a limiting factor for fish than temperature. McKinnon (1997) suggests that lengthy inundation of floodplain habitats often result in poor water quality conditions such as low dissolved oxygen levels (i.e. anoxia). Limited dissolved oxygen is expected in wetlands because soils are flooded long enough to develop anaerobic conditions and oxygen becomes depleted (Mitsch and Gosselink 1993). Therefore, in wetland environments it would be advantageous for fish to tolerate or avoid adverse water quality conditions (King et al. 2003). Low dissolved oxygen concentrations has been shown to limit activity and growth in some fish (Brett 1979). Experiments on Olympic mudminnow demonstrate that this species can tolerate low dissolved oxygen levels (0.18mg/l; Meldrim 1968). For other native species there is insufficient information to determine whether adaptations to poor water quality or avoidance have occurred. Juvenile coho salmon can tolerate dissolved oxygen concentrations as low as 2 mg/l but show reduced consumption and weight loss (Colt et al. 1979). The declining DO concentrations in wetlands may trigger a volitional fish outmigration response (Henning, in prep 2004). Patterns of movement from this study suggest high salmon outmigration occurred with large negative changes in dissolved oxygen concentrations coinciding with DO levels below 2 mg/l.

As DO levels decreased in May, the condition factor of yearling coho salmon also decreased from the previous month. The decreased salmon condition factor in May is probably related, at least in part, to decreased water quality conditions. Fish bioenergetics models suggest that feeding must be sufficient to offset increased metabolic requirements from higher water temperatures or other stressors in the environment (Sommer et al. 2001). In April, yearling coho salmon at restored wetlands had the highest condition index compared to other sampled months. This could be related to high temperatures that increase invertebrate production and enhance prey availability while water quality was sufficient to not harm fish performance. Zooplankton biomass has been shown to positively correlate with temperature (Thorp et al. 1994). Sommer et al. (2001) found that the Yolo Bypass floodplain had significantly higher temperatures and juvenile salmon ate significantly more prey than the main river. Faster growth rates reflect enhanced habitat conditions and can lead to improved river and ocean survival. On the other hand, salmon at the off-channel site had the highest condition factor in January and the condition factor decreased every month there after. The off-channel site may have low food availability or salmon may be using this habitat differently (i.e. refugia from mainstem for short duration 1-2 days). Further sampling is needed to understand juvenile salmon use of floodplain wetlands and trade-offs between longer residence in the wetland for higher growth and future survival while risking mortality in a less predictable habitat (i.e. stranding or low water quality).

Fish diversity indices in floodplain wetlands were relatively low compared to relative Shannon-Wiener index values, which usually range from 1.5 and 3.5 (Margalef 1972). Species richness was similar to other temperate floodplain studies (Baber et al. 2002; King et al. 2003), but much lower than fish assemblages sampled in the Amazonian floodplain, which can exceed 90 species (Petry et. al 2003 and Silvano et al. 2000). The number of species inhabiting a system is largely a function of the size of the river or some correlation of basin area, which influences the number of ecological niches (Welcomme 1979).

Junk et al. (1989) suggests that for species to gain maximum benefit of the floodplain for recruitment, the spawning period should occur during years in which the floods and high temperatures are coupled. On the contrary, recruitment is poor if flooding occurs to soon before the warm growing season (Junk et al. 1989). The Chehalis River may not follow this coupling affect described in the flood pulse concept because the highest mean flows occur in winter and early spring as rain-fed floods, where as the highest water temperatures generally occur 4-6 months later in the summer. The Ovens River in Australia had similar decoupling results (King et al. 2003). They suggest that the flood pulse concept is too simplistic to describe fish recruitment within a system. Instead, fish adaptations to the river system and aspects of the hydrological regime such as duration and timing of floods control responses of the river's fish fauna to flooding. In the present study, fish spawning could be dependent on temperatures rather than flood timing however, recruitment of fishes to the floodplain could be dependent on flood timing, especially for YOY coho salmon that emerge from the gravels in early spring. If flood timing only occurs in winter before YOY coho salmon emergence, YOY will not have opportunity to access the floodplain for rearing that season.

Fish access in and out of wetlands

Riverine species recruitment to floodplain wetlands may be related to the frequency and duration of surface water connection between the habitat and riverine environment. High fish abundance did not seem to be related to the frequency of wetland access. This is due to the dominance of three-spine stickleback and Olympic mudminnow, which seem to prefer emergent wetlands. However, salmon abundance in floodplain habitats may be related to habitat connectivity. Off-channels that are frequently connected and recharged with riverine water conditions provide alternate rearing habitat for coho salmon compared to the river or other floodplain wetlands that are temporarily flooded. Bustard and Narver (1975) found that during winter, juvenile salmon used sidepools or alcoves, which are on the channel margin protected by the stream bank. Also, coho salmon were the dominant species in the Clearwater River ponds and Coldwater River off-channel ponds (Cederholm and Scarlett 1981; Swales and Levings 1989). In these studies, ponds were more similar to stream habitat characteristics than seasonal emergent wetlands.

There may be temporal differences in utilization of wetlands by YOY and yearling coho salmon. The number of yearling coho salmon out-migrants peaked earlier than YOY coho salmon at both restored sites. This appears to be related to timing of YOY emergence and life history requirements of yearling coho salmon. Coho salmon have the opportunity to access floodplain habitat in the spring after emerging from the gravels, which occurs in late February. Therefore, it would not be expected to capture YOY until March, if flooding occurs. Alternatively, yearlings have already spent a year in the riverine system and have to begin migrating to the ocean. Also, the temporal outmigration differences in the two age classes of coho salmon may be related to differences in dissolved oxygen requirements

(Henning, in prep 2004). Yearlings, because of their size and vulnerability while enduring smoltification, are possibly less tolerant to low dissolved oxygen conditions compared to YOY coho salmon.

Floodplain wetlands as fish habitat

There is a paucity of studies on fish use of floodplain wetlands. Thus, aquatic habitats in the floodplain have not been extensively defined. As floodplain habitats are managed and conserved it is crucial that land managers and scientists are careful with the use of floodplain terminology to avoid misinterpreted information. For example, results of studies in small coastal streams with in-stream beaver blockages have been inferred to large river-floodplain systems suggesting that all beaver ponds are important salmon rearing habitat. Salmon overwintering areas have been extensively studied in small headwater coastal streams and include habitats such as: side-channels, alcoves, beaver ponds and tributaries (Appendix F). Many of these off-channel habitats contain groundwater and function as a flow-through system with connection to a stream. These overwinter habitats can vary between systems especially when compared to large river-floodplains. Also, off-channel areas created by the river (i.e. side-channel) can be vastly different than habitats containing emergent wetland characteristics and thus, have differing fish utilization results. The extrapolation of data to emergent floodplain wetlands has created an assumption that floodplain wetlands (because its considered to be off-channel) are important overwintering habitat for juvenile coho salmon. Emergent wetlands provide higher productivity than side-channels because they contain emergent vegetation, stagnant water, and have high decomposition rates. However, emergent wetlands usually are not connected to a stream and thus have lower water quality compared to side-channels.

Floodplain habitats in large temperate systems are diverse and represent different characteristics in the landscape, particularly for fish use. Part of the confusion with defining floodplain habitats may lie in the overlap in fisheries and wetland disciplines. Neither profession has extensively focused on river-floodplains related to fishes in temperate systems. Floodplain wetlands have per se ‘slipped through the cracks’. In the Northwest, fish biologists have mostly focused on habitats related to in-stream riverine processes while wetland professionals have focused more on wetland characteristics such as nutrient cycling, soils, vegetation, and water chemistry. Aquatic habitats in the floodplain are dynamic. The difficulty in defining these habitat types are related the development of the floodplain through geomorphic processes that create habitat heterogeneity in a floodplain. The characteristic stages in the life cycle of floodplain habitats can exist in a river meander that is cut off and forms an oxbow lake. Over time that oxbow lake fills in with sediment from river floods and forms a wetland (Appendix G). Wetland formation can be a function of flooding regimen, soils, and vegetation. The wetland can transition into upland or reverse to a river channel depending on river movement and flooding. This dynamic spatial and temporal process forming and creating heterogeneity among the river-floodplain is crucial for the ecology of the system. But, it does make floodplain habitats difficult to categorize into habitat types.

Many classification systems have been developed for wetlands and two that are widely used include Cowardin et al. (1979) and Brinson (1993). These classification systems lack the resolution to distinguish among many wetland types that are commonly used in a geographic region (Brinson 1993). Aquatic habitats in the floodplain are formed from geomorphic and riverine processes. Thus for fishery associations, a classification system is needed that combines both riverine and wetland characteristics and is specific enough to encompass a geographic region or basin. Defining floodplain habitats rather than categorizing may prove an alternate option for better understanding aquatic habitats in the floodplain.

<u>Amphibians</u>

Many amphibian species depend on both terrestrial and aquatic habitats for their life cycle (Morand and Joly 1995). Seasonal wetlands are critical breeding habitats for many salamander and frog species. Except for N1, restored and natural wetlands had the highest abundance of adult frog and salamander species. These wetlands also contained the highest abundance of tadpoles. Important controlling factors affecting amphibian breeding in a wetland are hydroperiod, stillwater (no significant flow visible), and emergent vegetation. Hydroperiod is important for determining if tadpoles are able to metamorphose in a short hydroperiod (Rowe and Dunson 1995) and determining the composition of predators in a long hydroperiod (Babbitt and Tanner 2000). Emergent vegetation is important for cover, increases food availability, and is crucial in egg mass attachment for some amphibians. The natural wetland N1 and off-channel site A2, contained low amphibian abundances that may be explained by short-water duration (hydroperiod) and low diversity of emergent vegetation. Both sites were dominated by reed canarygrass, which supports a poor insect prey base (Hayes, personal comm. 2004). Also, the off-channel site had fluctuating wetland water levels and currents caused by river flooding during the breeding season. Northern red-legged frogs breed in stillwater habitat with emergent vegetation to which they attach their egg masses. Water current can affect their egg mass attachment. Low amphibian abundance in the beaver pond (A1) could be explained by permanent water, which is suggested to correlate with fish predation (Morand and Joly 1995) and minimal emergent vegetation. Fish predators, such as warmwater species, can dominate permanent ponds; however, wetlands that have an annual cycle of filling and drying, such as restored wetlands that have a summer draw down, generally prevent fish populations from becoming permanently established (Babbitt and Tanner 2000). In restored wetlands, high abundances of Northwestern salamander were captured. These habitats had long hydroperiod (>8 months) but dry in summer months. The embryos of Northwestern salamander develop slowly and embryonic development to hatching requires six to eight weeks. Additionally, Northwestern salamanders usually spend one full year as larvae before metamorphosing into the terrestrial form (Leonard et al. 1993). Alternatively, long-toed salamander (*Ambystoma macrodactylum*) is the earliest salamander to breed in Washington, and embryos have exceptional rates of development (e.g. approximately two weeks; Leonard et al. 1993). Long-toed salamanders were captured in relatively high abundances in the natural wetland N1, which contained the shortest hydroperiod compared to the other sampled wetlands. Thus, it is evident that salamander habitat requirements are species specific and hydroperiod is a variable of considerable importance (Rowe and Dunson 1995).

The bullfrog has been associated with declines of Northern red-legged frog and other amphibians in much of western North America (Hayes and Jennings 1986; Kiesecker and Blaustein 1998). In this study, Northern red-legged frog was captured in wetlands that did contain bullfrog with the exception of the beaver pond. This suggests that these species are co-occurring. Adams (1999) suggests that red-legged frog presence is more closely associated with habitat structure and non-native fish than the presence of bullfrog. The increase in exotics is correlated with a shift toward habitats with greater water permanence (Adams 1999). Non-native fishes and bullfrogs occur in permanent waters and may exclude some native amphibians from permanent wetlands (Hayes and Jennings 1986). Restored and natural wetlands were better amphibian habitat than the beaver pond and off-channel habitat. Conservation efforts for native amphibian populations should focus on more ephemeral wetlands, with longer hydroperiod but dries in late summer, and emergent vegetation, which will directly benefit natives and reduce non-native fish and bullfrog habitat (Adams 1999).

Fyke nets were successful in capturing frog and salamander species and obtaining a relative abundance to compare between wetlands. Gee's crayfish traps were not as successful at capturing amphibians compared to the fyke nets. This could be related to the fyke net having a larger trapping area compared to the Gee's crayfish trap. Gee's crayfish traps were not set consecutively between sites due to rising water levels. Thus, a CPUE comparison between sites was not completed because of variable sampling periods.

Conclusion

Human influence has degraded watersheds and impacted wetlands creating the need for restoration. Restoring wetlands using water control structures can enhance the hydrology of degraded systems and provide conditions to allow the control of reed canarygrass, the germination and colonization of native wetland vegetation, and the increase of primary and secondary productivity. Wetland restoration projects in the Chehalis River floodplain maintain wetland habitat and provide wetted habitat for a longer duration than currently exists on the floodplain. They provide rearing habitat for numerous fishes, including coho salmon, and provide breeding habitat for amphibians. Modifications of the floodplain (i.e. ditching) may have the greatest effect on non-game fishes that depend on wetlands for the majority of their life cycle. Seasonally flooded wetlands with water control structures allow fish to rear longer or spawn and still out-migrate after river water levels have receded. Fish survival is dependent on exiting restored wetlands before water quality conditions become harmful to species not adapted to anoxia of emergent wetlands or can not aestivate during dry months.

This study suggests high fish utilization of floodplain wetlands, which the author is not aware of being documented in the Pacific Northwest. Fish abundance is not significantly different between restored and natural wetlands. Salmon are utilizing floodplain wetlands, including two-age classes of juvenile coho salmon. Coho salmon yearling abundance is significantly higher in restored wetlands compared to natural wetlands. Salmon are in higher abundances in the side-channel habitat compared to the seasonal wetlands (restored and natural wetlands). Seasonal wetlands may be critical habitat for many non-game species such as Olympic mudminnow, a State Candidate species, which is spawning in these habitats. Also, amphibian use is highest in seasonal wetlands compared to the off-channel and beaver pond habitat.

There is a wide range of aquatic habitats in the floodplain that contain a diversity of habitat characteristics (e.g. water permanence, vegetation, and river connectivity). Those characteristics can change the results of fish and amphibian presence. Lastly, dissolved oxygen is an important driver for fish use in floodplain wetlands. This parameter becomes an important limiting factor for year round fish rearing.

The results provide insight into the potential consequences and benefits to fish populations utilizing wetlands with and without water control structures, off-channel habitats, and beaver ponds in the Chehalis agricultural landscape. Knowledge of fish utilization of wetland habitat can assist land managers, fish and wildlife biologists, and restoration ecologists to better manage agricultural floodplains and rehabilitate wetlands. This study suggests that floodplain wetlands function differently and provide a diversity of biological responses such as fish rearing and amphibian breeding. The combination of off-channels, oxbows, beaver ponds, seasonal wetlands, and restored habitats are supporting a diversity of fish and wildlife species and floodplain management should focus on maintaining this habitat complexity.

Habitat managers can increase wetland habitats by working with landowners to restore parcels that offer the highest potential for wetland restoration (i.e. hydric soils, water recharge). Agricultural areas that have wet conditions, marginalizing farm productivity, are good candidates for restoration. Resource managers can provide information to landowners to enroll in conservation incentive programs such as the Wetland Reserve Program of the U.S. Department of Agriculture that protect and restore wetland habitats.

Future studies on juvenile salmon growth rate, residence, and in-wetland survival would increase our understanding of the role of floodplain habitats for salmon populations. Until additional research is completed it is premature to say the benefits of floodplain emergent wetlands for salmon and whether it is advantageous for salmon to utilize restored wetland habitats. Complimentary research is continuing with investigations focusing on juvenile coho salmon use of restored wetlands in floodplains. This research will explore the performance of juvenile salmon by examining their growth and residence time in restored wetlands. The 2-year data set will contribute to our understanding of fish use of wetlands and provide a template to answer more detailed questions in future research studies.

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APPENDICES A-G

Appendix A. 2003 out-migrant trap data for regulated and alternative wetlands. Data includes daily fish totals, coho salmon yearling and YOY totals, and other salmonids captured.

OUT-MIGRANT TRAP TOTAL

DATE	R1 total fish	R1 coho smolt	R1 coho YOY	R1 chum YOY	R1 cutthroat	R1 chinook YOY	R2 total fish	R2 coho smolt	R2 coho YOY	R2 cutthroat	R2 chinook YOY
3/4/03	303	3	0	0	0	0					
3/5/03	60	5	0	0	0	0	759	2	0	1	0
3/6/03	13	3	0	0	0	0	654	0	0	0	0
3/7/03	567	4	0	0	0	0	633	13	0	0	0
3/8/03	421	3	0	0	0	0	95	6	0	0	0
3/9/03	255	16	0	0	0	0	308	38	0	0	0
3/10/03	841	12	0	0	0	0					
3/11/03	550	20	0	0	0	0	380	34	0	1	0
3/12/03	590	6	0	0	0	0	263	12	0	1	0
3/13/03	0	0	0	0	0	0	44	2	1		0
3/14/03	37	3	0	0	0	0	174	38	0	3	0
3/21/03							72	15	11	0	0
3/29/03	1561	300	91	30	1	0	3	0	1	0	0
3/30/03	1403	70	305	24	0	0	13	1	0	0	0
3/31/03	894	3	221	12	0	0	25	2	4	0	0
4/1/03	334	5	45	13	0	0	22	0	7	0	0
4/2/03	247	7	18	11	0	0	86	3	38	0	0
4/8/03	232	4	33	19	0	0	31	5	11	0	1
4/9/03	211	4	36	13	0	0	22	4	7	0	0
4/10/03	409	33	142	36	0	0	32	14	10	0	0
4/11/03	363	4	108	8	0	0	128	5	89	2	0
4/12/03	476	8	215	3	0	1	108	13	72	0	0
4/13/03			no sampling								
4/14/03	432	10	229	32	0	0	155	21	41	1	1
4/15/03	149	4	52	10	0	0	221	8	100	0	0
4/16/03	146	11	12	6	0	0	131	9	82	0	0
4/17/03	113	0	38	3	0	0	58	4	32	0	0
4/18/03	245	4	13	4	0	0	31	5	12	0	0
4/19/03	188	4	18	12	0	0	75	13	49	0	1
4/20/03			no sampling								
4/21/03	128	0	18	18	0	0	47	6	28	0	0
4/22/03	109	4	14	0	0	0	45	1	25	0	1
4/23/03	463	0	9	1	0	0	192	0	89	0	0
4/24/03	408	1	9	0	0	0	244	31	151	0	0
4/25/03	534	1	15	1	0	0	78	4	43	0	0
4/26/03	316	1	6	0	0	0	52	0	29	0	0
4/27/03	340	1	5	10	0	0	194	1	109	0	0
4/28/03	290	0	7	0	0	0	87	0	49	0	0
4/29/03	171	0	3	2	0	0	91	2	41	0	0

OUT-MIGRANT TRAP TOTAL

DATE	R1 total fish	R1 coho smolt	R1 coho YOY	R1 chum YOY	R1 cutthroat	R1 chinook YOY	R2 total fish	R2 coho smolt	R2 coho YOY	R2 cutthroat	R2 chinook YOY
4/30/03	423	3	5	0	0	0	173	2	98	0	2
5/1/03	360	0	8	1	0	0	239	18	138	0	0
5/2/03	659	10	7	2	0	0	171	5	101	0	0
5/3/03	498	4	20	4	0	0	75	0	38	0	0
5/4/03	731	2	14	0	0	0	69	2	39	0	0
5/5/03	1113	0	3	0	0	0	25	2	11	0	0
5/6/03	8129	1	17	0	0	0	56	8	20	0	0
5/7/03	4069	0	2	0	0	0	156	12	26	0	0
5/8/03	1463	1	2	1	0	0	36	2	18	0	0
5/9/03	1566	0	6	0	0	0	33	0	15	0	0
5/10/03	1184	0	3	0	0	0	177	1	92	0	0
5/11/03	2060	0	6	0	0	0	315	52	195	0	2
5/12/03	1206	1	3	0	0	0	74	7	30	0	0
5/13/03	1267	1	6	0	0	0	111	11	57	0	1
5/14/03	493	0	3	0	0	0	186	1	21	0	1
5/15/03	6564	39	24	0	0	0	431	20	287	0	2
5/16/03	397	2	5	0	0	0	90	0	68	0	0
5/17/03	175	0	2	0	0	0	114	0	75	0	0
5/18/03	6486	1	4	0	0	0	125	11	67	0	1
5/19/03	2391	0	0	0	0	0	231	4	119	0	0
5/20/03	7667	0	0	0	0	0	132	2	85	0	0
5/21/03	16137	0	0	0	0	0	143	5	67	0	0
5/22/03	1316	0	0	0	0	0	131	1	87	0	1
5/23/03	2423	0	0	0	0	0	486	4	289	0	0
5/24/03	1405	0	0	0	0	0	240	1	163	0	0
5/25/03			no sampling								
5/26/03	4217	0	0	0	0	0	206	0	75	0	0
5/27/03	1350	0	0	0	0	0	311	2	223	0	0
5/28/03	1253	0	0	0	0	0	63	0	15	0	0
5/29/03	421	0	0	0	0	0	29	0	2	0	0
5/30/03	1197	0	0	0	0	0	86	0	2	0	0
5/31/03	2134	0	0	0	0	0	107	0	4	0	0
6/1/03			no sampling								
6/2/03	5436	0	0	0	0	0	137	0	7	0	0
6/3/03	2071	0	0	0	0	0	75	0	2	0	0
6/4/03	816	0	0	0	0	0	1508	0	13	0	0
6/9/03							86	2	5	0	0

DATE	A1 total fish	A1 coho smolt	A1 coho YOY	A2 total fish	A2 coho smolt	A2 coho YOY	A2 chinook YOY	A2 chum YOY	A2 Cutthroat
3/4/03	8	0	0						
3/5/03	10	0	0						
3/6/03	1	0	0						
3/7/03	1	0	0	no sampling because of water levels					
3/8/03	8	0	0						
3/9/03	2	0	0						
3/10/03	8	0	0						
3/11/03	0	0	0						
3/12/03	2	0	0						
3/13/03	7	0	0						
3/14/03	0	0	0						
4/8/03	1	0	0	143	8	123	8	2	0
4/9/03	2	0	0	137	0	132	4	0	0
4/10/03	1	0	0	99	0	86	10	1	0
4/11/03	4	0	0	77	2	64	7	0	0
4/12/03	8	0	0	114	10	86	16	0	0
4/13/03									
4/14/03	44	0	0	unable to sample b/c of flood					
4/15/03	19	0	0	unable to sample b/c of flood					
4/16/03	7	0	0	unable to sample b/c of flood					
4/17/03	3	0	0	7	0	1	4	1	0
4/18/03	2	0	0	24	0	9	13	0	0
4/19/03	3	0	0	9	0	5	1	0	0
4/20/03									
4/21/03	1	0	0	16	3	8	2	0	0
4/22/03	0	0	0	17	5	5	5	1	0
4/23/03	1	0	0	1	0	0	1	0	0
4/24/03	1	0	0	0	0	0	0	0	0
4/25/03	2	0	0	5	10	0	4	1	0
4/26/03	5	0	0	7	1	0	0	0	1
4/27/03	11	0	0	9	7	0	0	0	0
4/28/03	15	0	0	35	33	0	1	0	0
4/29/03	12	0	0	27	23	1	1	0	0
4/30/03	15	6	8	9	6	0	0	0	0
5/1/03	14	3	1	16	10	0	4	0	0
5/2/03	11	0	1	20	16	0	0	0	0
5/3/03	5	0	0	16	10	2	2	0	0
5/4/03	30	0	27	11	4	0	2	0	0
5/5/03	10	0	2	26	13	1	6	0	0
5/6/03	16	0	1	25	1	22	0	0	0
5/7/03	11	0	0	66	0	64	0	0	0
5/8/03	17	0	0	71	5	60	3	0	0

DATE	A1 total fish	A1 coho smolt	A1 coho YOY	A2 total fish	A2 coho smolt	A2 coho YOY	A2 chinook YOY	A2 chum YOY	A2 Cutthroat
5/9/03	3	0	0	34	0	32	0	0	0
5/10/03	5	0	0	138	0	131	1	0	0
5/11/03	0	0	0	412	10	368	9	0	0
5/12/03	9	0	1	176	2	168	6	0	0
5/13/03	9	0	0	51	0	48	1	0	0
5/14/03	0	0	0	0	0	0	0	0	0
5/15/03	3	0	2	0	0	0	0	0	0
5/16/03	1	0	0	No water (n/a)		n/a	n/a	n/a	n/a
5/17/03	2	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/18/03	2	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/19/03	2	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/20/03	2	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/21/03	0	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/22/03	2	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/23/03	5	0	2	n/a	n/a	n/a	n/a	n/a	n/a
5/24/03	1	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/25/03				n/a	n/a	n/a	n/a	n/a	n/a
5/26/03	2	0	1	n/a	n/a	n/a	n/a	n/a	n/a
5/27/03	0	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/28/03	7	0	4	n/a	n/a	n/a	n/a	n/a	n/a
5/29/03	4	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/30/03	5	0	0	n/a	n/a	n/a	n/a	n/a	n/a
5/31/03	6	0	0	n/a	n/a	n/a	n/a	n/a	n/a
6/1/03				n/a	n/a	n/a	n/a	n/a	n/a
6/2/03	3	0	0	n/a	n/a	n/a	n/a	n/a	n/a
6/3/03	5	0	0	n/a	n/a	n/a	n/a	n/a	n/a
6/4/03	5	0	1	n/a	n/a	n/a	n/a	n/a	n/a

Appendix B. Sampling schedule for the number of fyke net sets each month at regulated wetlands, non-regulated wetlands, and alternative wetlands in Chehalis River floodplain, Washington, 2003.

	January	March	April	May
R1	5	15	8	4
R2	5	20	8	4
N1	4	11	4	0
N2	4	12	6	3
A1	5	9	8	4
A2	4	8	5	2
TOTAL FYKE NET SETS	27	75	39	17

Appendix C. Fyke net fish data for 2003. Total fish captured in each net, total salmon yearlings and YOY captured in each net for sites R1, R2, N1, N2, A1, and A2 in the Chehalis River, Washington.

R1	salmon yearlings	salmon YOY	Trap	fish totals per trap	mean fish/ trap night	standard deviation
1/8/03	0	0	1	54		
	2	0	2	120		
	1	0	3	5		
	0	0	4	25		
	37	0	5	109	62.6	50.62904
3/4/03	2	0	1	44		
	1	0	2	360		
	0	0	3	16		
	0	0	4	3		
	26	0	5	695	223.6	302.0104
3/11/03	0	0	1	109		
	0	0	2	16		
	1	0	3	100		
	0	0	4	0		
	10	0	5	380	121	152.7514
3/28/03	0	0	1	40		
	0	0	2	8		
	0	0	3	313		
	16	0	4	196		
	1	0	5	235	158.4	130.2125
4/9/03	0	0	1	3		
	0	0	2	373		
	2	0	3	145		
	3	0	4	98	154.75	157.0316
4/23/03	2	0	1	840		
	0	0	2	512		
	0	1	3	1501		
	1	1	4	776	907.25	420.5198
5/6/03	0	0	1	1575		
	0	0	2	1606		
	0	0	3	4214		
	0	0	4	2241	2409	1241.855

Appendix C(ii). Regulated wetland, R2

R2	salmon yearlings	salmon YOY	Trap	fish totals per trap	mean fish/ trap night	standard deviation
1/9/03	0	0	1	556		
	0	0	2	151		
	0	0	3	393		
	0	0	4	5		
	0	0	5	5	222	244.9571
3/6/03	0	0	1	125		
	0	0	2	177		
	0	0	3	2		
	0	0	4	0		
	0	0	5	0	60.8	84.37239
3/13/03	0	0	1	59		
	0	0	2	0		
	2	0	3	211		
	0	0	4	0		
	0	0	5	1	54.2	91.26171
3/20/03	0	0	1	8		
	0	0	2	1		
	4	0	3	83		
	0	0	4	195		
	1	0	5	36	64.6	79.70132
3/30/02	0	0	1	15		
	0	0	2	29		
	1	0	3	174		
	0	0	4	47		
	1	0	5	29	58.8	65.39266
4/15/03	0	0	1	11		
	0	0	2	41		
	1	3	3	193		
	3	1	4	62	76.75	80.27609
4/25/03	0	0	1	2		
	0	0	2	171		
	1	0	3	13		
	4	0	4	79	66.25	77.67185
5/8/03	1	0	1	82		
	1	1	2	61		
	0	0	3	234		
	0	0	4	73	112.5	81.45551

Appendix C(iii). Non-regulated wetland, N1

N1	salmon yearlings	salmon YOY	Trap	fish totals per trap	mean fish/ trap night	standard deviation
1/7/03	0	0	1	85		
	0	0	2	32		
	0	0	3	12		
	0	0	4	7	34	35.67
3/4/03	0	0	1	0		
	0	0	2	0	0	0
3/14/03	0	0	1	1		
	0	0	2	0	0.5	0.707107
3/20/03	0	0	1	0		
	0	0	2	0		
	0	4	3	70	23.33333	40.41452
3/29/03	0	0	1	1		
	0	0	2	0		
	0	4	3	39		
	0	9	4	39	19.75	22.23173
4/11/03	0	5	1	57		
	0	9	2	4	30.5	37.47666
4/24/03	0	0	1	4		
	0	0	2	1	2.5	2.12132

Appendix C(iv). Non-regulated wetland, N2

N2	salmon yearlings	salmon YOY	Trap	fish totals per trap	mean fish/ trap night	standard deviation
1/23/03	0	0	1	9		
	0	0	2	105		
	0	0	3	1		
	0	0	4	1	29	50.80682
3/6/03	0	0	1	0		
	0	0	2	80		
	0	0	3	0		
	0	0	4	2	20.5	39.67787
3/31/03	0	0	1	27		
	0	0	2	19		
	0	2	3	192		
	0	2	4	174	103	92.7254
4/16/03	0	0	1	11		
	0	0	2	190		
	0	0	3	476	225.67	234.54
4/17/03	0	0	1	0		
	0	0	2	816		
	0	0	3	414	410	408.01
5/9/03	0	0	1	297		
	0	0	2	409		
	0	1	3	316	340.67	59.94

Appendix C(v). Alternative wetland, A1

A1	salmon yearlings	salmon YOY	Trap	fish totals per trap	mean fish/ trap night	standard deviation
1/22/03	0	0	1	6		
	0	0	2	3		
	0	0	3	6		
	0	0	4	2		
	0	0	5	4	4.2	1.788854
3/5/03	0	0	1	10		
	0	0	2	0		
	0	0	3	17		
	0	0	4	0		
	0	0	5	1	5.6	7.635444
4/3/03	0	0	1	11		
	0	0	2	2		
	0	0	3	7		
	0	0	4	10	7.5	4.041452
4/10/03	0	0	1	12		
	0	0	2	7		
	0	0	3	16		
	0	0	4	6	10.25	4.645787
4/28/03	0	2	1	40		
	0	3	2	343		
	0	0	3	10		
	0	0	4	56		
5/2/03	0	0	1	11		
	0	0	2	23		
	4	0	3	89		
	0	0	4	7	32.5	38.27532

Appendix C(vi). Alternative wetland, A2

A2	salmon yearlings	salmon YOY	Trap	fish totals per trap	mean fish/ trap night	standard deviation
1/21/02	8	0	1	9		
	0	0	2	0		
	1	0	3	1		
	0	0	4	0	2.5	4.358899
3/11/03	0	0	1	0		
	0	0	2	0		
	0	0	3	0		
	2	0	4	5	1.25	2.5
4/1/03	0	0	1	2		
	0	2	2	4		
	4	3	3	8		
	7	3	4	10	6	3.651484
4/8/03	0	0	1	1		
	5	4	2	9		
	9	20	3	32	14	16.093
4/24/03	46	37	1	85		
	39	1	2	41	33.6	33.0424
5/7/03	34	122	1	221		
	13	376	2	393	307	121.6224

Appendix D. Three and four letter code names used for data collection with common and Latin names of the fishes and amphibians.

CODE	COMMON NAME	LATIN NAME	FAMILY
BLG	Bluegill	*Lepomis macrochirus*	Centrarchidae
BRB	Brown bullhead	*Ameiurus nebulosus*	Ictaluridae
BUZ	Bullfrog	*Rana catesbeiana*	Ranidae
BUZT	Bullfrog tadpole	*Rana catesbeiana*	Ranidae
CAP	Common carp	*Cyprinus carpio*	Cyprinidae
CHI	Chinook salmon	*Oncorhynchus tschawytscha*	Salmonidae
CHO	Coho salmon	*Oncorhynchus kisutch*	Salmonidae
CHOF	Coho salmon YOY	*Oncorhynchus kisutch*	Salmonidae
CHU	Chum salmon	*Oncorhynchus keta*	Salmonidae
COT	Unidentified sculpin	*Unidentified Cottus*	Cottidae
CRP	Crappie spp.	*Pomoxis spp.*	Centrarchidae
CUT	Coastal cutthroat trout	*Oncorhynchus clarki*	Salmonidae
LGD	Longnose dace	*Rhinichthys cataractae*	Cyprinidae
LGS	Largescale sucker	*Catostomus macrocheilus*	Catostomidae
LMB	Largemouth bass	*Micropterus salmoides*	Centrarchidae
LSZ	Long-toed salamander	*Ambystoma macrodactylum*	Ambystomatidae
NSQ	Northern pikeminnow	*Ptychocheilus oregonensis*	Cyprinidae
NSZ	Northwestern salamander	*Ambystoma gracile*	Ambystomatidae
OLY	Olympic Mudminnow	*Novumbra hubbsi*	Umbridae
OLYy	YOY Olympic Mudminnow	*Novumbra hubbsi*	Umbridae
PAL	Pacific lamprey	*Lampetra tridentata*	Petromyzontidae
PFZ	Pacific tree frog	*Pseudacris regilla*	Hylidae
PRS	Prickly sculpin	*Cottus asper*	Cottidae
PUMP	Pumpkinseed	*Lepomis gibbosus*	Centrarchidae
RBT	Rainbow trout	*Oncorhynchus mykiss*	Salmonidae
RFZ	Northern red-legged frog	*Rana aurora*	Ranidae
RFZT	N. Red-legged frog tadpole	*Rana aurora*	Ranidae
ROCK	Rock bass	*Ambloplites rupestris*	Centrarchidae
RTS	Reticulate sculpin	*Cottus perplexus*	Cottidae
RNZ	Rough-skinned newt	*Taricha granulosa*	Salamandridae
RSS	Redside shiner	*Richardsonius balteatus*	Cyprinidae
SKD	Speckled dace	*Rhinichthys osculus*	Cyprinidae
TSS	Three-spine stickleback	*Gasterosteus aculeatus*	Gasterosteidae
TSSy	YOY three-spine stickleback	*Gasterosteus aculeatus*	Gasterosteidae
WAM	Warmouth	*Lepomis gulosus*	Centrarchidae
YEB	Yellow bullhead	*Ameiurus natalis*	Ictaluridae
YEP	Yellow perch	*Perca flavescens*	Percidae

Appendix E. Fish average fork length (mm), standard deviation of average fork length, average weight (grams) and standard deviation of weight for fish species. Fish fork length and weight are separated by date, site, and species. This data was collected from the fyke nets in the Chehalis floodplain, Washington 2003.

DATE	SITE	SPECIES	AVER_FL	SD_FL	AVER_WT	SD_WT
1/8/03	R1	TSS	46.72414	8.298791		
1/8/03	R1	CHO	93.925	10.75458	9.1375	3.164522
1/8/03	R1	COT	59			
1/8/03	R1	LGS	63.5	23.53508		
1/8/03	R1	OLY	52.89744	10.34356		
1/8/03	R1	RSS	59			
3/4/03	R1	OLY	45.25806	5.944004		
3/4/03	R1	TSS	39	5.895644		
3/4/03	R1	CHO	100.9655	7.993224	10.844828	2.449575
3/11/03	R1	OLY	45.19231	5.381593		
3/11/03	R1	TSS	43	5.775976		
3/11/03	R1	CHO	113.4545	13.77943	16.090909	5.776583
3/11/03	R1	PRS	132			
3/28/03	R1	CHO	123.4118	6.423189	19.991765	3.935944
3/28/03	R1	OLY	52.22951	7.70799	1.8265909	0.850841
3/28/03	R1	RTS	68			
3/28/03	R1	TSS	47.29032	6.05086		
4/9/03	R1	CHO	120	9.460444	19.798	4.884017
4/9/03	R1	OLY	55	9.406639		
4/9/03	R1	RTS	87	11.04536		
4/9/03	R1	TSS	46.81818	4.869898		
4/23/03	R1	BLG	148			
4/23/03	R1	BRB	155			
4/23/03	R1	CHO	126.6667	5.131601	23.21	4.751758
4/23/03	R1	CHOF	66.5	4.95	3.38	
4/23/03	R1	NSQ	65			
4/23/03	R1	OLY	56.30303	8.079623	2.3796429	0.986113
4/23/03	R1	PRS	64			
4/23/03	R1	RTS	92	12.72792		
4/23/03	R1	TSS	48.51613	3.43386		
4/23/03	R1	YEP	174			
5/6/03	R1	BLG	70			
5/6/03	R1	OLY	58.29167	7.82126	2.6128571	0.954569
5/6/03	R1	OLYy	29.91304	3.356311		
5/6/03	R1	RTS	65			
5/6/03	R1	TSS	49.09091	5.70638		
5/6/03	R1	TSSy	25.95238	2.376472		
1/9/03	R2	BLG	91			
1/9/03	R2	BRB	140			
1/9/03	R2	LGS	125.6667	60.53098		
1/9/03	R2	NSQ	86.30769	26.28176		
1/9/03	R2	OLY	47.71429	10.49943		
1/9/03	R2	TSS	36.4	4.157254		

Appendix E continued.

DATE	SITE	SPECIES	AVER_FL	SD_FL	AVER_WT	SD_WT
3/6/03	R2	COT	78.5	14.84924		
3/6/03	R2	LGS	109.5	7.778175		
3/6/03	R2	NSQ	55	12.19289		
3/6/03	R2	OLY	57.33	9.073772		
3/6/03	R2	RSS	71.2	6.140033		
3/6/03	R2	TSS	40.88235	4.035935		
3/13/03	R2	BLG	101.6667	23.50177		
3/13/03	R2	BRB	164	24.38579		
3/13/03	R2	CUT	210.5	60.10408		
3/13/03	R2	LGS	89.75	20.40221		
3/13/03	R2	NSQ	64.61	16.15151		
3/13/03	R2	OLY	75			
3/13/03	R2	RSS	62			
3/13/03	R2	TSS	43	2.729153		
3/20/03	R2	BLG	103		20.65	
3/20/03	R2	BRB	168			
3/20/03	R2	CHO	104.6	11.58879	12.38	3.971813
3/20/03	R2	LGS	52.5	20.5061		
3/20/03	R2	NSQ	68.33	4.50925		
3/20/03	R2	OLY	57.5	0.707107		
3/20/03	R2	RTS	66	3.464102		
3/20/03	R2	TSS	45.46939	4.123621		
3/30/03	R2	BLG	139			
3/30/03	R2	BRB	143.5	13.43503		
3/30/03	R2	CHO	101		12.09	
3/30/03	R2	COT	82.5	0.707107		
3/30/03	R2	CUT	140		25.34	
3/30/03	R2	NSQ	71.5	3.535534		
3/30/03	R2	OLY	64.4	5.85662	2.96	0.92844
3/30/03	R2	RSS	68.5	6.363961		
3/30/03	R2	TSS	44.52632	3.399021		
3/30/03	R2	YEP	128			
4/15/03	R2	BLG	154	110.3087		
4/15/03	R2	CHO	118.3333	10.78579	19.193333	5.305679
4/15/03	R2	CHOF	48.5	2.516611		
4/15/03	R2	COT	64			
4/15/03	R2	CUT	217		97.41	
4/15/03	R2	LGS	58	4.582576		
4/15/03	R2	NSQ	63.69231	11.36229		
4/15/03	R2	OLY	50			
4/15/03	R2	RTS	55	4.242641		
4/15/03	R2	TSS	44.36667	3.576584		
4/25/03	R2	BLG	117.25	19.39716		
4/25/03	R2	BRB	191.2857	47.30297		
4/25/03	R2	CHO	114.5	13.43503	16.94	5.317443
4/25/03	R2	CUT	159.6667	36.22614	45.003333	27.92322
4/25/03	R2	OLY	59.5	2.516611		
4/25/03	R2	RTS	72.75	10.68711		
4/25/03	R2	TSS	46.46875	4.399299		
5/8/03	R2	BLG	76.66667	6.350853		
5/8/03	R2	BRB	165.5714	19.61171		

Appendix E continued.

DATE	SITE	SPECIES	AVER_FL	SD_FL	AVER_WT	SD_WT
5/8/03	R2	CHO	130	2.828427	24.55	1.767767
5/8/03	R2	CHOF	61			
5/8/03	R2	NSQ	70.03704	5.064822		
5/8/03	R2	OLY	59.71429	12.13417		
5/8/03	R2	RSS	71			
5/8/03	R2	RTS	74.30769	12.18185		
5/8/03	R2	TSS	46.53333	3.857222		
1/7/03	N1	OLY	45.00			
1/7/03	N1	PAL	123.33	32.15		
1/7/03	N1	TSS	41.38	7.37		
3/20/03	N1	CHO	44.00	0.82		
3/20/03	N1	OLY	89.50	16.26		
3/20/03	N1	PAL	110.00			
3/20/03	N1	TSS	47.43	5.75		
3/29/03	N1	BRB	118.00			
3/29/03	N1	CHOF	43.23	3.11		
3/29/03	N1	OLY	53.50	13.44		
3/29/03	N1	TSS	48.43	6.28		
4/11/03	N1	CHOF	55.00	2.12		
4/11/03	N1	CHU	55.78	1.92		
4/11/03	N1	OLY	54.25	5.97	1.93	0.80
4/11/03	N1	TSS	51.20	3.75		
4/25/03	N1	TSS	51.00	2.92		
1/23/03	N2	OLY	54.8	10.4		
1/23/03	N2	TSS	45.7	3.5		
3/31/03	N2 BLG	85.0				
3/31/03	N2	CHOF	45.3	1.7		
3/31/03	N2	LGS	90.5	38.9		
3/31/03	N2	NSQ	75.8	6.8		
3/31/03	N2	OLY	56.3	8.2		
3/31/03	N2	TSS	49.1	3.3	2.09	1.03
4/16/03	N2	BLG	86.0			
4/16/03	N2	NSQ	73.3	11.0		
4/16/03	N2	OLY	60.5	11.6		
4/16/03	N2	TSS	48.6	5.1	3.05	1.59
4/16/03	N2	WAM	126.0			
4/17/03	N2	BLG	87.0			
4/17/03	N2	LGS	66.3	30.9		
4/17/03	N2	NSQ	73.5	3.1		
4/17/03	N2	OLY	55.9	8.2		
4/17/03	N2	TSS	49.9	3.5		
5/9/03	N2	CHOF	70.0			
5/9/03	N2	LGS	130.0			
5/9/03	N2	NSQ	78.7	9.3		
5/9/03	N2	OLY	60.3	7.8		

Appendix E continued.

DATE	SITE	SPECIES	AVER_FL	SD_FL	AVER_WT	SD_WT
5/9/03	N2	OLYy	33.0	3.0	2.56	0.90
5/9/03	N2	TSS	52.8	3.1		
5/9/03	N2	TSSy	24.0	2.1		
1/22/03	A1	BRB	230.00			
1/22/03	A1	COT	87.00	5.29		
1/22/03	A1	LGS	342.50	64.35		
1/22/03	A1	NSQ	135.00			
1/22/03	A1	PRS	107.00	59.40		
1/22/03	A1	TSS	39.27	5.53		
3/5/03	A1	BRB	188.00	48.08		
3/5/03	A1	COT	80.00	17.32		
3/5/03	A1	LGS	214.25	87.55		
3/5/03	A1	OLY	56.67	2.89		
3/5/03	A1	PRS	87.00	8.49		
3/5/03	A1	TSS	38.21	5.59		
4/3/03	A1	COT	65.50	31.82		
4/3/03	A1	NSQ	92.00			
4/3/03	A1	RTS	54.00			
4/3/03	A1	TSS	44.36	6.04		
4/10/03	A1	COT	56.00	25.46		
4/10/03	A1	OLY	49.88	8.80		
4/10/03	A1	PRS	38.50	2.12		
4/10/03	A1	TSS	40.18	5.20		
4/28/03	A1	CHOF	62.60	2.51		
4/28/03	A1	LGS	302.50	2.12		
4/28/03	A1	NSQ	94.78	16.06		
4/28/03	A1	OLY	67.00			
4/28/03	A1	PRS	67.75	41.14		
4/28/03	A1	RTS	68.00	13.86		
4/28/03	A1	TSS	42.48	4.43		
4/28/03	A1	YEP	186.50	13.44		
5/2/03	A1	BRB	133.00			
5/2/03	A1	CHO	135.50	7.05	24.52	4.63
5/2/03	A1	LGS	258.00			
5/2/03	A1	PRS	55.00	21.21		
5/2/03	A1	RSS	98.50	6.36		
5/2/03	A1	TSS	40.97	3.03		
1/22/03	A2	CHO	88.88889	30.34569		
3/11/03	A2	CHO	118.5	0.707		
3/11/03	A2	LGS	375	25.45584		
3/11/03	A2	NSQ	331			
4/1/03	A2	BLG	32			
4/1/03	A2	CHI	54.42857	6.704654		
4/1/03	A2	CHO	126.1818	8.0724	21.724545	4.914117
4/1/03	A2	CHU	54			
4/1/03	A2	OLY	46			

Appendix E continued.

DATE	SITE	SPECIES	AVER_FL	SD_FL	AVER_WT	SD_WT
4/1/03	A2	TSS	39			
4/1/03	A2	YEP	167			
4/8/03	A2	CHI	55	3		
4/8/03	A2	CHO	132.2143	6.51836	24.731429	3.170777
4/8/03	A2	CHOF	39.28571	2.261479		
4/8/03	A2	CUT	202.6667	18.77054	78.686667	14.85369
4/8/03	A2	OLY	48			
4/24/03	A2	BLG	92			
4/24/03	A2	CHI	67.21212	10.26754	5.1833333	1.192434
4/24/03	A2	CHO	132.1463	9.777932	24.427927	5.240691
4/24/03	A2	CHOF	52.6	7.797435		
4/24/03	A2	CUT	206.3333	17.55942		
4/24/03	A2	ROCK	186			
4/24/03	A2	TSS	53			
5/7/03	A2	CHI	68.93939	8.219411		
5/7/03	A2	CHO	123.6	9.41	19.176	4.576916
5/7/03	A2	CHOF	54.13793	5.533819		
5/7/03	A2	PRS	92			
5/7/03	A2	PRS	102.5	14.84924		
5/7/03	A2	SKD	67			
5/7/03	A2	SKD	66.5	0.707107		
5/7/03	A2	TSS	67			

Appendix F. Different definitions of overwintering habitats for juvenile salmonids and definitions of wetlands using water regime modifiers. Sources cited.

Author	Habitat Name	Definition	Location	Dominate Species
Swales et al. (1986)	Off-channel pond	Adjacent to main river and originated as cutoff river meanders. Beaver dams on the outlet streams impound groundwater inflow into the area, creating a shallow pond. Aquatic community and water quality are good. Substrate was decaying organic matter and mud.	Small interior river of B.C.	Coho and Chinook
Swales et al. (1986)	Side-channels	No exact definition cited. Has flow though and substrate is sand, gravel and organic debris.		Coho and Chinook
Peterson and Reid (1984)	Wall-base channels	A type of channel formed on the floodplain by the channeling of runoff through swales created by the migration of the mainstem. Channels appear to develop along abandoned meander scars and follow the foot of the valley. They are formed by the cutoff of meander bends or the interception and channeling of runoff from an upper terrace. Most channels are small and contain silt substrate, low gradient and their catchments are of low relief and are heavily vegetated.	Clearwater basin on Olympic Peninsula, WA	Coho
Peterson (1982a)	Riverine ponds	Ponds that originating as cutoff river meanders that receive near-surface groundwater flow, and functionas flow-through systems connected by an outlet stream	Clearwater, WA	Coho, cutthrout, prickly sculpin, speckled dace
Bustard and Narver (1975)	Flooded side-pools and tributaries	A series of interconnected, mud-bottomed pools formed behind old deserted beaver dams. Drained an area of 14-ha. Winter flows <1cfs and creek is dry in summer months.	Carnation Creek, BC	Coho, steelhead, and sculpin
Beechie et al. (1994)	Side-channels	Small channels branching off-the main stem. Typically abandoned river channels or over flow channels on the floodplain. Maintain pool or pond-like characteristics during flooding	Skagit River Basin, WA	Coho
Scarlett and Cederholm (1984)	Overwintering habitat	Juvenile coho salmon were re-distributed during fall and winter freshets as far as 28km downstream to tributary sites.	3rd order stream in Clearwater River,WA	Coho
Nickelson et al. (1992) adopted by Bisson et al. (1982)	Dammed pool, includes beaver dams	A pool impounded upstream from a completed or nearly complete channel blockage	2nd to 6th order coastal streams in Oregon.	Coho

Appendix F continued.

Author	Habitat Name	Definition	Location	Dominate Species
Nickelson et al. (1992) adopted by Bisson et al. (1982)	Backwater pool	An eddy or slack water along the channel margin separated from the main current by a gravel bar or small channel obstruction		
Nickelson et al. (1992) adopted by Bisson et al. (1982)	Alcove	A slack water along the channel margin separated from the main current by streambanks or large channel obstructions such tha t it remains quiet even at high flows		
Swales and Levings (1989)	Off-channel ponds	Small (0.1-0.3 ha) shallow permanent ponds that are groundwater or spring fed and inhabited by beavers. Substrate is decaying organic matter overlaying mud and silt.	3rd order stream, Coldwater River, BC	5-species captured
Brown (1987)	Off-stream habitat	Those sites removed from the main stream, including all tributaries, swamps, and flooded land.	Carnation Creek, Vancouver Island, BC	Coho
Brown (1987)	Intermittent tributaries	Those sites (usually 1st order tributaries) containing visible flowing water all winter but isolated pools during the driest summer months. Substrate is sand and gravel dominated.		Coho
Brown (1987)	Ephemeral swamps	Those sites (sloughs, swamps, temporary channels) that contain standing water during winter base flow, but are completely dry in summer. Substrate contains muck.		Coho
Landers et al. (2002)	Off-channel habitats	Are those bodies of water adjacent to the main channel that have surface water connections to the main river channel at summer discharge levels.	Willamette River, OR	
Landers et al. (2002)	Side channels	Flowing water bodies with clearly identifiable upstream and downstream connections to the main channel	Willamette River, OR	
Landers et al. (2002)	Alcoves	Bodies of water that maintain a downstream connection to the main channel at summer low flow, but have no upstream connection.		
Cowardin et al. (1979)	Permanently flooded	Water covers land surface throughout year in all years	A1	
Cowardin et al. (1979)	Semipermanently flooded	Surface water persists throughout growing season in most years. When surface water is absent, water table is at or near surface.		
Cowardin et al. (1979)	Seasonally flooded	Surface water is present for extended periods, especially in early growing season but is absent by the end of the season.	R1, R2, N2	

Appendix F continued.

Author	Habitat Name	Definition	Location	Dominate Species
Cowardin et al. (1979)	Saturated	Substrate is saturated for extended periods during growing season but surface water is seldom present		
Cowardin et al. (1979)	Temporarily flooded	Surface water is present for brief periods during growing season but water table is otherwise well below the soil surface.	N1, A2	
Cowardin et al. (1979)	Intermittently flooded	Substrate is usually exposed but surface is present for variable periods with no seasonal periodicity.		

Note: sampled wetlands in the present study are put into Cowardin et al (1979) wetland categories.

Appendix G. A diagram of the formation of wetlands and other aquatic habitats in the floodplain. Diagram from Saucier 1994.