SEASONAL COMPOSITION AND DISTRIBUTION OF FISH SPECIES IN THE LOWER COLUMBIA SLOUGH

COMPLETION REPORT 2009

Project Period: 1 March 2008 to 28 February 2009

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IGA Number 37908

September 2009

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ABSTRACT

This report summarizes data collected during a cooperative effort between the Oregon Department of Fish and Wildlife (ODFW) and the City of Portland, Bureau of Environmental Services from March 2008 through February 2009. The goal of this study was to identify and describe characteristics of the fish assemblage in the lower Columbia Slough. Specific objectives of this research were to: 1) evaluate variation in the composition of the fish assemblage among seasons, and 2) characterize the seasonal distribution of fish species inhabiting the lower Columbia Slough. To address these objectives, we set hoop traps at eight sites in the lower 13.5 km (8.4 miles) of the Columbia Slough during spring, summer, fall, and winter. Primary data collected at each site described species presence, fish length, and components of physical habitat. Throughout the investigation, 4,887 individual aquatic animals, comprising 26 aquatic species and 12 families, were identified in our catches. The 12 families encountered consisted of one amphibian, two crustacean, and nine fish. Non-native aquatic animals dominated catches, accounting for 77.8% of all individuals. In general, fork lengths of fish captured throughout this study varied considerably within and among species. Catch metrics describing fish assemblages in the lower Columbia Slough revealed variation both seasonally and among sites. Although catch per unit effort values calculated for Chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch* differed numerically, spatial and temporal differences were not statistically significant. Results from this study provide an initial characterization of fish assemblages in the lower Columbia Slough, highlighting the dynamic nature of species compositions. Continued monitoring and research, in addition to the application of more rigorous analytical techniques, should help further elucidate the role of the Columbia Slough habitat in supporting viable fish communities.

INTRODUCTION

Characterizing aquatic assemblages has become an important step in effectively managing aquatic resources (EPA 2007; OWEB 2007; ODFW 2009). The cornerstone of assessing aquatic assemblages, and ultimately biotic integrity, has involved integrating ecological considerations for each species identified in a population (Karr 1981; Plafkin et al. 1989). This has been accomplished using a suite of life functions and conditions for a broad assemblage of animals in an ecoregion, and has been recommended to encompass metrics measured over regular intervals of time (Fore 2003). Continued monitoring by regularly measuring responses related to aquatic disturbance requires an understanding of a minimally disturbed condition (Hughes 1995). This information establishes a standard (baseline or reference condition) for what should be expected in an ecosystem if left to function undisturbed. Understanding the composition of the aquatic assemblage can provide the insight needed for assembling a multi-dimensional assessment of ecosystem health, and to inform resource managers on actions needed for restoring functionally impaired aquatic resources.

Understanding seasonal use and distribution of single species or a community of animals is of interest in managing aquatic resources. In order for ecological descriptors to be relevant they should include comprehensive seasonal coverage across the entire ecosystem of interest (Kwak and Peterson 2007). However, seasonal variation can profoundly influence an assemblage in open water bodies (streams, sloughs, estuaries) where animals move freely among habitats. With this in mind, variation may be more pronounced when collecting a mix of animals that exhibit different life history characteristics, growth, and recruitment. Providing an initial characterization of an assemblage both seasonally and spatially may lead to a better understanding of the dynamics of the measured assemblage, and guide managers in implementing effective policy in a region.

Many of the efforts to restore aquatic ecosystems in the Columbia River ecoregion revolve around recovering distinct populations of Pacific salmon and steelhead that are managed by Endangered Species Act (ESA) legislation. Of the six anadromous species of Pacific salmon *Oncorhynchus spp.* and steelhead *O. mykiss* known to use streams in the Columbia River ecoregion (NOAA Fisheries 2009), four have been regularly observed in sampling activities in the Portland Metropolitan area (Farr and Ward 1993; Friesen et al. 2007). Characterizing the distribution and habitat requirements of each species involves rigorous measurement of their presence and use of localized habitats. Although there is little doubt that all six ESA listed species utilize the lower Columbia River as a migratory corridor, both as adults returning to spawn (FPC 2009a) and as juveniles moving seaward (FPC 2009b), a more focused sampling effort is needed to fully understand the ecological importance of this system for Pacific salmon and steelhead.

The City of Portland in cooperation with Oregon Department of Fish and Wildlife set out to describe the aquatic assemblage and overall distribution of fish species inhabiting the lower 13.5 km of the Columbia Slough, Portland, Oregon. The primary objective of this effort was to 1) determine if the composition of the fish assemblage changes among seasons, and 2) characterize the seasonal distribution of fish species inhabiting the lower Columbia Slough. In addition, there was an interest in exploring these two objectives looking specifically at the extent of use by ESA listed salmonid species. Information obtained through this work should enhance coordination between jurisdictions involved in the protection of ESA listed and Oregon sensitive species while providing insight for restoring habitat throughout the area.

STUDY AREA

The Columbia Slough is a series of lakes and waterways that parallel the Columbia River for approximately 29 km. The area surrounding the Columbia Slough supports many different land uses including heavy industry, retail commerce, recreation, and residential neighborhoods. The lower 13.5 km of the Columbia Slough is tidally influenced, ebbing and flowing due to its connection to the Willamette River. The lower Columbia Slough is separated from the middle and upper portions of the Columbia Slough by a levee system that inhibits the passage of dispersing fish or other aquatic life. Areas upstream of the lower Columbia Slough are actively managed for flood control and some irrigation.

Hughes et al. (1998) established a process for evaluating fish assemblage integrity based on a list of 45 fishes found in wadeable streams in the Willamette Valley ecoregion. Although this list of fishes is comprehensive to the ecoregion as a whole, it may overestimate the actual assemblage in the Columbia Slough. Similarly, earlier efforts have identified 32 species of fish residing in water bodies in the Portland Metropolitan area (Farr and Ward 1993; Friesen et al. 2007). Among fishes identified in this earlier work are native species of interest that have been found inhabiting surrounding streams and waterways in the Portland Metropolitan area, including parts of Columbia Slough (Ward 1995; Tinus et al. 2003; Friesen et al. 2007; C. Baker, Ducks Unlimited, personal communication). Lamprey *Lampetra spp.*, listed as sensitive by the State of Oregon, have been noted in other nearby waterways (Tinus et al. 2003), and have been documented using limited portions of the Columbia Slough, and Smith and Bybee Wetlands (C. Baker, Ducks Unlimited, personal communication). Non-native game species like smallmouth bass *Micropterus dolomieu*, bluegill *Lepomis macrochirus*, catfish *Ameiurus spp./Ictalurus spp.*, and other aquatic invasive species such as oriental weatherfish *Misgrunus anguillicaudatus* and mosquitofish *Gambusia affinis* have been documented in other nearby waterways (Tinus et al. 2003; Friesen et al. 2007). Yet, the community composition of fishes, and their use of the lower 13.5 km of the Columbia Slough is not well defined.

Pacific salmon species known to occur in Portland Metropolitan area water bodies have been found distributed in natal tributary streams (Tinus et al. 2003), in rearing habitats in and off primary channels (Friesen et al. 2003; Sather et al. 2009), and within migratory corridors (Farr and Ward 1993; Friesen et al. 2007). However, the extent to which these species use the lower 13.5 km of the Columbia Slough, or if their use varies among the four seasons remains uncertain. Aquatic sampling conducted by City of Portland personnel found ESA-listed species of salmonid in the lower 5.6 km from Wapato Wetland downstream to the confluence with the Willamette River (City of Portland, unpublished data). Recently, Teel et al. (2009) identified the proportional occurrence by origin of nine grouped stocks of Chinook salmon *O. tshawytscha* residing in and around the Columbia Slough. Additional information on the relative abundance and seasonal distribution of this and other ESA listed salmonids may prove valuable in better understanding the role of the lower Columbia Slough for important life functions of these species.

METHODS

We used unbaited hoop traps (Hans and Wenzel 2005) to collect data characterizing fish assemblages at eight sites in the lower 13.5 km (8.4 miles) of the Columbia Slough during spring, summer, fall, and winter, 2008-2009. Traps were approximately 2.7 meter (9 feet) long, and 0.9 meter (3 feet) diameter with a fyke opening of 15 cm (6 inch) diameter. Traps were covered with 7 mm (5/16 inch) Vexar® plastic sheet netting. We divided the lower Columbia Slough into eight 1.7 kilometer (~1 mile) segments starting at the confluence with the Willamette River and moving upstream to an impassable levee at the Multnomah County Drainage District No. 1 pumping station (Figure 1; Appendix B site 8). One site in each segment was selected for repeated sampling during the entirety of the investigation.

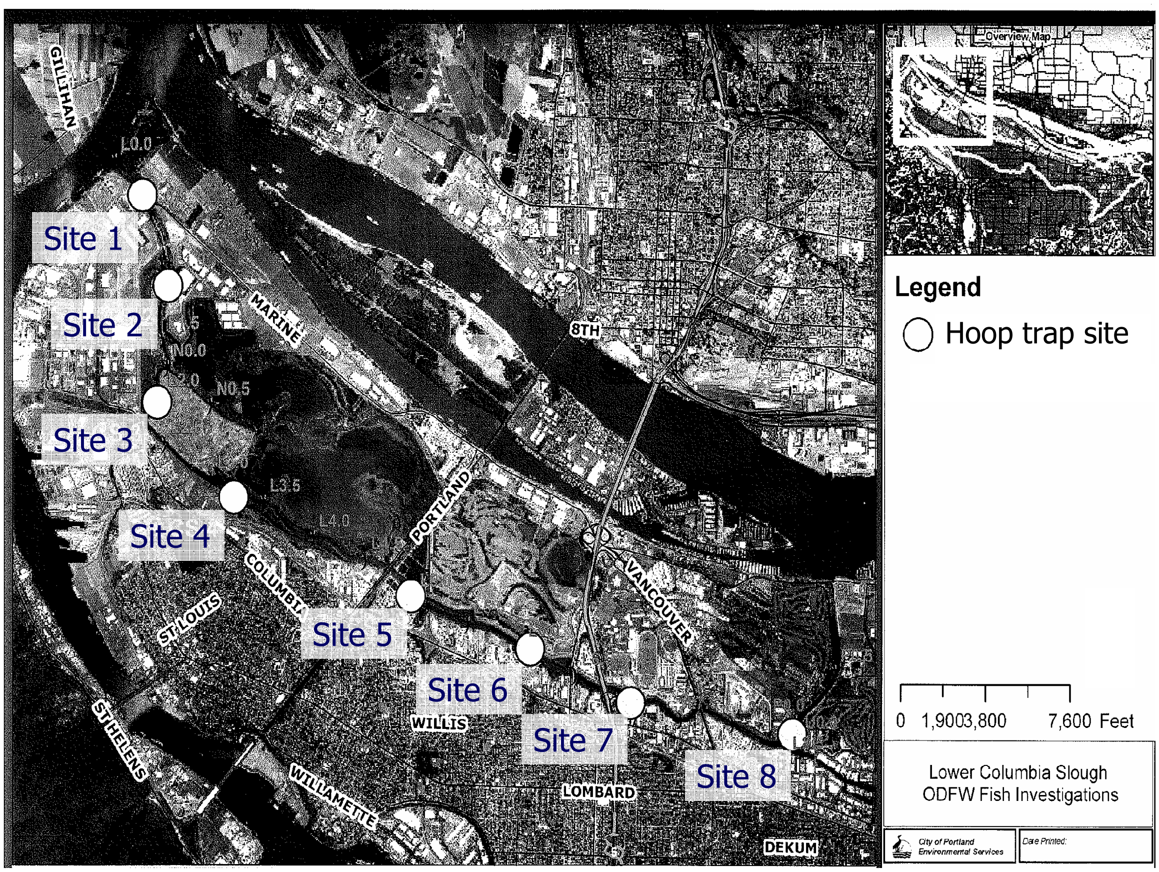


Figure 1. An overview of lower Columbia Slough with site locations where hoop traps were fished spring, summer, fall, and winter 2008–2009.

We defined each season using equinox or solstice dates (USNO 2008). Hoop traps were deployed during a two week period within the first four weeks of each season. We randomly selected four segments to be sampled per week during each season. Traps were deployed on Monday, and checked daily until final removal on Friday. This allowed for four fishing periods (days) per segment in each season. At each site, upon deployment and at removal, we measured the distance from the mouth of the submerged trap to the shoreline at the active channel mark. Although traps were secured to the bank with anchors, they were not fixed or anchored to the slough bottom. Water temperature was measured to the nearest 1° C upon arrival at each site daily.

Catch was enumerated by species and rearing type daily at each site. For non-salmonid species, we measured the fork length (nearest 1 mm) of up to 20 fish per species captured. Salmonids were anesthetized in a bath of sodium bicarbonate (525mg/10 L water; 0.02 ounces/2.6 gal) to minimize handling stress. We measured the fork length (nearest 1 mm) of each salmonid captured. In addition, a tissue sample (partial fin clip) was collected from each fish captured, and preserved in a vial containing 70% denatured alcohol (v/v) for delivery to City of Portland staff for future genetic analysis. Anesthetized fish were allowed to recover in an aerated container before release back into the area of their capture.

Calculation of Catch Metrics

We calculated the catch per day (CPUE) by species captured at each trap site during a season using the equation

$$\text{CPUE}_{ikl} = \frac{\sum_{j=1}^{n} C_{ijkl}}{n}, \tag{1}$$

where

CPUE_{ikl} = catch of species i at site k during season l,
C_{ijkl} = the number of species i individuals captured on day j at site k during season l, and
n = the number of days the hoop trap fished.

In applying this model to our data, we assumed the following: 1) the number of fish captured is proportional to the amount of effort expended, 2) the population does not gain or lose individuals during sampling, and 3) capture probabilities do not change during sampling. Violations of these assumptions may introduce inherent bias that overlooks the influence of differences among species in terms of migration behavior, habitat preference, and life history or functional behavior traits unique to each species captured during the season. Therefore, these estimates should be viewed as relative measures of fish presence.

To characterize assemblages, we standardized percent CPUE for each species using the equation

$$\%CPUE_{ijk} = \frac{x_{ijk}}{\sum_{i=1,\, j=1}^{n} x_{ijk}}, \tag{2}$$

where

$\%CPUE_{ijk}$ = percent CPUE for species i captured at site j during season k, and
x_{ijk} = CPUE for species i captured at site j during season k

To balance our data matrices for subsequent analyses, we defined the fish assemblage as being comprised of all species observed throughout the year, regardless of site. Thus, even if a given species included in the putative assemblage was not observed during a sampling episode, we assumed it was available for capture. We used the balanced data matrix to conduct analyses of catch among both seasons and sites (See below).

Seasonal Shift in Fish Assemblage

We summarized the number and relative abundance of fish species and the frequency of occurrence of native and non-native families captured during each season. In addition, we evaluated seasonal variation in CPUE for each salmonid species in the lower Columbia Slough.

We assessed seasonal differences among fish assemblages using Kruskal-Wallis one way analysis of variance (ANOVA; $\alpha = 0.05$). Seasonal differences among assemblages were evaluated for the entire population and among individual sites. When differences among seasons were found to be statistically significant we conducted further post hoc analyses (Dunn's test; $\alpha = 0.05$) to identify specific significant pairwise comparisons.

Fish Distribution

We used site specific CPUE to evaluate the spatial distribution of each species during each season. We used standardized percentage CPUE (equation 2) to characterize species distribution throughout the lower Columbia Slough. As with the seasonal analyses of fish assemblages, we summarized the frequency of occurrence of native and non-native families, and evaluated spatial variation in salmonid CPUE during each season.

We assessed differences in fish assemblage among trap sites using Kruskal-Wallis one way ANOVA ($\alpha = 0.05$). When differences among site median values were found to be statistically significant, we used Dunn's test ($\alpha = 0.05$) to identify which site(s) differed among seasons.

RESULTS

Table 1 contains a site specific summary of trapping activities in the lower Columbia Slough. Each site contained a trap that was fished four days each season. We moved the trap at site 7 from the north shore directly across to the south shore after the first day of spring sampling to diversify the habitat types being sampled among the eight sites. The trap at site 7 was fished on the south shore for the remainder of the investigation. Water temperatures varied across seasons with spring, summer, fall, and winter temperatures averaging 9.4°, 21.3°, 15.4°, and 7.7 ° C (48.9°, 70.3°, 59.7°, and 45.9 ° F), respectively.

We identified 26 aquatic species in the lower Columbia Slough during the course of the investigation (Table 2). These 26 aquatic species comprised 12 families of which one was amphibian, two were crustaceans, and nine were fish. Of the 4,887 individuals captured during the entire investigation (Figure 2), amphibians made up 0.1%, crustaceans composed 1.5% while fish represented 98.4%. We were unable to identify 0.02% of the fish to family (all during fall

Table 1. Seasonal trapping information for each site used in the lower 13.5 km of the Columbia Slough 2008-2009. A horizontal bar indicates no data collected for attribute.

	Initial deploy			Final retrieval		
Season, Site number, (WGS 84 Latitude/Longitude)	Date and time	Distance from shore 0.1 m (ft.)	Water temperature 1° C (F)	Date and time	Distance from shore 0.1 m (ft.)	Water temperature 1° C (F)
Spring,						
1 (45.38402 122.45847)	3/24/08 12:34	12.2 (40.0)	9 (48)	3/28/08 09:20	7.0 (23.0)	8 (46)
2 (45.37818 122.45556)	3/24/08 11:48	4.4 (14.4)	8 (46)	3/28/08 11:37	3.0 (9.8)	—
3 (45.37057 122.45642)	3/24/08 11:10	13.2 (43.3)	9 (48)	3/28/08 12:14	10.7 (35.1)	—
4 (45.36452 122.76070)	3/24/08 10:13	9.1 (29.9)	10 (50)	3/28/08 10:59	7.6 (24.9)	7 (45)
5 (45.35510 122.42550)	3/31/08 10:30	19.2 (63.0)	11 (52)	4/4/08 10:04	15.2 (49.9)	12 (54)
6 (45.35320 122.41380)	3/31/08 11:30	10.6 (34.8)	11 (52)	4/4/08 10:43	7.1 (23.3)	12 (54)
7[a] (45.35140 122.40340)	3/31/08 13:36	2.6 (8.5)	11 (52)	4/1/08 11:28	2.6 (8.5)	10 (50)
7[b] (—)	4/1/08 11:29	8.2 (26.9)	10 (50)	4/4/08 11:28	8.0 (26.2)	12 (54)
8 (45.35100 122.38520)	3/31/08 12:14	5.0 (16.4)	11 (52)	4/4/08 08:59	4.4 (14.4)	12 (54)
Summer,						
1 (45.38410 122.45842)	6/23/08 12:14	10.0 (32.8)	20 (68)	6/27/08 10:13	4.0 (13.1)	20 (68)
2 (45.37820 122.45553)	7/7/08 10:34	4.0 (13.1)	21 (70)	7/11/08 10:50	1.5 (4.9)	23 (73)
3 (45.37070 122.45639)	6/23/08 11:23	3.0 (9.8)	21 (70)	6/27/08 10:50	2.5 (8.2)	21 (70)
4 (45.36459 122.44811)	7/7/08 11:29	6.0 (19.7)	23 (73)	7/11/08 11:42	6.0 (19.7)	24 (75)
5 (45.35852 122.42896)	6/23/08 10:47	6.1 (20.0)	21 (70)	6/27/08 11:30	2.7 (8.9)	22 (72)
6 (45.35531 122.41640)	7/7/08 09:41	2.0 (6.6)	21 (70)	7/11/08 10:03	0.5 (1.6)	22 (72)
7[b] (45.35195 122.40574)	6/23/08 10:05	7.0 (23.0)	20 (68)	6/27/08 09:30	4.0 (13.1)	21 (70)
8 (45.35023 122.38860)	7/7/08 12:37	7.6 (24.9)	20 (68)	7/11/08 09:05	6.1 (20.0)	20 (68)

a) Initial site location on north shoreline. Trap fished for one day before it was moved across slough to south shoreline.

b) South shoreline location used for all sampling except first day of spring, when trap was fished on north shoreline. Global positioning system (GPS) coordinates were not available for this site in spring.

Table 1 continued.

Season, Site number, (WGS 84 Latitude/Longitude)	Initial deploy Date and time	Distance from shore 0.1 m (ft.)	Water temperature 1° C (F)	Final retrieval Date and time	Distance from shore 0.1 m (ft.)	Water temperature 1° C (F)
Fall,						
1 (45.38415 122.45828)	10/6/08 11:45	17.4 (57.1)	17 (63)	10/10/08 12:40	11.0 (36.1)	12 (54)
2 (45.37818 122.45561)	9/29/08 11:00	1.8 (5.9)	16 (61)	10/3/08 10:40	5.0 (16.4)	18 (64)
3 (45.37052 122.45643)	10/6/08 11:00	5.5 (18.0)	15 (59)	10/10/08 11:40	3.4 (11.2)	12 (54)
4 (45.36462 122.44838)	9/29/08 12:15	6.0 (19.7)	16 (61)	10/3/08 11:50	13.1 (43.0)	17 (63)
5 (45.35839 122.42887)	10/6/08 10:05	6.0 (19.7)	15 (59)	10/10/08 10:40	12.3 (40.4)	12 (54)
6 (45.35527 122.41643)	9/29/08 09:24	5.4 (17.7)	14 (57)	10/3/08 09:50	6.8 (22.3)	16 (61)
7[b] (45.35206 122.40583)	9/29/08 10:10	7.5 (24.6)	14 (57)	10/3/08 09:00	8.4 (27.6)	16 (61)
8 (45.35021 122.38861)	10/6/08 09:10	3.4 (11.2)	15 (59)	10/10/08 08:55	3.4 (11.2)	12 (54)
Winter,						
1 (45.38245 122.45509)	1/5/09 13:37	6.0 (19.7)	7 (45)	1/9/09 12:15	8.0 (26.2)	—
2 (45.37491 122.45336)	1/5/09 12:51	3.0 (9.8)	7 (45)	1/9/09 10:12	0.0 (0.0)	7 (45)
3 (45.37031 122.45388)	1/12/09 12:07	2.0 (6.6)	8 (46)	1/16/09 11:40	1.5 (4.9)	8 (46)
4 (45.36272 122.44490)	1/12/09 13:16	2.5 (8.2)	8 (46)	1/16/09 10:00	6.9 (22.6)	7 (45)
5 (45.35508 122.42552)	1/12/09 09:30	1.3 (4.3)	8 (46)	1/16/09 08:50	1.3 (4.3)	8 (46)
6 (45.35318 122.41383)	1/5/09 12:23	7.0 (23.0)	7 (45)	1/9/09 09:37	0.1 (0.3)	8 (46)
7[b] (45.35119 122.40355)	1/12/09 11:05	1.0 (3.3)	8 (46)	1/16/09 12:45	1.5 (4.9)	7 (45)
8 (45.35014 122.38515)	1/5/09 11:22	7.0 (23.0)	6 (43)	1/9/09 11:38	1.0 (3.3)	8 (46)

Table 2. Aquatic assemblage found in the lower 13.5 km of the Columbia River Slough 2008-2009.

Water body, Common group	Family	Genus species	Common name	Origin
Columbia Slough				
Amphibian	Ranidae	*Rana catesbeana*	Bullfrog	Non-native
Crustacean	Astacoidea	*Pacifastacus*	Crayfish	—
	Palaemonoidea	*Exopalaemon modestus*	Siberian prawn	Non-native
Fish	Catostomidae	*Catostomus macrocheilus*	Largescale sucker	Native
	Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	Non-native
		Lepomis gulosus	Warmouth	Non-native
		Lepomis macrochirus	Bluegill	Non-native
		Micropterus dolomieu	Smallmouth bass	Non-native
		Pomoxis annularis	White crappie	Non-native
		Pomoxis nigromaculatus	Black crappie	Non-native
	Cottidae	*Cottus asper*	Prickly sculpin	Native
	Cyprinidae	*Acrocheilus alutaceus*	Chiselmouth	Native
		Cyprinus carpio	Common carp	Non-native
		Mylocheilus caurinus	Peamouth	Native
		Notemigonus crysoleucas	Golden shiner	Non-native
		Ptychocheilus oregonensis	Northern pikeminnow	Native
		Richardsonius balteatus	Redside shiner	Native
	Gasterosteidae	*Gasterosteus aculeatus*	Threespine stickleback	Native
	Ictaluridae	*Ameiurus melas*	Black bullhead	Non-native
		Ameiurus natalis	Yellow bullhead	Non-native
		Ameiurus nebulosus	Brown bullhead	Non-native
		Ictalurus catus	White catfish	Non-native
	Percidae	*Perca flavescens*	Yellow perch	Non-native
	Poeciliidae	*Gambusia affinis*	Western mosquitofish	Non-native
	Salmonidae	*Oncorhynchus kisutch*	Coho salmon	Native
		Oncorhynchus tshawytscha	Chinook salmon	Native

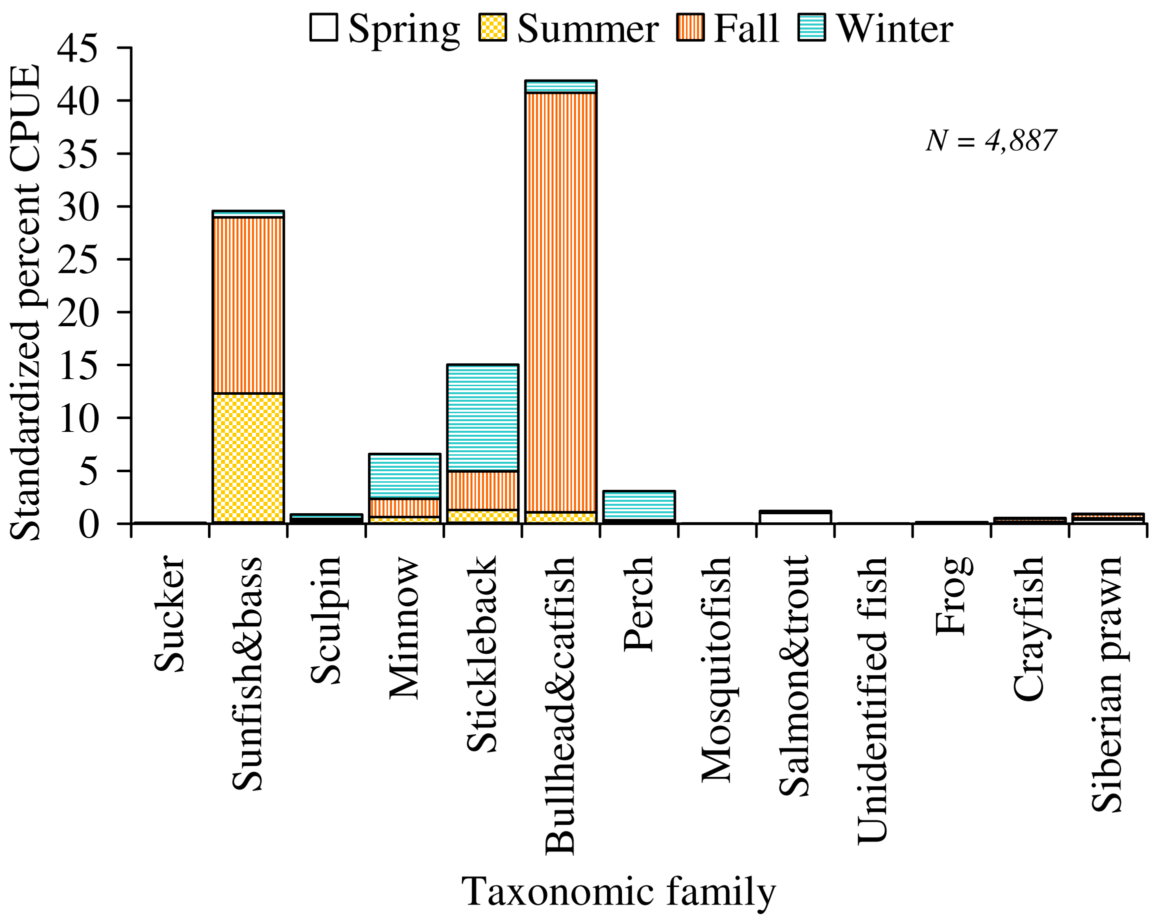


Figure 2. Standardized percent catch per unit of effort (CPUE) of all individuals captured in hoop traps in the lower 13.5 km of the Columbia Slough, 2008–2009. List includes fish that were not identified to family (0.02% in fall only) because their development was not advanced enough to show noticeable characteristics without sacrificing the fish.

collections; and none were family Salmonidae) because their development was not advanced enough to show noticeable characteristics without sacrificing the fish. Overall, 22.2% of the individuals captured were native species while 77.8% were non-native species. The family Salmonidae represented 1.2% of the total individuals captured during the investigation, and consisted of both juvenile Chinook salmon and juvenile coho salmon *O. kisutch*.

We measured the fork length of 1,995 individuals (Table 3). Of the 23 species of fish captured in the lower Columbia Slough, 13 were composed of both juvenile and adult size fish, seven were made up solely by juvenile size fish, and three were represented by adult size fish only. Chinook salmon and coho salmon encountered in the lower Columbia Slough were of juvenile size only. Appendix Table 1 contains descriptive statistics for fork lengths of fish species measured by season.

Table 3. Descriptive statistics for fork length (FL; mm) by species of fish measured in the lower Columbia Slough 2008-2009. To convert from mm to inches multiply mm by 0.0394.

Family, *Genus species*	Common name	n	Mean FL (Std)	Minimum/ Maximum	Maturity (FL mm)[a]
Catostomidae					
Catostomus macrocheilus	Largescale sucker	4	157.0 (30.6)	129/200	J (300)
Centrarchidae					
Lepomis gibbosus	Pumpkinseed	248	90.8 (24.8)	34/167	J/A (80)
Lepomis gulosus	Warmouth	5	114.4 (27.8)	81/154	A (76)
Lepomis macrochirus	Bluegill	282	68.8 (26.3)	23/150	J/A (75)
Micropterus dolomieu	Smallmouth bass	2	46.5 (9.2)	40/53	J (150)
Pomoxis annularis	White crappie	171	74.0 (43.7)	44/300	J/A (180)
Pomoxis nigromaculatus	Black crappie	152	106.7 (60.5)	47/255	J/A (180)
Cottidae					
Cottus asper	Prickly sculpin	42	113.9 (22.4)	53/151	* (50)
Cyprinidae					
Acrocheilus alutaceus	Chiselmouth	4	70.3 (8.5)	61/78	J (245)
Cyprinus carpio	Common carp	91	95.2 (40.1)	45/318	J/A (305)
Mylocheilus caurinus	Peamouth	64	125.1 (40.4)	67/210	J/A (180)
Notemigonus crysoleucas	Golden shiner	16	94.5 (22.5)	68/135	A (64)
Ptychocheilus oregonensis	Northern pikeminnow	18	96.5 (20.3)	60/136	J (250)
Richardsonius balteatus	Redside shiner	2	74.5 (10.6)	67/82	J/A (70)
Gasterosteidae					
Gasterosteus aculeatus	Threespine stickleback	348	46.8 (8.0)	21/70	J/A (30)
Ictaluridae					
Ameiurus melas	Black bullhead	98	62.9 (20.3)	46/159	J/A (100)
Ameiurus natalis	Yellow bullhead	8	92.0 (46.2)	57/183	J/A (170)
Ameiurus nebulosus	Brown bullhead	277	89.2 (45.2)	40/269	J/A (170)
Ictalurus catus	White catfish	2	118.0 (76.4)	64/172	J (b)
Percidae					
Perca flavescens	Yellow perch	102	102.7 (33.5)	77/223	J/A (100)
Poeciliidae					
Gambusia affinis	Western mosquitofish	1	49.0 (—)	—/—	A (c)
Salmonidae					
Oncorhynchus kisutch	Coho salmon	2	95.0 (14.1)	85/105	J (d)
Oncorhynchus tshawytscha	Chinook salmon	56	72.7 (13.7)	55/140	J (d)

a) Fork length (FL) used to distinguish juvenile (J) from adult (A) maturity stage based on Carlander (1977) and Wydoski and Whitney (2003)

b) Wydoski and Whitney (2003) state white catfish mature at size > yellow bullhead (170 mm FL)

c) Western mosquitofish mature soon after emerging (4–6 weeks; Wydoski and Whitney 2003)

d) Used jack salmon FL, but mature precocious fish may be 85–140 mm FL (Van Dyke et al. 2008)

* Cottidae < 50 mm FL were captured but generally did not get identified to species.

Seasonal Shift in Fish Assemblage

We identified unique seasonal assemblages across the four seasons. During spring (March 24–April 4, 2008), the combined catch was composed of 10 families containing 12 different species (Appendix Table 2). Only juvenile Chinook salmon had a CPUE greater than 2 individuals per day. Juvenile salmonidae had the highest standardized percent CPUE (52%) of all families captured in spring (Figure 3). Native species had a higher standardized percent CPUE (68%) than non-native species (32%) captured in spring. Chinook salmon were the only salmonid species observed during spring. All but one of the Chinook salmon observed were of hatchery origin (adipose fin missing), and all but one of these fish were from 62 to 77 mm fork length (2.44 to 3.03 inches). The remaining Chinook salmon of hatchery origin was much larger in size 140 mm fork length (5.5 inches).

During summer (June 23–July 11, 2008), the combined catch was composed of 11 families containing 18 different species (Appendix Table 2). There were seven different species (black crappie *Pomoxis nigromaculatus*, bluegill, pumpkinseed *L. gibbosus*, white crappie *P. annularis*, northern pikeminnow *Ptychocheilus oregonensis*, threespine stickleback *Gasterosteus aculeatus*, and brown bullhead *A. nebulosus*) that had CPUE values greater than 2 individuals per day. Centrarchidae had the highest standardized percent CPUE (77%) of all families captured during summer (Figure 3). Native species had a lower standardized percent CPUE (15%) than non-native species (85%). As in spring, Chinook salmon were the only salmonid specie observed during summer. All three fish were of natural origin (adipose fin intact), and were from 55 to 70 mm (2.44 to 3.03 inches) fork length.

During fall (September 29–October 10, 2008), the combined catch was composed of 9 families containing 20 different species (Appendix Table 2). There were eight different species (black crappie, bluegill, pumpkinseed, white crappie, common carp *Cyprinus carpio*, threespine stickleback, black bullhead *A. melas*, and brown bullhead) that had CPUE values greater than 2 individuals per day. Ictaluridae had the highest standardized percent CPUE (63%) of all families captured during fall (Figure 3). Native species had a lower standardized percent CPUE (7%) than non-native species (93%). No salmonids were captured during fall.

During winter (January 5–16, 2009), the combined catch was composed of 11 families containing 21 different species (Appendix Table 2). There were five different species (brown bullhead, peamouth *Mylocheilus caurinus*, prickly sculpin *Cottus asper*, threespine stickleback, and yellow perch *Perca flavescens*) that had CPUE values greater than 2 individuals per day. Gasterosteidae had the highest standardized percent CPUE (52%) of all families captured during winter (Figure 3). Native species had a higher standardized percent CPUE (74%) than non-native species (26%). Both Chinook salmon and coho salmon were captured during winter. All three Chinook salmon and both coho salmon were of natural origin (adipose fin intact), and were from 73 to 130 mm (2.87 to 5.12 inches) and from 85 to 108 mm (3.35 to 4.25 inches) fork length, respectively.

Ranked CPUE for fish assemblages was found to be different among seasons (Kruskal-Wallis; $H = 12.243$, $df = 3$, $P = 0.007$). Pairwise multiple comparisons found that only fall and

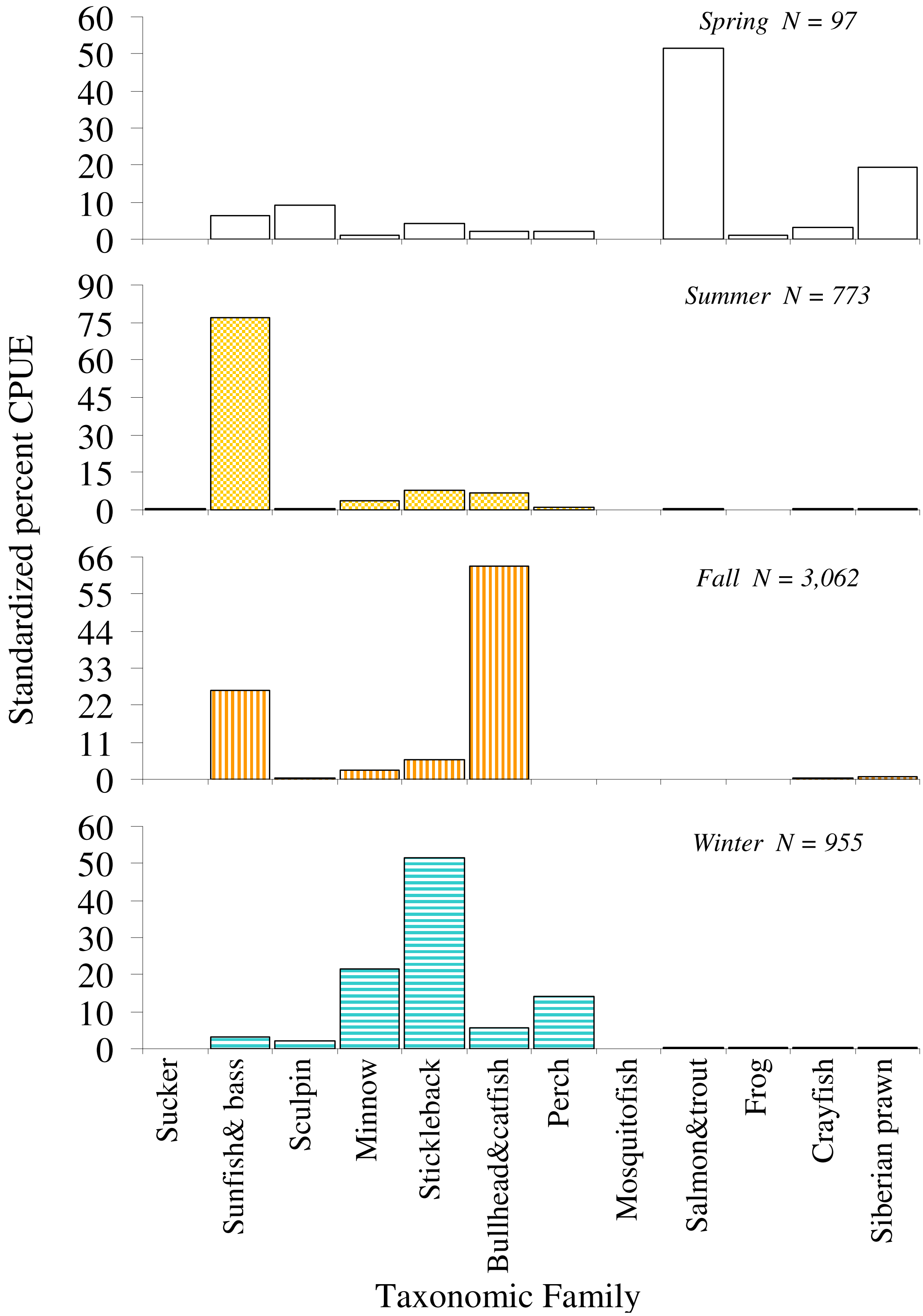


Figure 3. Standardized percent catch per unit of effort (CPUE) of fish assemblage captured each season in hoop traps in the lower 13.5 km of the Columbia Slough, 2008–2009.

winter differed from spring (Dunn's method; $P < 0.05$). Differences between the other four pairs were not found to be statistically significant (Dunn's method; $P > 0.05$).

Ranked CPUE for species of native and non-native origin were found to be different among seasons (Kruskal-Wallis; H = 33.086, df = 7, $P < 0.001$). There were five of 28 pairwise multiple comparisons found to be significantly different between seasons (Dunn's method; $P < 0.05$). These were: 1) fall non-native vs. spring native, 2) fall non-native vs. spring non-native, 3) fall non-native vs. summer native, 4) summer non-native vs. spring native, and 5) summer non-native vs. spring non-native assemblages were not statistically significant (Dunn's method; $P > 0.05$).

Although ranked CPUE for Chinook salmon were numerically different among seasons, variability was not found to be statistically significant (Kruskal-Wallis; H = 2.403, df = 3, $P = 0.493$). Ranked CPUE for coho salmon were numerically higher in winter than spring, summer, and fall. Differences among the seasons were not statistically significant (Kruskal-Wallis; H = 6.200, df = 3, $P = 0.102$).

Fish Distribution

Overall, there were numeric differences in fish assemblage and diversity among the eight trapping sites (Table 4). The CPUE for the 26 aquatic species found in the lower Columbia Slough was zero per day 33% of the time. Overall, site 1 captured the fewest individuals (44), and the CPUE never exceeded 2 per day (Table 4). Site 8 captured the most individuals (3,157) with 15 measurements with CPUE >2 per day. Over the course of the investigation, sites 1 and 7 captured the fewest species (11 and 10, respectively) while sites 5 and 8 captured the most (25 and 23, respectively). Overall, threespine stickleback was the most prevalent species at sites 1 through 5, and was the second and third most prevalent at sites 7 and 6, respectively. Yellow perch, white crappie, and brown bullhead were the most prevalent species captured at site 6, 7 and 8, respectively.

Both native and non-native species were found at all sites in the lower Columbia Slough (Figure 4). Standardized percent CPUE values were generally highest at site 8 with native species predominating in spring, and non-native species dominating in summer and fall. Standardized percent CPUE values were highest at site 2 in winter with native species predominating.

Members of the family Salmonidae had the highest CPUE at site 8, and were not captured at all at sites 5, 6, and 7 (Figure 5). Chinook salmon were captured at five of the eight sites while coho salmon were captured in two of the eight sites. With the exception of site 8 (CPUE 12.25 per day), Chinook salmon had low CPUE (0.75 or 0.25 per day). Coho salmon had low CPUE (0.25 per day) at both sites 3 and 8, and were not captured at the other six sites. As mentioned earlier, the majority of the Chinook salmon (85%) captured were of hatchery origin, and both coho salmon were of natural origin. In general, the low representation of these species hampers vigorous quantitative or qualitative analysis.

Table 4. Catch per unit of effort by trap site and season sampled in the Columbia Slough 2008–2009. The summary at the bottom of the table includes the total number of individuals captured, the median, 20th and 80th percentiles of CPUE by site. Descriptive statistics were calculated using an all inclusive list of 26 species captured during the investigation.

Season, Common name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Spring								
Siberian prawn	0.00	0.00	0.00	0.00	0.75	1.75	1.75	0.50
Black crappie	0.25	0.00	0.00	0.00	0.50	0.00	0.00	0.00
Bluegill	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
Brown bullhead	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25
Chinook salmon	0.00	0.25	0.00	0.00	0.00	0.00	0.00	12.25
Common carp	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Crayfish	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.50
Prickly sculpin	0.00	0.00	0.00	0.00	0.25	0.75	0.00	1.00
Pumpkinseed	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.25
Tadpole (bullfrog)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Threespine stickleback	0.25	0.00	0.00	0.00	0.25	0.00	0.00	0.50
Yellow perch	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00
Summer								
Siberian prawn	0.00	0.00	0.50	1.00	0.00	0.00	0.00	0.00
Black bullhead	0.75	2.75	1.00	2.25	4.25	2.25	1.00	0.00
Bluegill	0.00	0.50	1.50	0.50	1.50	2.50	1.00	55.50
Brown bullhead	0.00	0.25	0.25	0.00	0.00	2.25	0.25	9.75
Chinook salmon	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common carp	0.00	0.00	0.00	0.25	0.00	0.25	0.25	0.00
Crayfish	0.00	0.00	0.00	0.00	0.00	0.50	0.75	0.25
Golden shiner	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
Largescale sucker	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.25
Northern pikeminnow	0.00	0.00	0.00	0.50	0.25	0.25	0.00	3.00
Peamouth	0.00	0.25	0.25	0.00	0.50	0.50	0.00	1.00
Prickly sculpin	0.25	0.00	0.25	0.00	0.00	0.25	0.00	0.75
Pumpkinseed	0.00	0.00	4.75	1.75	2.50	4.75	2.75	45.75
Tadpole (bullfrog)	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Threespine stickleback	0.00	2.50	0.00	0.00	0.25	0.00	0.25	12.00
White crappie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Yellow bullhead	0.00	0.00	0.50	0.25	2.50	0.50	0.00	0.00
Yellow perch	0.25	0.00	0.25	0.25	0.00	0.25	0.00	1.25
Fall								
Siberian prawn	1.25	0.00	1.25	0.50	1.25	0.50	0.00	0.00
Black bullhead	0.00	1.25	0.75	0.00	0.50	0.25	0.00	88.50

Table 4. Continued

Season, Common name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Fall cont.								
Black crappie	0.00	0.00	2.00	0.75	3.00	0.00	0.75	58.50
Bluegill	0.50	0.50	7.25	5.25	1.25	2.50	2.75	48.75
Brown bullhead	0.00	6.50	2.75	10.00	2.25	4.50	0.75	363.50
Common carp	0.00	0.25	0.25	1.75	0.75	1.25	0.00	15.75
Crayfish	0.00	0.50	0.25	0.50	0.50	0.25	0.25	1.25
Golden shiner	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25
Peamouth	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
Prickly sculpin	0.00	0.25	0.50	0.00	0.25	0.25	0.00	0.75
Pumpkinseed	0.00	1.00	2.00	2.25	0.25	0.50	0.25	20.50
Redside shiner	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.25
Smallmouth bass	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Threespine stickleback	2.00	0.75	20.50	5.25	11.00	1.50	2.00	1.50
Warmouth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Western mosquitofish	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
White catfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
White crappie	1.25	1.00	1.00	10.50	2.00	5.50	11.75	8.00
Yellow bullhead	0.00	0.00	0.25	0.25	0.00	0.00	0.00	1.25
Yellow perch	0.00	0.25	0.00	0.50	0.00	0.00	0.00	0.50
Winter								
Siberian prawn	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
Black bullhead	0.00	0.00	0.25	0.50	0.00	0.75	0.00	0.50
Bluegill	0.50	1.25	0.00	1.75	0.00	0.50	0.25	0.25
Brown bullhead	0.00	0.25	0.00	1.50	0.00	4.25	0.25	5.25
Chinook salmon	0.00	0.00	0.25	0.50	0.00	0.00	0.00	0.00
Chiselmouth	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Coho salmon	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25
Common carp	0.00	0.00	0.25	0.75	0.00	0.50	0.00	1.25
Crayfish	0.00	0.00	0.50	0.00	0.00	0.25	0.25	0.00
Golden shiner	0.00	1.50	0.00	0.25	0.00	2.00	0.00	0.00
Largescale sucker	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00
Northern pikeminnow	0.25	0.25	0.00	0.00	0.00	0.25	0.00	0.00
Peamouth	1.00	41.25	0.00	0.50	0.00	0.50	0.00	0.00
Prickly sculpin	0.00	0.00	0.50	0.75	0.00	2.25	0.00	1.50
Pumpkinseed	0.00	0.25	0.25	0.00	0.00	0.25	0.00	0.50
Tadpole (bullfrog)	0.00	0.00	0.00	0.75	0.50	0.00	0.00	0.00
Threespine stickleback	0.25	58.75	3.00	27.75	0.00	8.50	1.75	23.00
Warmouth	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00

Table 4. Continued

Season, Common name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8
Winter cont.								
White crappie	0.00	1.00	0.25	0.00	0.00	0.00	0.25	0.00
Yellow bullhead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Yellow perch	0.50	6.75	3.00	6.75	0.00	16.50	0.00	0.25
Individuals captured	***44***	***526***	***233***	***369***	***157***	***295***	***120***	**3,157**
Median CPUE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
20th percentile CPUE	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80th percentile CPUE	**0.25**	**1.00**	**1.00**	**1.68**	**0.75**	**2.18**	**0.60**	**11.33**

Ranked CPUE for fish assemblages was found to be significantly different among sites (Kruskal-Wallis; H = 116.925, df = 31, $P < 0.001$). Pairwise multiple comparisons found that only six of the 496 groupings differed significantly (Dunn's method; $P < 0.05$). Site 8 in fall differed from site 5 in winter and differed from sites 1, 2, 3, 4, and 7 in spring. Differences between the other 490 pairs were not significantly different (Dunn's method; $P > 0.05$).

Ranked CPUE for species of native and non-native origin were numerically different among sites, however these differences were not statistically significant (Kruskal-Wallis; H 19.349, df 15, $P = 0.198$). This was also the case when comparing CPUE values among sites for native species (Kruskal-Wallis; H = 8.399, df = 7, $P = 0.299$), and non-native species alone (Kruskal-Wallis; H = 7.923, df = 7, $P = 0.339$).

Although ranked CPUE values for Chinook salmon were numerically different, these values were not statistically significant (Kruskal-Wallis; H = 3.482, df = 7, $P = 0.837$). Ranks of site specific CPUE for coho salmon were also numerically higher at sites 3 and 8, but differences among sites were not statistically significant (Kruskal-Wallis; H: 6.200, df 7, $P = 0.517$).

DISCUSSION

Our catch represents an introductory and relative assessment of the composition of fish species inhabiting the lower Columbia Slough, and includes an amphibian and two crustacean species that were susceptible to the gear type used. Our catch data suggest the lower Columbia Slough is being utilized to varying degrees by many of the fish species found in earlier studies in the Columbia and Willamette rivers (Farr and Ward 1993; Friesen et al. 2003; Poe et al. 1991; ODFW unpublished data). Unlike these earlier studies, we observed black bullhead and white catfish *I. catus* in the lower Columbia Slough; taxa known to be present in the Columbia River ecoregion (Wydoski and Whitney 2003). There were seven species of fish found in the surrounding area (dace *Rhinichthys spp.*, eulachon *Thaleichthys pacificus*, lamprey, American shad *Alosa sapidissima*, sand roller *Percopsis transmontanus*, starry flounder *Platichthys stellatus*, and sturgeon *Acipenser spp.*) that were not captured during our investigation in the

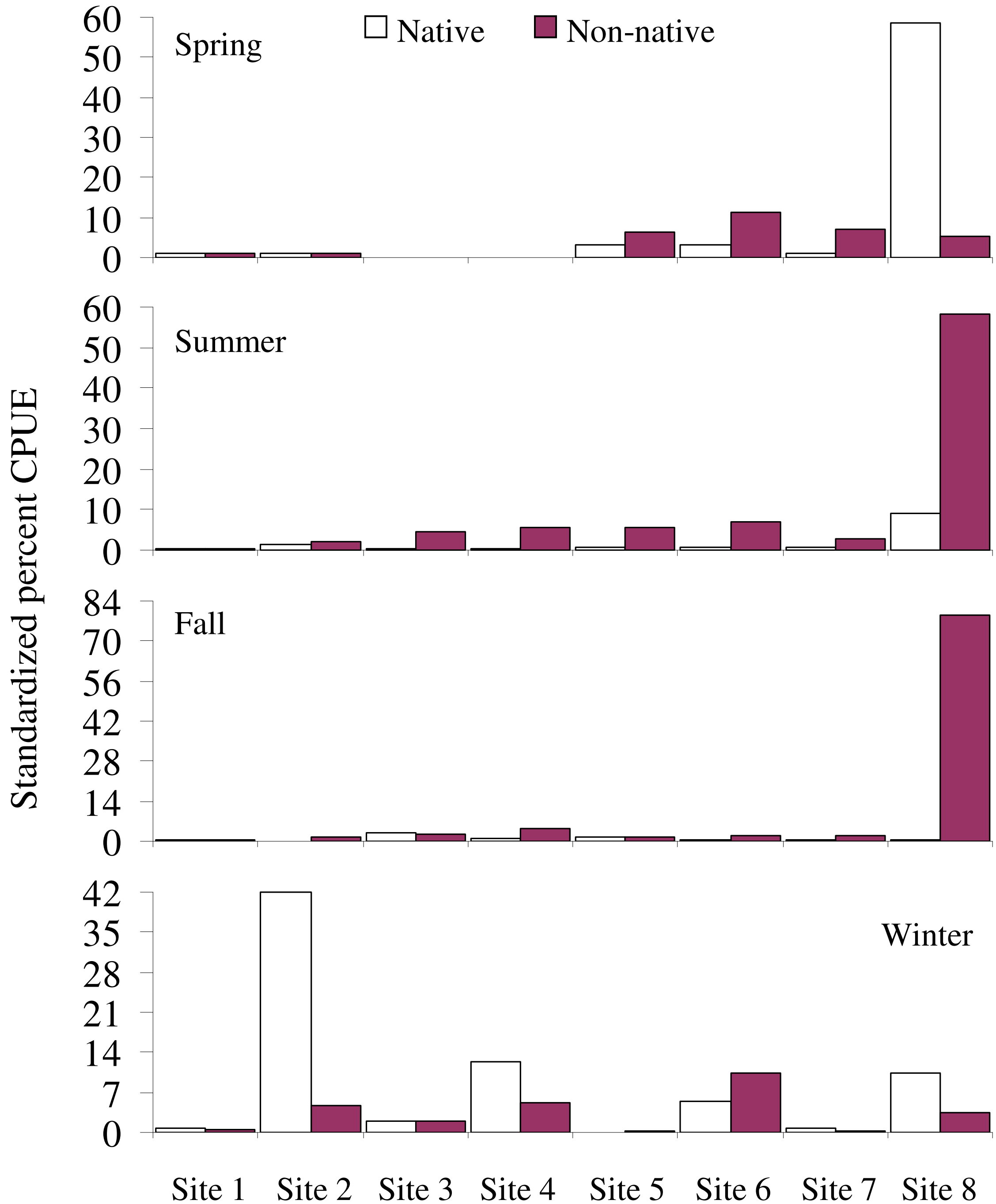


Figure 4. Standardized percent catch per unit of effort (CPUE) for native and non-native species captured in hoop traps at specified sites in the lower 13.5 km of the Columbia Slough, 2008–2009.

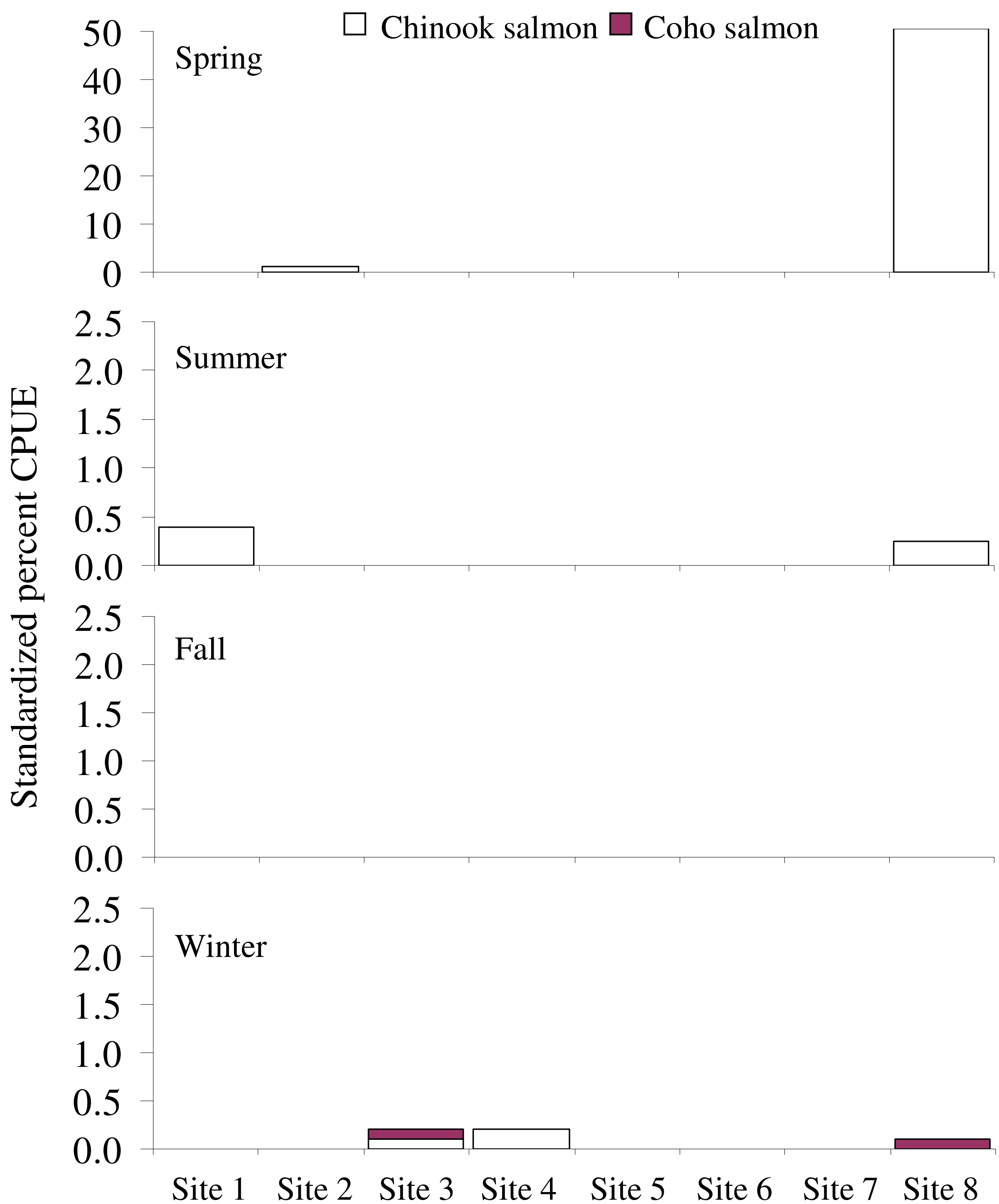


Figure 5. Standardized percent catch per unit of effort (CPUE) for Chinook salmon and coho salmon captured in hoop traps at specified sites in the lower 13.5 km of the Columbia Slough, 2008–2009. No Pacific salmon or trout were captured during fall.

lower Columbia Slough. Threespine stickleback was encountered frequently in our catch. This species is one of many found in the region for which basic information is considered lacking (ODFW 2006). The level of risk, habitat requirements, and abundance could be clarified by an enhanced assessment of their use of the Columbia Slough. Additional monitoring in the Columbia Slough could provide a better understanding of the role the system plays in sustaining aquatic community in the larger Columbia River ecoregion.

Throughout this study, the composition of the fish assemblage in the lower Columbia Slough changed seasonally and by site. Life history characteristics and ontogeny, in addition to the magnitude and direction of species interactions have been shown to vary among seasons for numerous fishes (Crowder 1990; Kwak and Peterson 2007). Based on the composition of our catches and documented knowledge of ecology of many species we encountered, the lower Columbia Slough is likely no exception. Our stated objectives did not include a direct evaluation of interactions among the species. Instead, this work sought to characterize the composition of fishes in the lower Columbia Slough assemblage. Looking at species interaction in more detail could provide a level of understanding needed to define the ecology of the fish community in the lower Columbia Slough.

Both native and non-native species were captured during the course of this investigation. Although we did not evaluate use of lower Columbia Slough habitats by either native or non-native fishes for important life functions including reproduction, we presume the system is important for both adult and juvenile rearing activities. Much research has shown that native salmonid species use off channel habitats including wetlands and sloughs during early life (Nickelson et al. 1992; Murray and Rosenau 1989; Teel et al. 2009). Likewise, Wydoski and Whitney (2003) reported that threespine stickleback spawn in slow velocity habitats containing benthic macrophytes or algae. Given the hydrology in the lower Columbia Slough, these types of habitats are likely readily available. The abundance of threespine stickleback has been shown to rapidly decrease in the presence of non-native brown bullhead (McPhail and Lindsey 1986). This may be the result of important and prevalent interactions between native and non-native species found in the lower Columbia Slough. Of the 23 non-native fish species documented as being present in the Columbia River ecoregion (Wydoski and Whitney 2003, Sytsma et al 2004), we captured 13 in the lower Columbia Slough. The relative species richness of introduced fish documented during this study is not surprising given habitat in the lower Columbia Slough is well suited to support their individual life histories. Understanding the balance between native and non-native species will continue to be an important topic. Efforts like this should continue to monitor and describe fish composition in aquatic habitats in the region.

Aquatic invasive species in the Pacific Northwest have been receiving greater attention in recent years (Wiedemer and Chan 2008). Bullfrog *Rana catesbeana* tadpoles, one of Oregon's most unwanted invasive species (ODFW 2006), were found in the lower Columbia Slough. Given many species of small sized fish were present in the lower Columbia Slough, knowledge of the prevalence of predation by adult bullfrogs, and an understanding of the role this interaction plays in regulating aquatic diversity, may be needed. We captured aquatic species common to the aquarium trade, found in ballast water, or introduced for biological control purposes in the lower Columbia Slough (Sytsma et al. 2004). Among these species, Siberian prawn

Exopalaemon modestus and western mosquitofish may be impacting the survival of native species through competition for habitat and prey items, predation, or disease transmission. Enhancing our understanding of the overall abundance and use of the Columbia Slough by invasive taxa could help minimize their impacts on native species in the area. Additional monitoring and control measures for these aquatic invasive species may be needed in the Columbia Slough.

Only two salmonid species, Chinook salmon and coho salmon, were found in the lower Columbia Slough. Although catch metrics differed numerically in both seasonal presence and spatial distribution, these differences were not statistically significant. Grant and Kramer (1990) were not able to effectively detect changes in fish densities when fish densities were very low. Hubert and Fabrizio (2007) cautioned against using the catch per unit effort metric to identify temporal trends when samples sizes are very small. Variation in recruitment, growth, and survival can change between and among seasons, leading to violations of the underlying assumptions of the CPUE model. Diversity in the early life history of anadromous salmonid species has been well documented (Groot and Margolis 1991, Quinn 2005). Dispersal behavior exhibited by both Chinook salmon and coho salmon may involve either securing a localized territory and remaining in the area they hatched, or moving among habitats in a wide juvenile rearing area (Nielsen 1992; Van Dyke et al. 2008 and 2009). Those fish that depart from natal areas may be found dispersing into less than optimal non-natal habitats (Murray and Rosenau 1989; Scrivener et al. 1994). Developing an understanding of the importance of the lower Columbia Slough for juvenile salmonids may require a more rigorous sampling regimen that utilizes standardized gear types (e.g. electrofishing, seining, migrant traps). Future efforts of this kind could benefit from an intensive inventory of the habitat, in addition to a more robust method for estimating abundance (e.g., mark-recapture). Continued research could help identify how juvenile fish are entering and leaving the lower Columbia Slough. Our investigation was unable to specifically address these questions.

The majority of the Chinook salmon captured in the lower Columbia Slough were fry of hatchery origin (adipose fin missing), and all but one of the fish captured in spring were presumably released directly into Spring Creek from USFWS Spring Creek National Fish Hatchery March 7 and 8, 2008 (FPC 2009c). The remaining Chinook salmon of hatchery origin may have been residualized fish or yearling smolt released from an undetermined location. Understanding the importance of the lower Columbia Slough for rearing juvenile fish, of any origin, could help describe important associations related to habitat requirements of these fish. Off channel rearing habitat has been shown to be important for overwintering coho salmon (Nickelson et al. 1992; Quinn and Peterson 1996). However in addition to capturing Chinook salmon and coho salmon in the lower Columbia Slough during winter, we encountered young fish in spring and summer. In the Fraser River, juvenile Chinook salmon have been shown to use a similar dispersal behavior (Murray and Rosenau 1989; Scrivener et al. 1994). However, in these cases non-natal stream rearing occurred for a short period of time. Quantifying the importance of these types of habitat in other seasons may prove important in achieving conservation and management objectives in the Columbia River ecoregion. Additional insight on fish behavior in the lower Columbia Slough may provide an opportunity to identify such an association.

RECOMMENDATIONS

We recommend continued monitoring of fish assemblages in the lower Columbia Slough and other aquatic habitats in the region. Continued efforts to provide this type of information is needed to effectively identify risk levels for species of interest, available habitats, and trends in abundance for the multiple species found in the ecoregion. We are committed to fostering partnerships with the City of Portland and others to continue critical monitoring and evaluation of fish community structure in the lower Columbia Slough and other aquatic habitats in the region.

We recommend a cooperative effort be explored for monitoring and controlling aquatic invasive species in the Columbia Slough.

We suggest conducting post hoc statistical analysis designed to evaluate the ability of interactions between seasons and sites to account for variability in assemblage composition. Submitting these analyses in manuscript form for peer review should aid in validating this work, and provide important insight related to this aquatic community.

We recommend continued research be explored that focuses on identifying ways in which juvenile Chinook salmon and coho salmon utilize the Columbia Slough. Sampling designs specific to dispersal behavior may be of interest. Providing an inventory of available habitat could benefit conservation management and enhancement efforts in the Columbia River ecoregion. These actions would be best achieved by employing more standardized sampling approach.

AKNOWLEDGEMENTS

We would like to thank Timothy Blubaugh, Bonnie Cunningham, David Helzer, Tucker Jones, Brian Monnin, Shaffryn Schade, Chad Smith, Peter Susi, Howard Takata, Eric Tinus, Michele Weaver and Justin Zweifel for assisting with field sampling during the course of this investigation. We would like to thank the Port of Portland for providing access by motor vehicle to Ramsey Wetland. We thank City of Portland Bureau of Environmental Sciences (BES) Columbia Boulevard Wastewater Treatment Plant and Portland International Raceway for allowing us to pass through their facilities and locked gates to access trap sites 5 and 6, respectively. We appreciate both Metro and Multnomah County Drainage District Number 1 for providing direct access to Wapato Wetlands (site 4) and the drainage district's (site 8) launch sites, as well as for temporary outdoor storage of our traps, trailer, and pontoon boat. We could not have completed this work without the support provided by ODFW North Willamette Watershed District personnel, (Todd Alsbury and Danette Faucera) for the use of their kayaks, pontoon boat, trailer, and other ancillary gear needed to effectively employ all of the equipment, and Karen Hans for providing four hoop traps for the full duration of sampling. We would also like to express our thanks to Gary Galovich and Don Wenzel for providing additional information regarding hoop trap design and use in small streams.

We would like to thank Danette Faucera, Nancy Hendrickson, Tucker Jones, Kaitlin Lovell, Christine Mallette, Chris Prescott, Mike Reed, Chad Smith, and Michele Weaver for reviewing this report. Their recommendations and comments were appreciated, and essential in the completion of this report. Thanks to Christine Mallette and Kaitlin Lovell for administering the project.

Thanks to the City of Portland for their continued commitment to proactive management of aquatic resources within the city boundaries. This commitment is essential in collecting needed information related to fish in the region, and has established a benchmark for other municipalities to strive for. Projects like this, serve to inform the public on how resource management works to achieve healthy functioning habitats for fish and wildlife that benefit present and future generations.

REFERENCES

Carlander, K. D. 1977. Handbook of freshwater fishery biology, volume 2. The Iowa State University Press, Ames, Iowa.

Crowder, L. B. 1990. Community Ecology. Pages 609–632 *in* C. B. Schreck and P. B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland.

EPA (Environmental Protection Agency). 2007. Biological assessment. Available: http://www.epa.gov/owow/monitoring/bioassess.html (August 7, 2009).

FPC (Fish Passage Center). 2009a. Adult passage data. Available: http://www.fpc.org/adultsalmon_home.html (August 3, 2009).

FPC (Fish Passage Center). 2009b. Smolt data. Available: http://www.fpc.org/smolt/SMP_queries.html (August 3, 2009).

FPC (Fish Passage Center). 2009c. Query hatchery releases within the Columbia and Snake river basins. Available: http://www.fpc.org/hatchery/HatcheryQuery_by_releasedates.html (August 3, 2009).

Farr, R. A., and D. L. Ward. 1993. Fishes of the lower Willamette River, near Portland, Oregon. Northwest Science 67:16:22.

Fore L. S. 2003. Developing biological indicators: lessons learned from Mid-Atlantic streams. U.S. Environmental Protection Agency 903/R-003/003. Fort Meade, Maryland.

Friesen, T. A., H. K. Takata, J. S. Vile, J. C. Graham, R. A. Farr, M. J. Reesman, and B. S. Cunningham. 2003. Relationships between bank treatment/nearshore development and anadromous/resident fish in the lower Willamette River, Oregon Department of Fish and Wildlife Annual (2001-2002). Report to the City of Portland, Portland, Oregon.

Friesen, T. A., J. S. Vile, and A. L. Pribyl. 2007. Outmigration of juvenile Chinook salmon in the lower Willamette River, Oregon. Northwest Science 81:173:190.

Grant, J. W. A., and D. L. Kramer. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences 47:1724-1737.

Groot, C. G., and L. Margolis, editors. 1991. Pacific salmon life histories. UBC press, Vancouver, British Columbia.

Hans, K., and D. Wenzel. 2005. Presence/absence monitoring of fish assemblages in Smallman Creek, Sucker Slough, and Bear Branch near Scio, OR. ODFW 2005 Shelburn Area Stationary Trap Report.

Hubert, W. A. and M. C. Fabrizio. 2007. Relative abundance and catch per unit effort. Pages 279–325 *in* C. R. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, Maryland.

Hughes, R. M. 1995. Defining acceptable biological status by comparing with reference conditions. Pages 31–47 *in* W. S. Davis and T. P. Simons, editors. Biological assessment and criteria: tools for water resource planning and decision making. Lewis publishers, Boca Raton, Florida.

Hughes, R. M., P. R. Kaufmann, A. T. Herlihy, T. M. Kincaid, L. Reynolds, and D. P. Larsen. 1998. A process for developing and evaluating indices of fish assemblage integrity. Canadian Journal of Fisheries and Aquatic Sciences 55:1618-1631.

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries 66:21:27.

Kwak, T. J. and J. T. Peterson. 2007. Community indices, parameters, and comparisons. Pages 677–763 *in* C. R. Guy and M. L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, Maryland.

McPhail, J. D., and C. C. Lindsey. 1986. Zoogeography of the freshwater fishes of Cascadia: the Columbia River system and rivers north to the Stikine. Pages 615–638 *in* C. H. Hocutt and E. O. Wiley, editors. The zoogeography of Nother American freshwater fishes. John Wiley and Sons, New York, New York.

Murray, C. B., and M. L. Rosenau. 1989. Rearing of juvenile Chinook salmon in nonnatal tributaries of the lower Fraser River, British Columbia. Transactions of the American Fisheries Society 118:284-289.

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

Nielsen, J. L. 1992. Microhabitat-specific foraging behavior, diet, and growth of juvenile coho salmon. Transactions of the American Fisheries Society 121:617-634.

NOAA (National Oceanic and Atmospheric Administration) Fisheries Service. 2009. Adult passage data. Available: http://www.fpc.org/ adultsalmon_home.html (August 3, 2009).

ODFW (Oregon Department of Fish and Wildlife). 2006. The Oregon Conservation Strategy. Available: http://www.dfw.state.or.us/conservationstrategy/document_pdf/b-species_3.pdf (August 5, 2009).

ODFW (Oregon Department of Fish and Wildlife). 2009. ODFW's Oregon plan monitoring program for coastal basins. Available: http://oregonstate.edu/dept/ODFW/freshwater/inventory/orplan/overview.htm (August 7, 2009).

OWEB (Oregon Watershed Enhancement Board). 2007. The Oregon plan for salmon and watersheds, 2005-2007 Biennial Report. Available: http://www.oregon.gov/OWEB/docs/pubs/biennialrpt_05-07/overview.pdf (August 7, 2009).

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Poe, T. P., H. C. Hansel, S. Vigg, D. E. Palmer, and L. A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:405-420.

Quinn, T. P. 2005. The behavior and ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, Maryland.

Quinn, T. P., and N. P. Petersen. 1996. The influence of habitat complexity and fish size on over-winter survival and growth of individually marked juvenile coho salmon (*Oncorhynchus kisutch*) in Big Beef Creek, Washington. Canadian Journal of Fisheries and Aquatic Sciences 53:1555-1564.

Sather, N. K., G. E. Johnson, A. J. Storch, D. J. Teel, J. R. Skalski, T. A. Jones, E. M. Dawley, S. A. Zimmerman, A. B. Borde, C. Mallette, and R. A. Farr. 2009. Ecology of juvenile salmon in shallow tidal freshwater habitats in the vicinity of the Sandy River Delta, lower Columbia River, 2008. Annual Progress Report 2008. Bonneville Power Administration, Portland, Oregon.

Scrivener, J. C., T. G. Brown, and B. C. Andersen. 1994. Juvenile Chinook salmon *Oncorhynchus tshawytscha*) utilization of Hawks Creek, a small and nonnatal tributary of the upper Fraser River. Canadian Journal of Fisheries and Aquatic Sciences 51:1139-1146.

Sytsma, M. D., J. R. Cordell, J. W. Chapman, and R. C. Draheim. 2004. Lower Columbia River aquatic nonindigenous species survey, 2001-2004. Final Technical Report 2004. United States Coast Guard and the United States Fish and Wildlife Service, Portland, Oregon.

Teel, D. J., C. Baker, D. R. Kuligowski, T. A. Friesen, and B. Shields. 2009. Genetic stock composition of subyearling Chinook salmon in seasonal floodplain wetlands of the lower Willamette River, Oregon. Transactions of the American Fisheries Society 138:211-217.

Tinus, E. S., J. A. Koloszar, and D. L. Ward. 2003. Abundance and distribution of fish in City of Portland streams. Final Report by ODFW to the City of Portland, Oregon.

USNO (United States Naval Observatory). 2008. Earth's seasons: equinoxes, solstictices, perihilion, and aphelion 2000-2020. Available: http://aa.usno.navy.mil/data/docs/EarthSeasons.php (July 8, 2009).

Van Dyke, E. S., D. L. Scarnecchia, B. C. Jonasson, and R. W. Carmichael. 2009. Relationship of winter concealment habitat quality on pool use by juvenile Chinook salmon *Oncorhynchus tshawytscha*) in the Grande Ronde River Basin, Oregon USA. Hydrobiologia 625:27-42.

Van Dyke, E. S., J. A. Yanke, J. W, Steel, B. C. Jonasson, and R. W. Carmichael. 2008. Investigations into the early life history of naturally produced spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report 2006. Bonneville Power Administration, Portland, Oregon.

Ward, D. L. 1995. Distribution of fish and crayfish, and measurement of available habitat in the Tualatin River basin. Final Report by ODFW to the Unified Sewerage Agency, Hillsboro, Oregon.

Wiedemer, S. and S. Chan. 2008. On the lookout for aquatic invaders: Identification guide for the Pacific Northwest. Oregon Sea Grant, Oregon State University, Corvallis, Oregon.

Wydoski, R. S. and R.R. Whitney. 2003. Inland fishes of Washington, 2nd edition. University of Washington Press, Seattle, Washington.

APPENDIX A

Taxa Listings by Season

Appendix Table 1. Descriptive statistics for fork length by season of fish measured in the lower Columbia Slough 2008-2009. To convert from mm to inches multiply mm by 0.0394.

Season, Family, *Genus species*	Common name	n	Mean fork length (Std)	Minimum/ Maximum	Maturity (FL mm)[a]
Spring					
Centrarchidae					
Lepomis gibbosus	Pumpkinseed	2	92.0 (39.6)	64/120	J/A (80)
Lepomis macrochirus	Bluegill	1	46.0 (—)	—/—	J/A (75)
Pomoxis nigromaculatus	Black crappie	3	207.0 (16.4	189/221	J/A (180)
Cottidae					
Cottus asper	Prickly sculpin	8	113.1 (24.8)	67/141	* (50)
Cyprinidae					
Cyprinus carpio	Common carp	1	235.0 (—)	—/—	J/A (305)
Gasterosteidae					
Gasterosteus aculeatus	Threespine stickleback	4	53.8 (2.6)	51/56	J/A (30)
Ictaluridae					
Ameiurus nebulosus	Brown bullhead	2	57.0 (7.1)	52/62	J/A (170)
Percidae					
Perca flavescens	Yellow perch	2	103.5 (34.6)	79/128	J/A (100)
Salmonidae					
Oncorhynchus tshawytscha	Chinook salmon	50	71.3 (10.5)	62/140	J (b)
Summer					
Catostomidae					
Catostomus macrocheilus	Largescale sucker	3	142.7 (13.1)	129/155	J (300)
Centrarchidae					
Lepomis gibbosus	Pumpkinseed	151	99.6 (21.9)	34/144	J/A (80)
Lepomis macrochirus	Bluegill	109	86.2 (15.3)	34/150	J/A (75)
Pomoxis annularis	White crappie	15	203.7 (44.0)	124/300	J/A (180)
Pomoxis nigromaculatus	Black crappie	54	176.0 (39.5)	118/225	J/A (180)
Cottidae					
Cottus Asper	Prickly sculpin	6	117.3 (20.9)	92/140	* (50)
Cyprinidae					
Cyprinus carpio	Common carp	3	211.0 (145.7)	45/318	J/A (305)
Mylocheilus caurinus	Peamouth	10	115.7 (10.2)	95/131	J/A (180)
Ptychocheilus oregonensis	Northern pikeminnow	15	93.3 (20.7)	60/136	J (250)

a) Fork length (FL) used to distinguish juvenile (J) from adult (A) maturity stage, and was based on information found in Carlander (1977) and Wydoski and Whitney (2003)

b) Mature precocious salmonidae may be 85-140mm FL (Van Dyke et al. 2008), based on jack salmon FL

*) Cottidae < 50mm FL were captured but we were not able to effectively identify these fish to species, so did not include an assessment of size in this table

Appendix Table 1. Continued

Season, Family, *Genus species*	Common name	n	Mean fork length (Std)	Minimum/ Maximum	Maturity (FL mm)[a]
Summer cont.					
Gasterosteidae					
Gasterosteus aculeatus	Threespine stickleback	32	43.3 (7.8)	35/70	J/A (30)
Ictaluridae					
Ameiurus nebulosus	Brown bullhead	42	126.1 (34.1)	89/234	J/A (170)
Ictalurus catus	White catfish	1	172.0 (—)	—/—	J (c)
Percidae					
Perca flavescens	Yellow perch	8	130.9 (11.5)	118/155	J/A (100)
Salmonidae					
Oncorhynchus tshawytscha	Chinook salmon	3	64.7 (8.4)	55/70	J (b)
Fall					
Centrarchidae					
Lepomis gibbosus	Pumpkinseed	90	76.0 (22.5)	41/167	J/A (80)
Lepomis gulosus	Warmouth	4	111.8 (31.4)	81/154	A (76)
Lepomis macrochirus	Bluegill	154	51.3 (16.2)	32/122	J/A (75)
Micropterus dolomieu	Smallmouth bass	2	46.5 (9.2)	40/53	J (150)
Pomoxis annularis	White crappie	150	60.6 (10.2)	44/94	J/A (180)
Pomoxis nigromaculatus	Black crappie	95	64.1 (8.4)	47/89	J/A (180)
Cottidae					
Cottus asper	Prickly sculpin	8	112.1 (27.4)	53/142	* (50)
Cyprinidae					
Cyprinus carpio	Common carp	76	87.8 (15.9)	55/149	J/A (305)
Mylocheilus caurinus	Peamouth	1	76.0 (—)	—/—	J/A (180)
Notemigonus crysoleucas	Golden shiner	1	80.0 (—)	—/—	A (64)
Richardsonius balteatus	Redside shiner	2	74.5 (10.6)	67/82	J/A (70)
Gasterosteidae					
Gasterosteus aculeatus	Threespine stickleback	132	45.2 (7.1)	21/60	J/A (30)
Ictaluridae					
Ameiurus melas	Black bullhead	91	61.9 (19.1)	46/159	J/A (100)
Ameiurus natalis	Yellow bullhead	7	79.0 (30.2)	57/146	J/A (170)
Ameiurus nebulosus	Brown bullhead	187	77.7 (42.9)	40/269	J/A (170)
Ictalurus catus	White catfish	1	64.0 (—)	—/—	J (c)
Percidae					
Perca flavescens	Yellow perch	5	118.6 (36.7)	82/170	J/A (100)

c) No FL available. Wydoski and Whitney (2003) state mature when larger than yellow bullhead (170mm FL)

d) Western mosquitofish mature soon after emerging (4–6 weeks; Wydoski and Whitney 2003)

Appendix Table 1. Continued

Season, Family, *Genus species*	Common name	n	Mean fork length (Std)	Minimum/ Maximum	Maturity (FL mm)[a]
Fall cont.					
Poeciliidae					
Gambusia affinis	Western mosquitofish	1	49.0 (—)	—/—	A (d)
Winter					
Catostomidae					
Catostomus macrocheilus	Largescale sucker	1	200.0 (—)	—/—	J (300)
Centrarchidae					
Lepomis gibbosus	Pumpkinseed	5	89.2 (20.8)	55/109	J/A (80)
Lepomis gulosus	Warmouth	1	125.0 (—)	—/—	A (76)
Lepomis macrochirus	Bluegill	18	113.7 (27.3)	23/142	J/A (75)
Pomoxis annularis	White crappie	6	83.5 (19.0)	62/114	J/A (180)
Cottidae					
Cottus asper	Prickly sculpin	20	114.0 (21.4)	65/151	* (50)
Cyprinidae					
Acrocheilus alutaceus	Chiselmouth	4	70.3 (8.5)	61/78	J (245)
Cyprinus carpio	Common carp	11	102.4 (43.1)	70/210	J/A (305)
Mylocheilus caurinus	Peamouth	53	127.8 (43.5)	67/210	J/A (180)
Notemigonus crysoleucas	Golden shiner	15	95.5 (22.9)	68/135	A (64)
Ptychocheilus oregonensis	Northern pikeminnow	3	112.7 (6.7)	107/120	J (250)
Gasterosteidae					
Gasterosteus aculeatus	Threespine stickleback	180	48.5 (8.3)	21/61	J/A (30)
Ictaluridae					
Ameiurus melas	Black bullhead	7	76.7 (31.1)	53/134	J/A (100)
Ameiurus natalis	Yellow bullhead	1	183.0 (—)	—/—	J/A (170)
Ameiurus nebulosus	Brown bullhead	46	103.6 (42.4)	53/180	J/A (170)
Percidae					
Perca flavescens	Yellow perch	87	120.3 (34.8)	77/223	J/A (100)
Salmonidae					
Oncorhynchus kisutch	Coho salmon	2	95.0 (14.1)	85/105	J (b)
Oncorhynchus tshawytscha	Chinook salmon	3	103.7 (28.7)	73/130	J (b)

Appendix Table 2. Aquatic taxa captured each season in the lower 13.5 km of the Columbia River Slough 2008-2009.

Season, Common group	Family	Genus species	Common name	Origin
Spring,				
Amphibian	Ranidae	*Rana catesbeana*	Bullfrog	Non-native
Crustacean	Astacoidea	*Pacifastacus*	Crayfish	—
	Palaemonoidea	*Exopalaemon modestus*	Siberian prawn	Non-native
Fish	Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	Non-native
		Lepomis macrochirus	Bluegill	Non-native
		Pomoxis nigromaculatus	Black crappie	Non-native
	Cottidae	*Cottus asper*	Prickly sculpin	Native
	Cyprinidae	*Cyprinus carpio*	Common carp	Non-native
	Gasterosteidae	*Gasterosteus aculeatus*	Threespine stickleback	Native
	Ictaluridae	*Ameiurus nebulosus*	Brown bullhead	Non-native
	Percidae	*Perca flavescens*	Yellow perch	Non-native
	Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon	Native
Summer,				
Amphibian	Ranidae	*Rana catesbeana*	Bullfrog	Non-native
Crustacean	Astacoidea	*Pacifastacus*	Crayfish	—
	Palaemonoidea	*Exopalaemon modestus*	Siberian prawn	Non-native
Fish	Catostomidae	*Catostomus macrocheilus*	Largescale sucker	Native
	Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	Non-native
		Lepomis macrochirus	Bluegill	Non-native
		Pomoxis annularis	White crappie	Non-native
		Pomoxis nigromaculatus	Black crappie	Non-native
	Cottidae	*Cottus asper*	Prickly sculpin	Native
	Cyprinidae	*Cyprinus carpio*	Common carp	Non-native
		Mylocheilus caurinus	Peamouth	Native
		Notemigonus crysoleucas	Golden shiner	Non-native
		Ptychocheilus oregonensis	Northern pikeminnow	Native
	Gasterosteidae	*Gasterosteus aculeatus*	Threespine stickleback	Native
	Ictaluridae	*Ameiurus nebulosus*	Brown bullhead	Non-native
		Ictalurus catus	White catfish	Non-native
	Percidae	*Perca flavescens*	Yellow perch	Non-native
	Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon	Native
Fall,				
Crustacean	Astacoidea	*Pacifastacus*	Crayfish	—
	Palaemonoidea	*Exopalaemon modestus*	Siberian prawn	Non-native
Fish	Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	Non-native
		Lepomis gulosus	Warmouth	Non-native

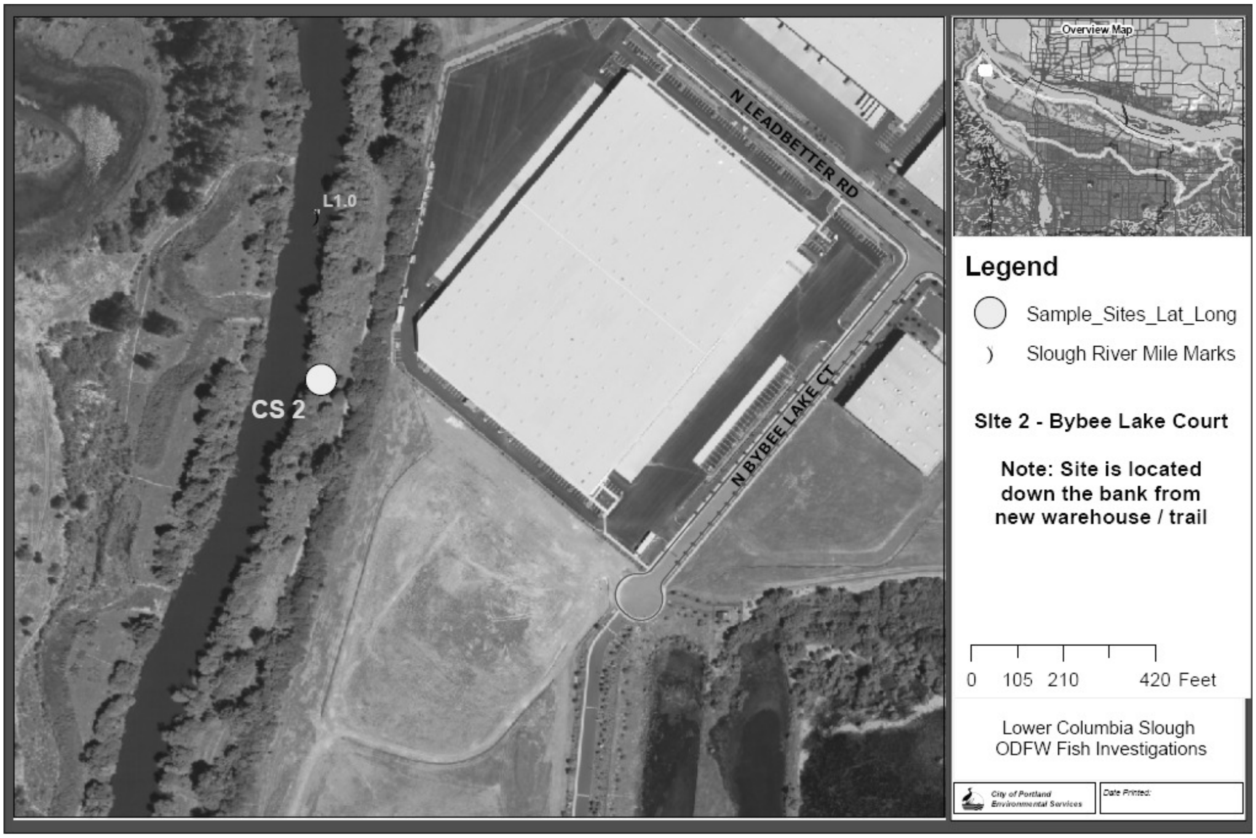
Appendix Table 2. Continued

Season, Common group	Family	Genus species	Common name	Origin
Fall cont.,				
Fish cont.		*Lepomis macrochirus*	Bluegill	Non-native
		Micropterus dolomieu	Smallmouth bass	Non-native
		Pomoxis annularis	White crappie	Non-native
		Pomoxis nigromaculatus	Black crappie	Non-native
	Cottidae	*Cottus asper*	Prickly sculpin	Native
	Cyprinidae	*Cyprinus carpio*	Common carp	Non-native
		Mylocheilus caurinus	Peamouth	Native
		Notemigonus crysoleucas	Golden shiner	Non-native
		Richardsonius balteatus	Redside shiner	Native
	Gasterosteidae	*Gasterosteus aculeatus*	Threespine stickleback	Native
	Ictaluridae	*Ameiurus melas*	Black bullhead	Non-native
		Ameiurus natalis	Yellow bullhead	Non-native
		Ameiurus nebulosus	Brown bullhead	Non-native
		Ictalurus catus	White catfish	Non-native
	Percidae	*Perca flavescens*	Yellow perch	Non-native
	Poeciliidae	*Gambusia affinis*	Western mosquitofish	Non-native
Winter,				
Amphibian	Ranidae	*Rana catesbeana*	Bullfrog	Non-native
Crustacean	Astacoidea	*Pacifastacus*	Crayfish	—
	Palaemonoidea	*Exopalaemon modestus*	Siberian prawn	Non-native
Fish	Catostomidae	*Catostomus macrocheilus*	Largescale sucker	Native
	Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	Non-native
		Lepomis gulosus	Warmouth	Non-native
		Lepomis macrochirus	Bluegill	Non-native
		Pomoxis annularis	White crappie	Non-native
	Cottidae	*Cottus asper*	Prickly sculpin	Native
	Cyprinidae	*Acrocheilus alutaceus*	Chiselmouth	Native
		Cyprinus carpio	Common carp	Non-native
		Mylocheilus caurinus	Peamouth	Native
		Notemigonus crysoleucas	Golden shiner	Non-native
		Ptychocheilus oregonensis	Northern pikeminnow	Native
	Gasterosteidae	*Gasterosteus aculeatus*	Threespine stickleback	Native
	Ictaluridae	*Ameiurus melas*	Black bullhead	Non-native
		Ameiurus natalis	Yellow bullhead	Non-native
		Ameiurus nebulosus	Brown bullhead	Non-native
	Percidae	*Perca flavescens*	Yellow perch	Non-native
	Salmonidae	*Oncorhynchus kisutch*	Coho salmon	Native
		Oncorhynchus tshawytscha	Chinook salmon	Native

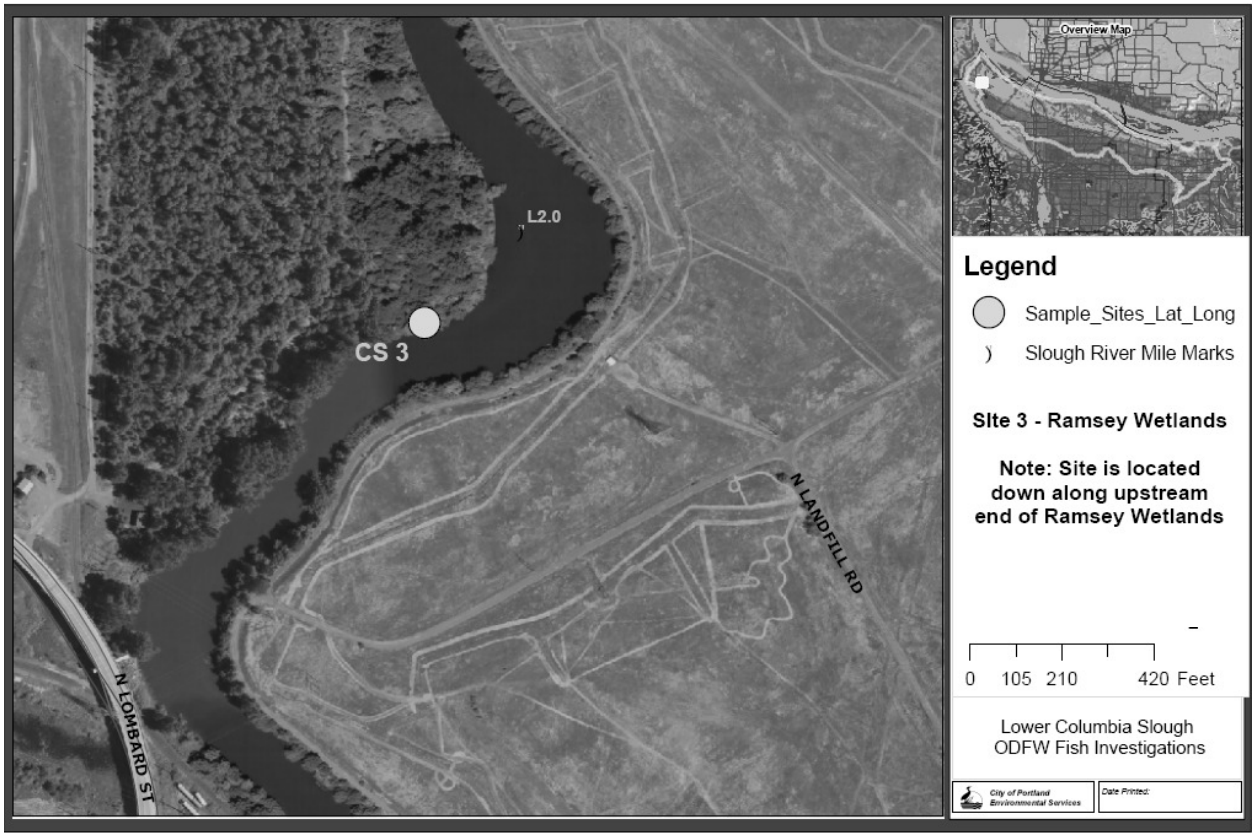
APPENDIX B

Overview of Sampling Sites

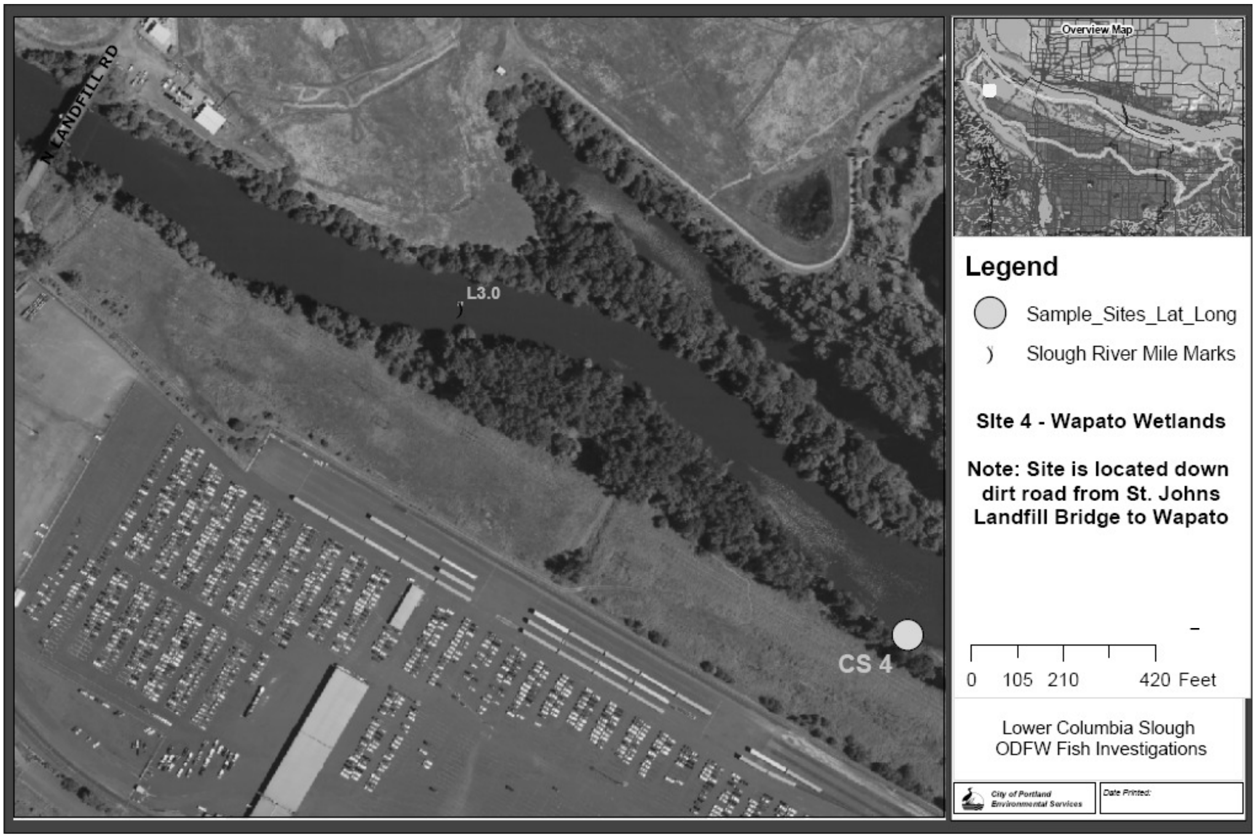
Site 1. The Kelley Point Park site was located on the southwest side of the Columbia Slough, and was accessed using kayaks from the public boat ramp on the northeast side of the channel. The stream bank adjacent to the site was a steep hill slope that was stabilized by grass, brush, and older broadleaf trees that provided shade. The trap typically fished adjacent to a complex of woody debris on a mud-silt bottom. Pictured below are the high and low water conditions found at site 1 during the spring (left) and fall (right).



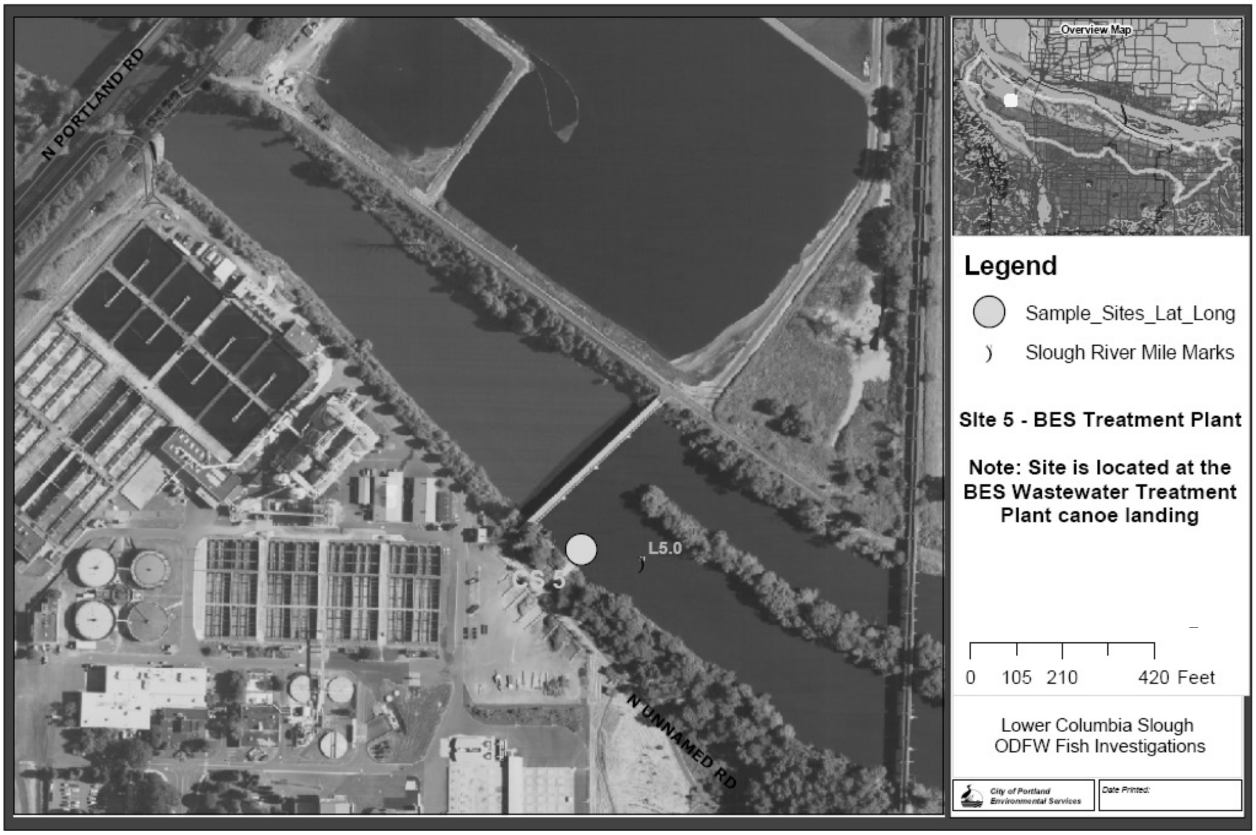
Site 2. The Bybee Lake Court site was located on the east side of the Columbia Slough. The stream bank was characterized as having bank stability provided by grass, brush and young broadleaf trees. This site was susceptible to flooding during high flow. The trap typically fished adjacent to an abrupt drop-off on a mud-silt bottom. Pictured below are the high and low water conditions found at site 2 during the summer (left) and spring (right).



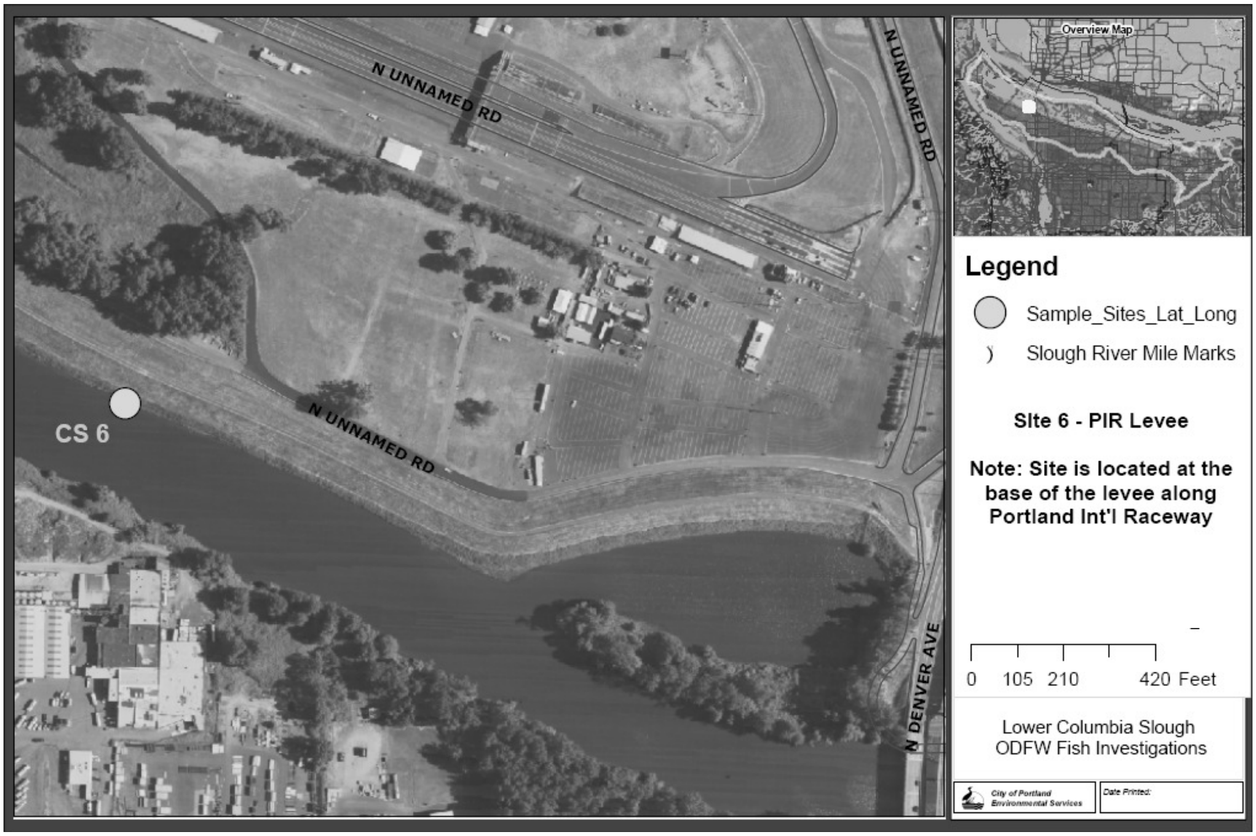
Site 3. The Ramsey wetlands site was located on the west side of the Columbia Slough, and was accessed using a private drive on the west side of the channel. The stream bank adjacent to the site was a steep hill slope that was stabilized by mixed aged broadleaf and conifer trees that provided shade. The trap typically fished among live trees on a mud-silt bottom, but in lower flow conditions was at the outer edge of this vegetation. Pictured below are the high and low water conditions found at site 3 during the summer (left) and spring (right).



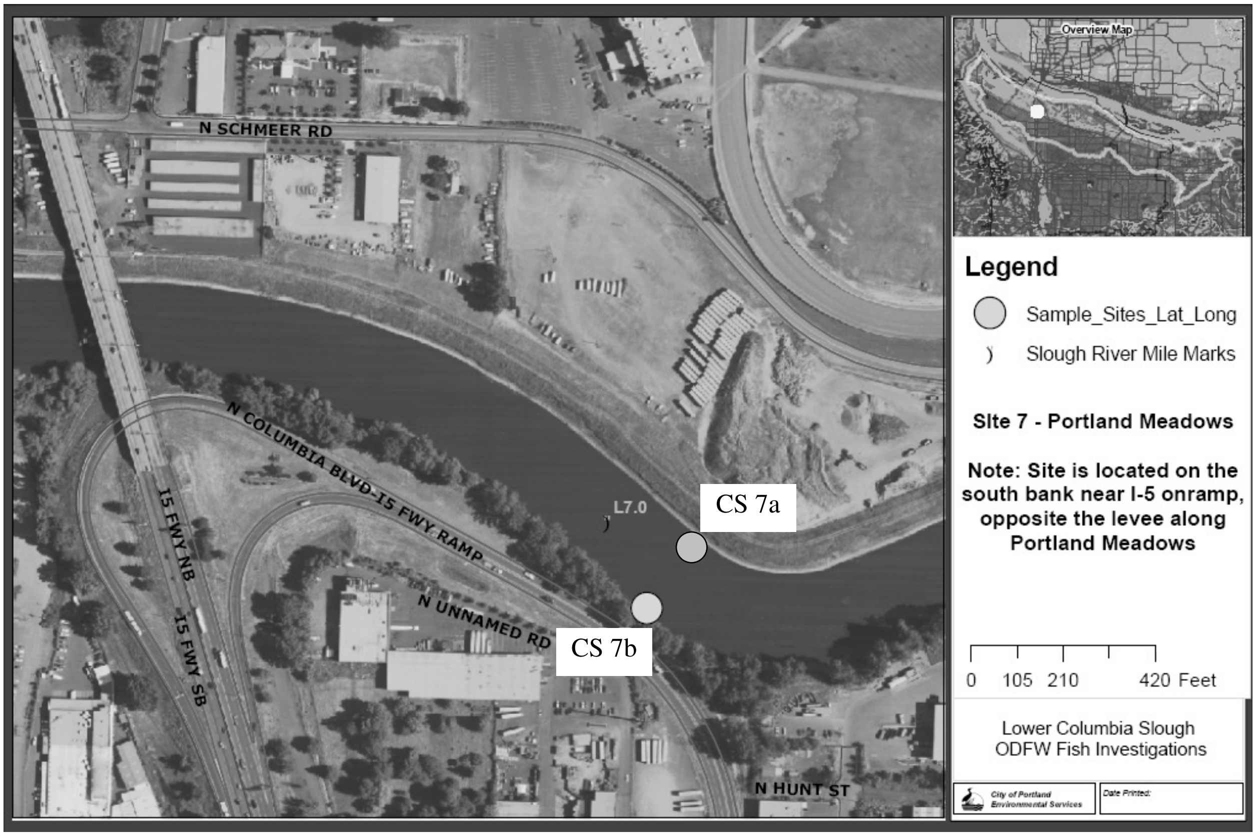
Site 4. The Wapato wetlands site was located on the south side of the Columbia Slough, and was accessed using boats and kayaks launched from the public boat ramp off landfill road on the South side of the channel. The stream bank adjacent to the site was constrained by a terrace feature that was stabilized by grass, brush, and young broadleaf trees. The trap typically fished on a mud-silt bottom void of instream structure. Pictured below are the high and low water conditions found at site 4 during the summer (left) and spring (right).



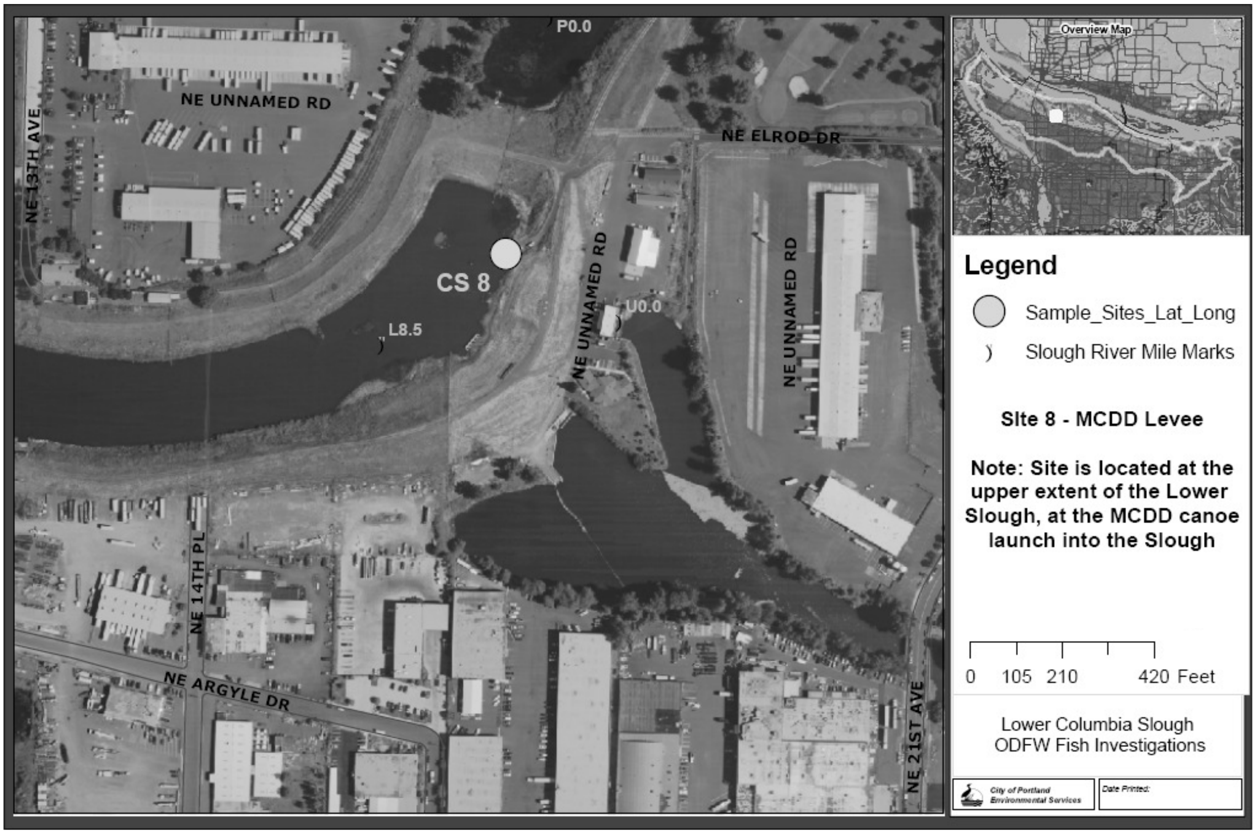
Site 5. The Bureau of Environmental Services (BES) waste treatment facility site was located on the southwest side of the Columbia Slough, and was on or near the canoe launched on the same side of the channel. The stream bank adjacent to the site was constrained by a terrace feature that was stabilized by a concrete landing accompanied by grass, brush, and broadleaf trees. The trap typically fished on a soft mud-silt bottom void of natural instream structure. Pictured below are the high and low water conditions found at site 5 during the summer (left) and spring (right).



Site 6. The Portland International Raceway (PIR) site was located on the northeast side of the Columbia Slough, and was accessed via a locked gate on the same side of the channel. The stream bank adjacent to the site was constrained by a terrace feature that was stabilized by fortified levee covered by grass. The trap typically fished in area void of natural instream structure. River mile 6.0 is just downstream of the left edge of the diagram. Pictured below are the high and low water conditions found at site 5 during the summer (left) and spring (right).



Site 7. The Portland Meadows site was fished in two locations. The first (7a) was located on the north side of the channel and was used for the initial day of sampling only. It was characterized as having a constraining terrace feature that was stabilized by fortified rip-rap levee covered by grass. The trap fished adjacent to rip-rap structure void of natural instream structure. The second site (7b) was located on the south side of the Columbia Slough, and was accessed using kayaks from the north side of the channel. The stream bank adjacent to the site was a steep hill slope that was stabilized by grass, brush, and older broadleaf trees that provided shade. The trap typically fished below a culvert outflow that was adjacent to an old piling complex that included some woody debris on a mud-silt bottom. Pictured on left is the initial site 7a with a view across to the primary site (7b), and on the right is site 7b fishing location looking north to initial site 7a.



Site 8. The Multnomah County Drainage District Number 1 (MCDD) site was located on the east side of the Columbia Slough, and was adjacent to the canoe launch on the same side of the channel. The stream bank adjacent to the site was constrained by a terrace feature that was stabilized by a fortified rip-rap levee covered by grass. The trap typically fished adjacent to an abrupt drop-off on a mud-silt bottom. Pictured below are the high and low water conditions found at site 5 during the summer (left) and spring (right).