U.S. Fish and Wildlife Service

Presence, distribution, movement, and biological characteristics of select aquatic species in Tide Creek, Merrill Creek, and Deer Island Slough, Columbia County, Oregon

2010 Annual Report

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U.S. Fish and Wildlife Service
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Vancouver, WA 98683

On the cover: *Location in South Deer Island Slough about 1 km upstream of tide gates. Photograph by J. Poirier, USFWS.*

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Abstract – The value of aquatic habitats (i.e., streams and sloughs) to anadromous fish at Deer Island has been limited by degradation and restricted fish passage due to dike construction, tide gate installation, and stream channelization. We are participating in a partnership with the Columbia Soil and Water Conservation District, Lower Columbia River Watershed Council, Oregon Department of Fish and Wildlife, and others to develop habitat restoration strategies intended to improve conditions of habitats and increase access for anadromous fish and other species. We are working to apply the strategic habitat conservation (SHC) approach, which is a form of adaptive management consisting of four main elements (biological planning, conservation design, conservation delivery, and monitoring and research), to provide the partnership with biological information assisting in decisions of the types and locations of habitat restoration actions. Our biological objectives were to: 1) evaluate whether Pacific lamprey and western brook lamprey spawn in streams; 2) determine coastal cutthroat trout occupancy within the two streams and distribution relative to barriers thought to prevent upstream movement; 3) determine if and when juvenile coho salmon and coastal cutthroat trout move among stream and slough habitats and the Columbia River; 4) determine how long juvenile coho salmon and coastal cutthroat trout reside in the habitats, 5) explore whether we can assess the adult return rates of coho salmon and cutthroat trout (relative to their use of slough habitat), and 6) investigate the reproductive timing of western pearlshell mussel. These objectives are being addressed through a variety of approaches, including field surveys to determine the presence and distribution of species, PIT tag arrays to determine timing of movement and location and duration of residency in select areas, and observations of reproductive condition. Information generated by our work primarily will be used in the biological planning and conservation design elements of SHC.

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Introduction

Multiple factors have contributed to the decline of anadromous fish throughout the Columbia River Basin. The lower Columbia River and estuary are of particular importance because all stocks of anadromous fish within the basin use the area to varying extents, especially as juvenile rearing habitat. Lower Columbia River habitats have been substantially altered by factors such as flow manipulation and reduced connectivity among the river, tidal wetlands, and the floodplain. For instance, the construction of dikes and associated tide gates as well as filling tidal wetlands has resulted in a 65% reduction of tidal marshes and swamps compared to that historically present (Bottom et al. 2005).

Restoring tidally-influenced wetlands to improve conditions for anadromous fish has been included in recovery and management plans and permit requirements, such as the Subbasin Plan for the Columbia Mainstem and Estuary (Lower Columbia Fish Recovery Board (LCFRB) 2004) and NOAA Fisheries' FCRPS Biological Opinions (NMFS 2008). While the focus of many of these plans has been on salmon (i.e., *Oncorhynchus* spp.), many of the plan components also hold true for other anadromous species such as Pacific lamprey (*Entosphenus tridentatus*) and coastal cutthroat trout (*O. clarki clarki*). Although restoring tidal wetlands (for rearing) and improving fish access (passage) to them are major components of recovery strategies for anadromous fish, considerable uncertainty exists concerning appropriate restoration actions. Information on specific passage and habitat requirements as well as restoration needs for juvenile fish in these areas is lacking (Bottom et al. 2005). Various monitoring designs can be used to assist in alleviating uncertainties and evaluating restoration strategies (see Roni et al. 2005). In the case of the lower Columbia River, the intent of such evaluations is to improve our understanding of the habitat requirements of aquatic species, including juvenile salmonids, and assist in developing and implementing additional restoration actions.

Strategic habitat conservation (SHC) is an adaptive management approach that was developed to guide fish and wildlife conservation at multiple spatial scales primarily through implementing habitat management actions (USFWS 2009). The ultimate intent of SHC is to identify the types, locations, and quantity or extent of habitat management actions necessary to achieve fish and wildlife population and habitat objectives, thus improving the transparency, accountability, and efficiency of resource management agencies (National Ecological Assessment Team 2006; National Technical Assistance Team 2008). Fully applying the SHC approach involves four elements, for which each may consist of several sub-elements (Figure 1): 1) biological planning (identification of priority species, population objectives, limiting factors, and current state of populations); 2) conservation design (developing population-habitat relations, species-habitat decision support tools, habitat objectives, and priority areas); 3) conservation delivery (implementation of habitat management actions); and 4) monitoring and research (outcome-based monitoring to assess progress toward objectives and assumption-driven research to revise assumptions and models). Results of monitoring and research contribute to the other elements of SHC (e.g., by further describing current state of populations and habitats, permitting evaluation of action efficacy, and refining assumptions and modeled relationships) so that information is incorporated into subsequent actions allowing for adaptive management (see Lyons et al. (2008) concerning the roles of monitoring). An important guiding principle in applying the SHC

approach is acknowledging that partnerships are essential for developing and implementing conservation strategies and communicating with the public.

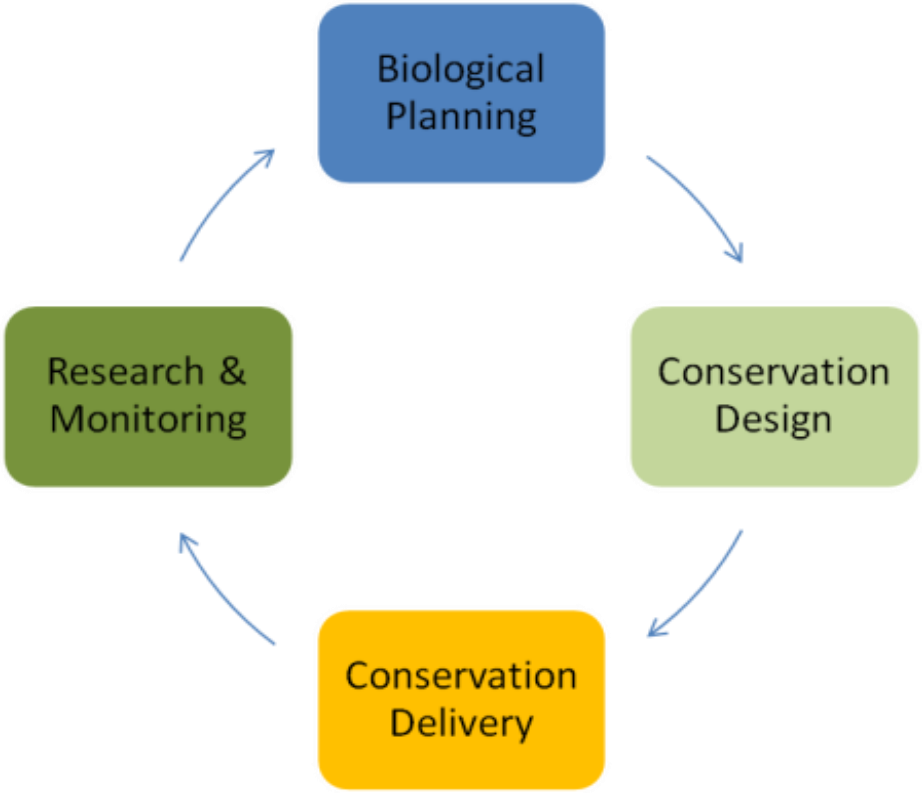


Figure 1. The four elements of strategic habitat conservation, for which this project presently is focused on biological planning and conservation design.

The Deer Island area of the lower Columbia River presents a relatively unique opportunity for habitat restoration that could benefit multiple aquatic species as well as increase understanding of the importance of tidal wetlands and sloughs to anadromous fish. Deer Island, located on the south shore of the Columbia River near the town of St. Helens, Oregon, historically consisted of tidally-influenced backwater slough habitats and relatively small tributaries, which were used by anadromous salmonids and other species. Presently, the value of these habitats for anadromous salmonids has been limited by degradation of environmental conditions and restricted fish passage due to activities such as dike construction, tide gate installation, and stream channelization. The Columbia River Fisheries Program Office (CRFPO) is participating in a partnership with the Columbia Soil and Water Conservation District, Lower Columbia River Watershed Council, Oregon Department of Fish and Wildlife, and others to develop appropriate habitat restoration strategies intended to improve conditions of aquatic habitats at Deer Island, and increase access to these habitats for anadromous fish and other species. To address uncertainties exemplified by the partnership's efforts to plan habitat restoration at Deer Island, we are working to apply the SHC approach. To specifically address biological planning and conservation design needs at Deer Island as identified in the SHC approach, we are furthering biological knowledge (e.g., where, when, and how long juvenile coho salmon use stream and

slough habitats) to assist the partnership and its technical advisory committee with decisions on conservation delivery actions to pursue.

Four species of anadromous fish (i.e., coho salmon (*O. kisutch*), steelhead (*O. mykiss*), coastal cutthroat trout, and Pacific lamprey) were believed to occur within Tide Creek, Merrill Creek, and Deer Island Slough (T. Murtagh, Oregon Department of Fish and Wildlife, pers. comm.). Information regarding habitat use, residency, and distribution of fish species in this area is currently limited. It is reasonable to speculate that the larval and juvenile stages of anadromous fish that spawn in Tide and Merrill creeks rear in the creeks, and perhaps Deer Island Slough, for some period before ultimately moving into the Columbia River. However, if and when juvenile fish enter the slough and how long they use this habitat are uncertain (Poirier et al. 2009). The partners' draft restoration plan identified 13 conceptual restoration projects at various areas of Deer Island (e.g., stream and slough habitats, tide gates). Refining our biological knowledge would not only assist the partnership in prioritizing potential habitat restoration actions (e.g., actions primarily affecting stream habitat versus actions focused on slough habitat), but would also improve our general understanding of life history and habitat relationships of these species in the lower Columbia River. Thus, refined biological information would primarily contribute to two elements of SHC, biological planning (e.g., identification of current state of populations relative to habitat use, and. limiting factors) and conservation design (e.g., population-habitat relations, and priority areas).

In spring 2009, the CRFPO conducted an initial biological assessment of Deer Island Slough and lower Tide Creek. This assessment was intended to begin informing biological planning by providing information about local natural resources (Poirier et al. 2009). In essence, this work assisted partners as they began to prepare a restoration plan. The assessment focused on determining whether juvenile salmonids were able to pass existing tide gates on South Deer Island Slough and described aquatic habitats and the fish community within Deer Island Slough and lower Tide Creek, a tributary to the slough. Preliminary findings of this assessment included: 1) the presence of juvenile coho salmon, Chinook salmon (*O. tshawytscha),* and steelhead, as well as coastal cutthroat trout, Pacific lamprey, western brook lamprey (*Lampetra richardsoni*) and Oregon floater mussels (*Anodonta oregonensis*); 2) anadromous fish, such as coho salmon, coastal cutthroat trout, and Pacific lamprey, potentially spawning in Tide Creek and Merrill Creek (a tributary to Tide Creek); and 3) juvenile Chinook salmon able to pass from the Columbia River through the South Deer Island Slough tide gates to an unknown degree and likely rear in Deer Island Slough. In addition to these findings, the assessment included recommendations of actions and information intended to refine our biological knowledge relative to potential habitat restoration in the area.

In late 2009, the CRFPO began further investigation to address the biological uncertainties identified in our original assessment (Poirier et al. 2010). The goal of the ongoing study is to inform biological planning and conservation design at the watershed scale. Our biological objectives are to: 1) evaluate whether Pacific lamprey and western brook lamprey spawn in Tide and Merrill creeks; 2) determine whether coastal cutthroat trout occupy the two streams and how they are distributed relative to barriers thought to prevent upstream movement; 3) determine if and when juvenile coho salmon and coastal cutthroat trout move from spawning areas (in Merrill Creek and Tide Creek) into Deer Island Slough and into the Columbia River; 4) determine how

long juvenile coho salmon and coastal cutthroat trout reside in Deer Island Slough; 5) explore whether we can assess the adult return rates of coho salmon and cutthroat trout (relative to their use of Deer Island Slough). Furthermore, work in 2009 resulted in the discovery of western pearlshell mussel (*Margaritifera falcata*) (WPM) beds in Merrill Creek. Relatively little information exists on the timing of WPM reproduction (see Adair and Miller 2010). General concern about the timing of WPM merited an additional concurrent objective in 2010: 6) investigate the reproductive timing of western pearlshell mussel (see Allard et al. 2012).

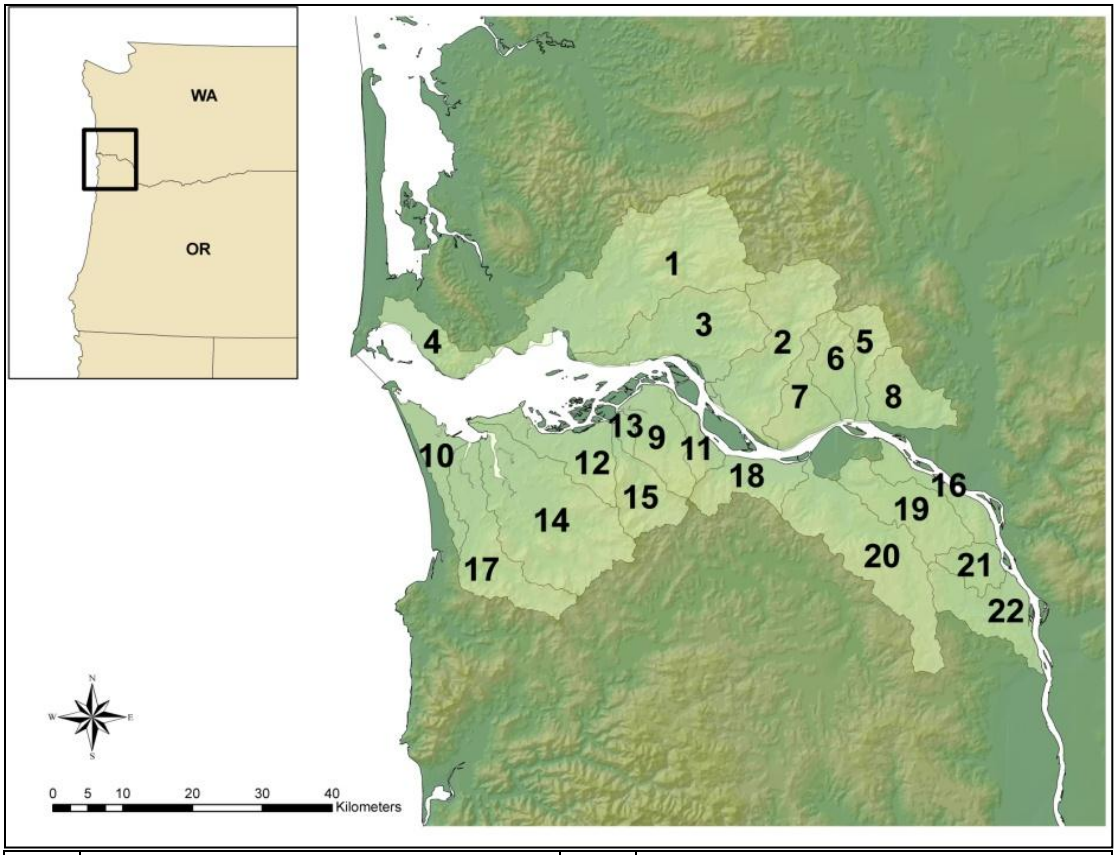
Study Area

Deer Island Complex

Aquatic habitats in the Deer Island Complex consist of the Tide Creek and Merrill Creek drainages and Deer Island Slough. These drainages were identified as 1 of 22 watershed units (Figure 2) selected for investigating coastal cutthroat trout occupancy and distribution in the lower Columbia River (Silver et al. 2008). The complex occurs 125-130 km upstream from the mouth of the Columbia River. To address the objectives of this study, Merrill and Tide creeks were considered separately.

Tide Creek and Merrill Creek

Tide Creek is a 21-km long tributary of South Deer Island Slough. Historically, the lower 3.6 km of Tide Creek flowed north parallel to Deer Island Slough before entering the Columbia River west of the north confluence of Deer Island Slough. Presently, lower Tide Creek has been diverted from its historical floodplain into a constructed channel flowing south and then east before entering South Deer Island Slough at a point about four kilometers upstream from its confluence with the Columbia River (Figure 3). A natural waterfall approximately 1.2 km upstream from the Highway 30 bridge likely restricts anadromous fish use to the lower 4.8 km of Tide Creek. Tide Creek extends approximately 16 km beyond this waterfall providing habitat for non-migratory species and possibly anadromous species if the waterfall does not prevent passage. Merrill Creek is an 11.0-km long tributary of lower Tide Creek. Merrill Creek enters Tide Creek approximately 1.8 km upstream from its confluence with South Deer Island Slough (Figure 3). Anadromous fish distribution (i.e., coho salmon), is believed to extend approximately 8.2 km upstream from the mouth of Merrill Creek where a waterfall and perched culvert likely block the passage of fish in most years.



No.	Watershed Unit	No.	Watershed Unit
1	Grays River	12	Bear Creek
2	Elochoman River	13	Fertile Valley
3	Skamokawa River	14	Youngs/Klaskanine
4	Chinook River	15	Big Creek
5	Germany Creek	16	Green Creek
6	Abernathy Creek	17	Lewis and Clark River
7	Mill Creek	18	Plympton Creek
8	Coal Creek	19	Beaver Creek
9	Gnat Creek	20	Clatskanie River
10	Skipanon River	21	Goble Creek
11	Hunt Creek	22	Tide-Merrill Creek

Figure 2. Lower Columbia River with 22 watershed units identified for coastal cutthroat trout investigations.

Deer Island Slough

Deer Island Slough is a 9.7-km backwater channel of the Columbia River that separates the western side of Deer Island from the adjacent floodplain. Most of Deer Island and adjacent lands are enclosed within levees. A dike constructed at about the midpoint of Deer Island Slough (4.3 km from the northern confluence) completely separates the slough into northern and southern portions, which we refer to as North Deer Island Slough and South Deer Island Slough

(Figure 3). Currently there is no direct, flowing water connection between North Deer Island Slough and South Deer Island Slough. Water levels within both sloughs are regulated by tide gates located on the northern-most (North Deer Island Slough) and southern-most (South Deer Island Slough) ends of the sloughs. The tide gates on South Deer Island Slough consist of four 1.8-m diameter, top-hinge steel gates. The gates are designed to open when the water elevation inside the slough is greater than the water elevation on the downstream (Columbia River) side of the tide gates. The tide gates on North Deer Island Slough are typically submerged beneath the Columbia River water elevation, even at low tide. There is very little information available regarding the design and operation of the North Deer Island Slough tide gates.

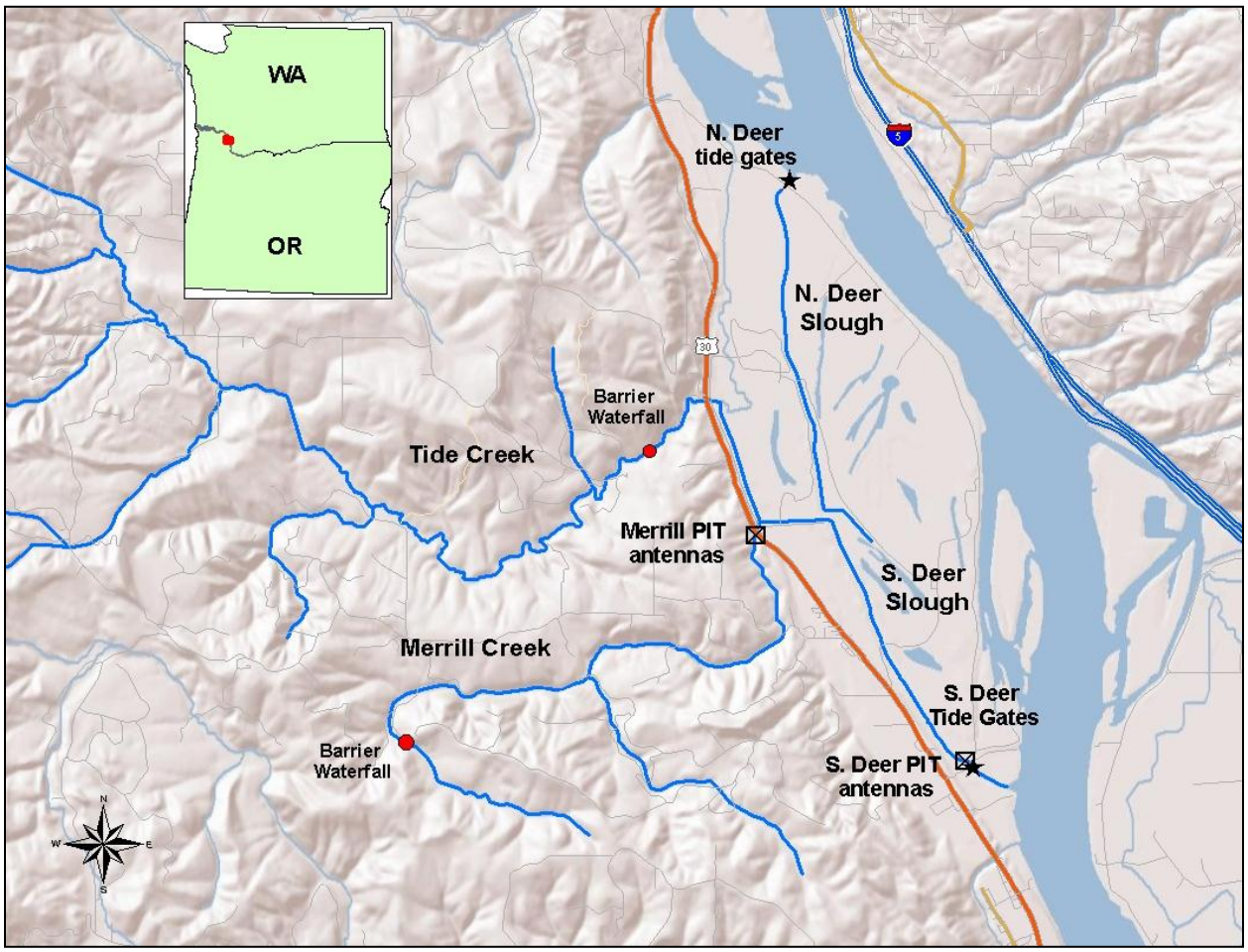


Figure 3. Area map of Deer Island showing project locations (i.e., Merrill Creek, Tide Creek, and South Deer Island Slough), tide gates (★), barrier waterfalls, and PIT tag antenna arrays (☒), 2010.

Methods

Lamprey

Adult Pacific lamprey spawning activity was assessed in three reaches in Merrill Creek through surveys conducted on 21 June and 22 June, 2010. Western brook lamprey spawning activity was not assessed. A survey for nests was made by a three-person crew, walking in an upstream direction, in three nonconsecutive reaches of Merrill Creek (Figure 4). The lowermost reach was surveyed from approximately 900 m below the Canaan Road crossing upstream to Canaan Road. The second survey reach started at Canaan Road and ended approximately 2,000 m upstream at the gated horse pasture. The most upstream reach began at the confluence of Merrill Creek and its largest unnamed tributary and ended approximately 1,300 m upstream. The three reaches encompassed a total of 4.2 km, and were selected based on access. Adult Pacific lampreys construct shallow, round depressions (nests) that are usually located in riffles and pool tail-out habitats where gravel substrates are dominant. Egg deposition and fertilization occur in the nest depression. The substrate was visually scanned during the survey for depressions characteristic of Pacific lamprey spawning. Nest locations were georeferenced using GPS technology.

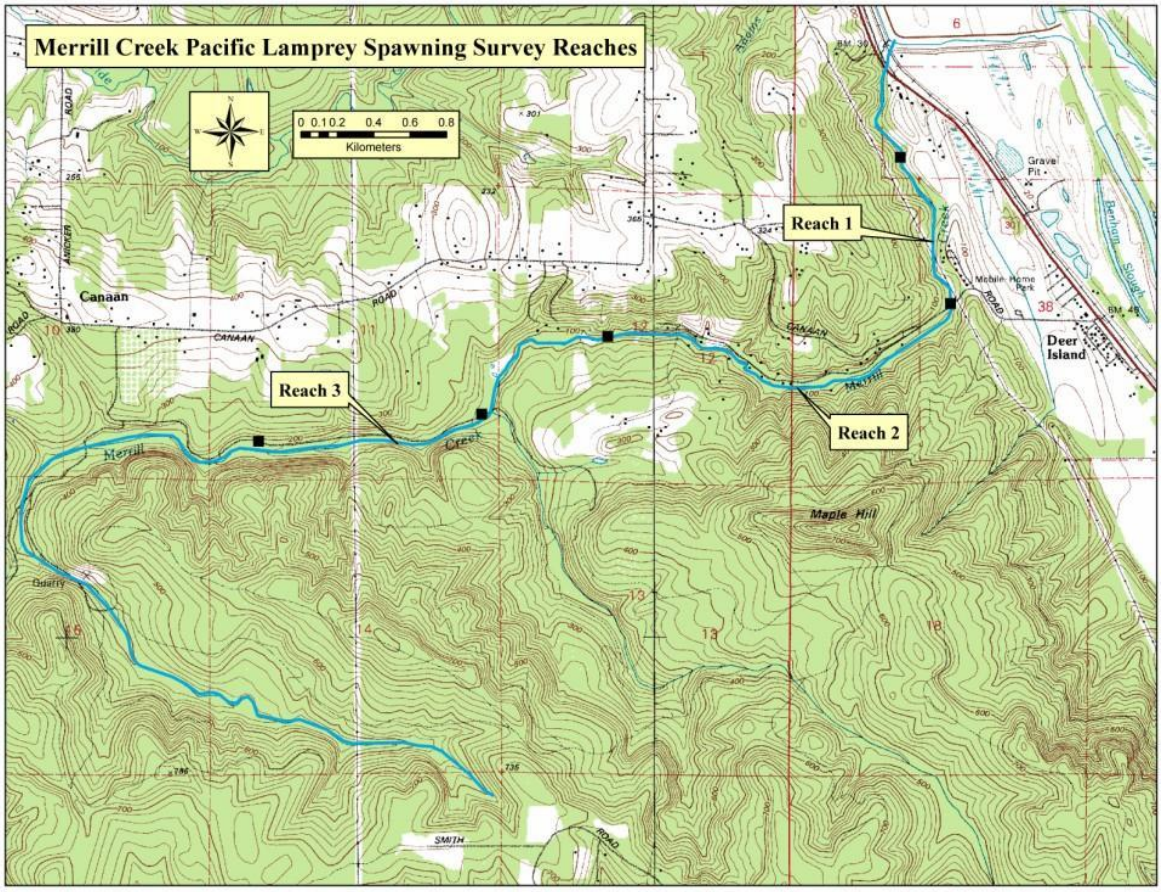


Figure 4. Locations of three reaches in Merrill Creek surveyed for Pacific lamprey spawning activity in June 2010.

Coastal Cutthroat Trout

Occupancy and Distribution – A generalized random-tesselation stratified (GRTS) design has been used to identify potential sample sites in ongoing work to assess cutthroat trout occupancy and distribution in watershed units throughout the lower Columbia River (Silver et al. 2008). To determine cutthroat trout occupancy within a watershed unit, up to seven sites per watershed unit are sampled and a detection probability of 30% (Silver et al. 2008) is assumed for all sampled sites. If two age classes (> 30-mm difference in fork length) of coastal cutthroat trout are captured within a watershed unit, it is considered occupied. If all seven sites are sampled, and trout representing two or more age classes are not captured, we calculate that there is an 80% probability that the watershed unit is not occupied (Figure 4; Recovery, Monitoring, Evaluation Group 2008). Increasing the number of sites sampled to 21 allows validation of the presumed, site-specific detection probability (SSDP) (30%). Additionally, this allows qualitative examination of distribution across the watershed. If detection probability proves to be higher, the probability of considering the watershed unit unoccupied increases. Conversely, if detection probability proves to be lower, the probability of considering a watershed unit unoccupied decreases (Figure 5).

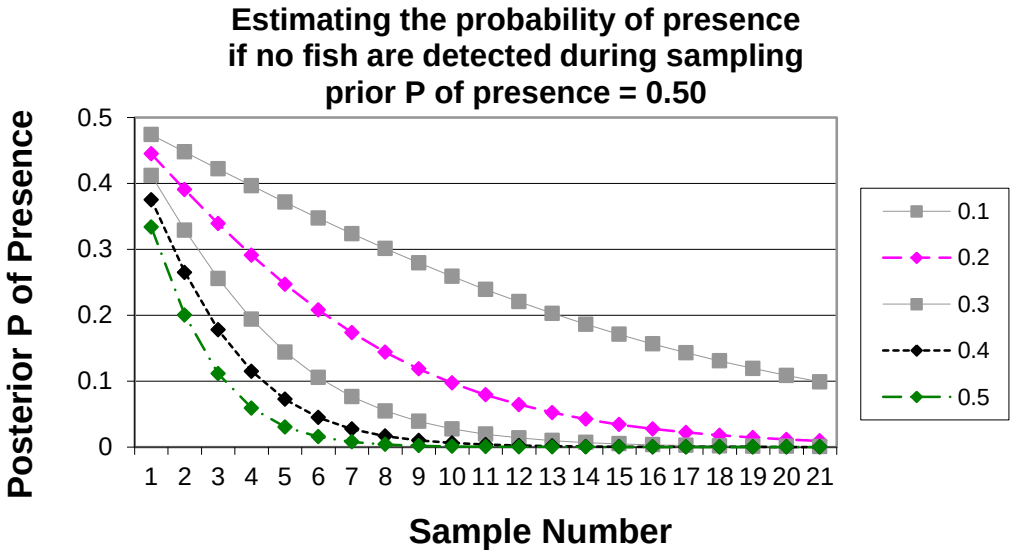


Figure 5. Probability of fish presence if no fish are found during sampling for five values of site-specific detection probabilities (0.1-0.5).

Occupancy and distribution of coastal cutthroat trout was assessed in Merrill Creek and Tide Creek by electrofishing 21, 50-m reaches in each watershed. Electrofisher (Smith-Root model LR24) settings were subject to modification depending on conditions (i.e. water temperature, water depth, conductivity, flow, and fish response). Each 50-m reach was sampled in an upstream direction without blocknets set at the boundaries. A crew of two worked together, one netter and one electrofisher, to complete a single pass per reach. Temperature and conductivity readings were then gathered and recorded.

All fish encountered were captured and identified. Coastal cutthroat trout fork length (FL) and mass (g) were documented to facilitate size class determination. Fish were anesthetized using 25 ppm clove oil. For individuals greater than 100 mm, a 23-mm long PIT tag (3.84 mm diameter, 0.6 g, full duplex) was surgically implanted on the ventral side, posterior to the pectoral fins (Roussel et al. 2000). For coastal cutthroat trout between 85-99 mm a 12-mm long PIT tag (2.15-mm diameter, 0.1 g, full duplex) was injected just behind the pectoral fin with a 12 gauge hypodermic needle. Tags were applied to coastal cutthroat to assess their movement and residency (see following sections). In addition, fin tissue was collected from the left pectoral fin of tagged fish for genetic analysis and scales were also collected for age determination. All fish were released alive within the sample site.

Sampling for coastal cutthroat trout occupancy and distribution was conducted in Merrill Creek during 8-17 September 2010 and in Tide Creek during 24 September-5 October 2010. The 21 reaches sampled in each stream were selected based on the order they were identified using the GRTS design. Reaches were omitted when located within private property boundaries where no permission for access had been granted, and appropriate alternate sites substituted according to the GRTS design.

Habitat – After the completion of fish sampling, information was collected to characterize habitat at each reach, including stream width, depth, cover (large woody debris (LWD), bank undercuts, canopy), habitat type (riffle, pool, run), substrate (silt, gravel, cobble, boulder, bedrock), gradient, and number of pools (Archer 2004). The gradient of each sampling site was measured using a hand-held clinometer. With both surveyors standing level with the water's edge, the person sighting the gradient measured against the person standing downstream. Gradient was measured for the top and bottom halves of the reach; these measurements were recorded and averaged.

Transects were flagged along the thalweg at every 10-m mark from 0 to 50 m. Channel dimensions were then measured along each of the six designated transects within the reach. For each transect, the current wetted width, bank full width, maximum depth along the transect line, and depth recordings at a ¼, ½, and ¾ distance across the wetted width were recorded.

The reach was sub-divided into habitat units (pool, riffle, or run). The sum of estimated habitat unit lengths equaled the length of the sample reach (50 m). Within each of these units, the percentage of substrate composition was estimated. Substrate was classified as: sand/silt/clay (fines), gravel (pea sized), cobble (softball-sized), boulder (basketball-sized), and bedrock. Total substrate composition in each habitat unit equaled 100%.

Within each reach, the number and type of LWD was categorized and counted. Only pieces of wood directly within the channel or within one meter of the water's surface were considered. Wood was classified into 4 categories: LWD >10 cm in diameter and >3 m in length, LWD >60 cm in diameter and >10 m in length, root wads, and LWD piles (aggregates of > 4 pieces of wood together) were quantified within each reach.

The number, type and size of undercut banks were measured along both sides of the sampling reach. Undercuts were defined as areas under boulders, banks, wood, or bedrock along the stream bank that were > 5 cm deep, > 10 cm in length, and > 5 cm in height (Kershner et al. 2004). Only undercuts within 0.5 m of the stream surface were considered.

Coastal Cutthroat Trout and Juvenile Coho Salmon Movement and Residency

Movement and Residency – Movement and residency of juvenile coho salmon were assessed using PIT tags. All juvenile coho salmon captured at reaches that were sampled to determine coastal cutthroat trout occupancy were also processed in the same manner as trout (i.e., anaesthetized, fork length and weight recorded), and individuals (> 65 mm) were implanted with a 12-mm full-duplex PIT tag. To increase the number of tagged salmon and trout, single-pass electrofishing was conducted in Merrill and Tide creeks during September-November 2010 to supplement numbers of both species tagged during the trout occupancy assessment.

For the supplemental effort in Merrill Creek, electrofishing focused on areas considered holding habitat for juvenile salmonids (i.e., pools, overhanging banks, areas with large woody debris) and did not include reaches sampled during the trout occupancy survey. Electrofishing began approximately 0.5 km downstream of the Canaan Road bridge (river kilometer (Rkm) 1.6). Stream segments in which access had been obtained were sampled moving upstream until 10-20 fish were captured resulting in a total of 12 supplemental reaches sampled. For the supplemental effort in Tide Creek, electrofishing began approximately 1 km above the waterfall barrier and continued upstream in an effort to tag a total of approximately 200 coastal cutthroat trout. A total of 13 supplemental reaches were sampled, each approximately 200 m in length. In addition, electrofisher settings and fishing techniques were modified as necessary, depending on fish behavior or aquatic conditions. At the completion of each sampled stream segment, a GPS point was taken to signify the end of a sample reach. All fish were scanned for PIT tags. Untagged fish were anaesthetized with clove oil and their weight and length were recorded. All healthy (i.e., active and apparently uninjured) salmon > 65 mm and trout > 85 mm were tagged in same manner as fish captured in GRTS reaches during the trout occupancy survey. Fish were released near their point of capture after recovery (i.e., active swimming) within an aerated bucket.

PIT Tag Antennas – A PIT tag antenna array was installed at the mouth of Merrill Creek on 19 November 2009 to monitor the stream residency and migration timing (in or out of the tributary) of coho salmon and cutthroat trout (Figure 3). This array is composed of two antennas mounted to the upstream end of the Highway 30 culvert to span the entire cross-sectional width of Merrill Creek (Figure 6). A second PIT tag antenna array was installed at the upstream end of the South Deer Island Slough (SDS) tide gates on 18 February 2010 to assess whether juvenile salmonids (tagged in Merrill Creek) leave the slough, or potentially return to the slough as adults (Figure 3). This array utilizes four antennas, one to interrogate each of the four tide gate culverts (Figure 6). When a tagged fish swims over or through any one of the antennas, the PIT tag emits a unique code that is detected, identified and logged on a Destron Fearing FS-1001M transceiver. The PIT tag detection data is downloaded from the transceiver to a computer, where the tagging date and origin of fish can be identified. The Merrill Creek array is currently powered by four 100ah, 12v AGM batteries. The batteries are charged with four 142W PV solar panels through a three stage solar charge controller. The SDS array is powered by two 12v AGM batteries which are charged by a propane fueled thermoelectric generator.

Figure 6. PIT tag antenna arrays on Merrill Creek (left) and South Deer Island Slough (right).

Results

Lamprey

A total of 4.2 km of Merrill Creek, representing 51% of the entire stream length downstream of the barrier waterfall, was surveyed among nonconsecutive reaches for Pacific lamprey nets or other evidence of spawning, such as carcasses. No evidence of Pacific lamprey spawning activity was observed in the three reaches surveyed and no Pacific lamprey carcasses were discovered. Coincidentally, western brook lamprey and unidentified lamprey were found in three GRTS reaches (4, 11, and 15; see Table 1 and Figure 7) sampled to determine coastal cutthroat trout occupancy in Merrill Creek.

Coastal Cutthroat Trout

Occupancy and Distribution – Forty-two reaches in Tide Creek and Merrill Creek were sampled to estimate coastal cutthroat trout SSPD and qualitatively describe distribution. Coastal cutthroat trout were captured in 76% (32/42) of the reaches (Table 1). Two or more size classes of coastal cutthroat trout were captured in 19 of the 42 reaches; 13 reaches resulted in only a single size class (see Figure 8 for length-frequency of all sites combined).

Twenty-one reaches were sampled in Merrill Creek during 2010 (Figure 7). Habitat data were collected in all reaches (Appendix A) and additional comments recorded (Appendix B). Overall, reaches required an average of 52 minutes per reach to survey. Electrofishing efforts in Merrill Creek totaled 6,657 seconds with an average of 317 seconds per reach. Electrofishing voltage range was 350-400, DC 12-14%, and 24-28 Hz.

Table 1. Reach, date, coastal cutthroat trout presence, size class difference (>30 mm FL), size classes, and other taxa observed at GRTS reaches in Merrill and Tide creeks, 2010.

Reach	Date	Cutthroat present	Size class difference	Size classes present	Other taxa present
			Merrill Creek		
1	9/13/2010	Y	N	IV	Cottid sp., Coho salmon
2	9/14/2010	Y	N	II, III	Cottid sp., Coho salmon, Crayfish
3	9/15/2010	Y	Y	I, III	Cottid sp.
4	9/14/2010	Y	Y	I, II, III	Cottid sp., Coho salmon, Lamprey
5	9/10/2010	N	---	---	---
6	9/8/2010	Y	Y	I, III	Cottid sp.
7	9/10/2010	Y	N	II	Cottid sp., Coho salmon
8	9/17/2010	Y	N	I	---
9	9/14/2010	Y	N	II	Cottid sp., Coho salmon
10	9/10/2010	Y	Y	I, II, IV	Cottid sp., Coho salmon, Crayfish
11	9/9/2010	N	---	---	Cottid sp., Newts, WB Lamprey
12	9/16/2010	Y	N	III	Cottid sp.
13	9/15/2010	Y	N	I, II	Cottid sp.
14	9/15/2010	Y	Y	I, II	Cottid sp., Coho salmon
15	9/13/2010	Y	N	VI	Cottid sp., Coho salmon, Lamprey
16	9/17/2010	Y	N	I	Coho salmon
17	9/9/2010	Y	N	I, II	Cottid sp., Newts
18	9/16/2010	N			Cottid sp., Newts
19	9/9/2010	Y	Y	II, III, IV, V	Cottid sp.
20	9/13/2010	Y	N	III	Cottid sp.
21	9/8/2010	N	---	---	Cottid sp., Coho salmon

Table 1. Continued.

Reach	Date	Cutthroat present	Size class difference	Size classes present	Other taxa present
			Tide Creek		
1	10/1/2010	N	---	---	Cottid sp., Salamander
2	9/30/2010	Y	Y	I, III, IV	Cottid sp., Crayfish, Mussels
3	9/27/2010	N	---	---	Cottid sp., Crayfish
4	10/1/2010	Y	N	I	---
5	9/28/2010	Y	N	IV, V	Cottid sp.
6	9/30/2010	Y	Y	I	---
8	10/4/2010	Y	Y	I, III, IV, V	Cottid sp.
9	9/28/2010	Y	Y	I, II, III	Cottid sp., Crayfish
10	10/4/2010	Y	N	I	Cottid sp.
11	9/29/2010	Y	N	III	Cottid sp.
12	9/29/2010	Y	Y	I, II	Cottid sp.
14	9/28/2010	N	---	---	Cottid sp., Salamander
15	9/27/2010	N	---	---	Mussels (bed > 10 individuals)
16	10/1/2010	Y	N	V	Cottid sp., Crayfish
17	9/27/2010	Y	N	I, II	Cottid sp., Crayfish
18	9/30/2010	N	---	---	Cottid sp., Salamander
20	9/24/2010	Y	Y	I, II, III	---
22	9/30/2010	N	---	---	---
25	10/5/2010	Y	Y	II, IV	Cottid sp., Crayfish
26	10/5/2010	Y	Y	I, III	Cottid sp.
27	10/5/2010	Y	Y	I, II, III	---

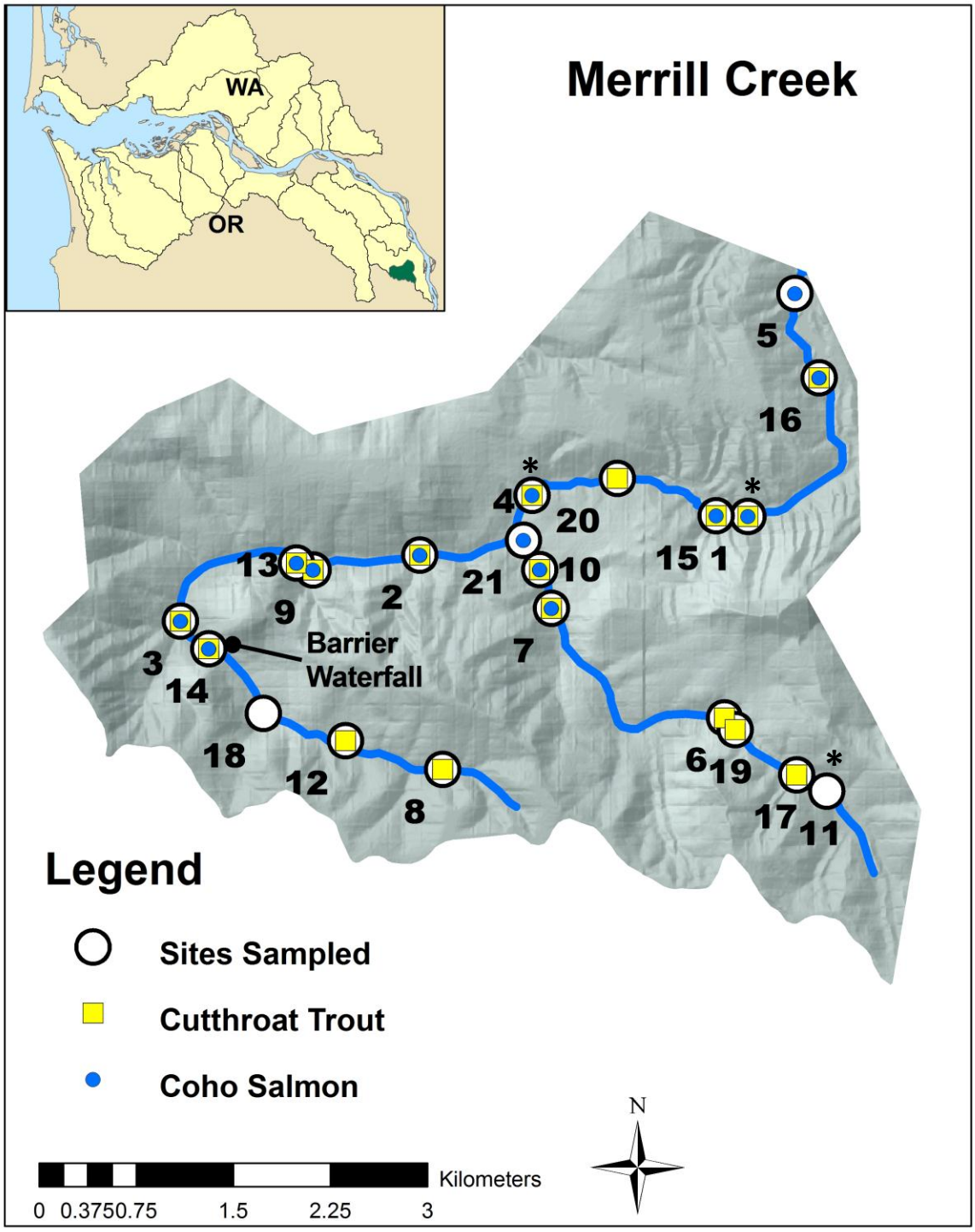


Figure 7. Reaches sampled in Merrill Creek in 2010. *Asterisk denotes reaches where lamprey also were collected.

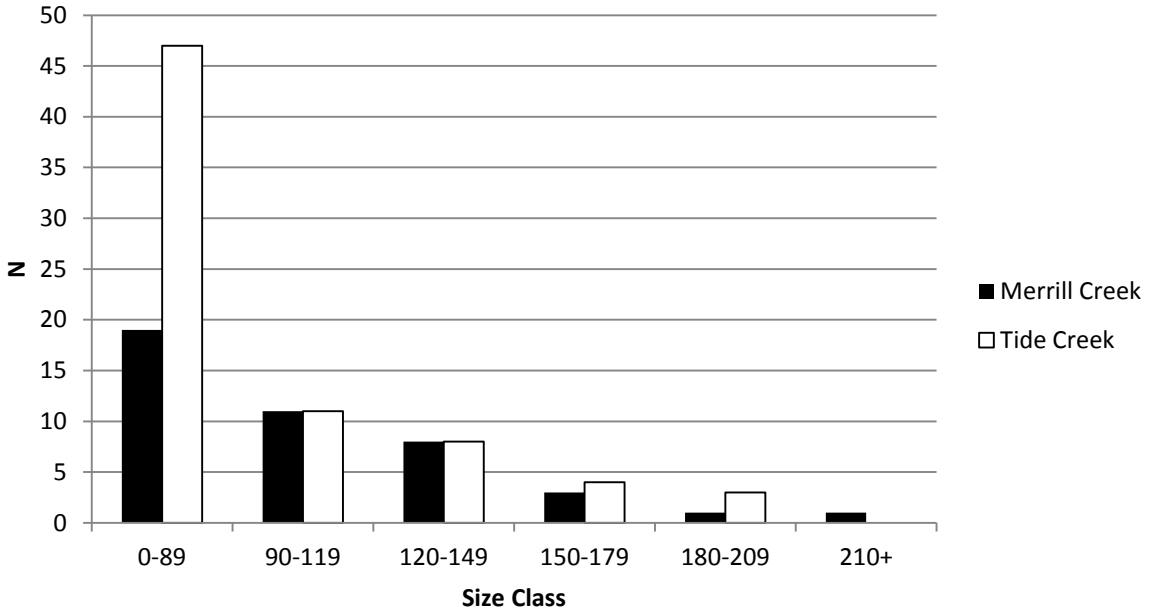


Figure 8. Length (FL mm) frequency of coastal cutthroat trout collected at trout occupancy reaches in Merrill and Tide creeks 2010.

The SSDP of coastal cutthroat trout in Merrill Creek was 81% (trout were found at 17 of 21 reaches; Figure 7). A total of 43 coastal cutthroat trout were captured throughout Merrill Creek. Water temperature range was 11.0-15.5°C (average 13.5°C; Appendix A). A potential waterfall barrier exists at the upstream end of reach 14 (Figure 9). Coastal cutthroat trout were found above this barrier in 2 of 3 reaches upstream (Figure 7).

Twenty-one GRTS reaches were sampled in Tide Creek during 2010 (Figure 10). Habitat data was collected in all reaches (Appendix A) and additional comments recorded (Appendix B). Overall, reaches required an average of 50 minutes per reach to survey. Electrofishing in Tide Creek totaled 5,372 seconds with an average of 256 seconds per reach to survey. Electrofishing voltage range was 300-400, DC 12-16%, and 28 Hz was used in all reaches in Tide Creek.

The SSDP of coastal cutthroat trout was 71% (trout were found in 15 of the 21 reaches, Figure 10). No salmonids were present in six reaches (Table 1), including the three lower-most reaches, suggesting distribution of coastal cutthroat trout does not extend to the lower part of the watershed. A total of 73 coastal cutthroat trout were captured throughout Tide Creek. Water temperature range was 8.5-9.5°C (average 9.0°C; Appendix A).

Habitat – Within both watershed units, habitat types were pools (32.6%), riffles (33.7%), and runs (31.4%), and the most common substrate type was sand (49%). The longest mean habitat lengths were runs (16.6 m) and the shortest were pools (8.3 m). Undercut banks were found at all reaches and range of occurrence was 3-72%. Large woody debris created 11% of undercut banks and 86% of the banks were formed by eroding soil banks.

Figure 9. Likely barrier waterfall in Merrill Creek.

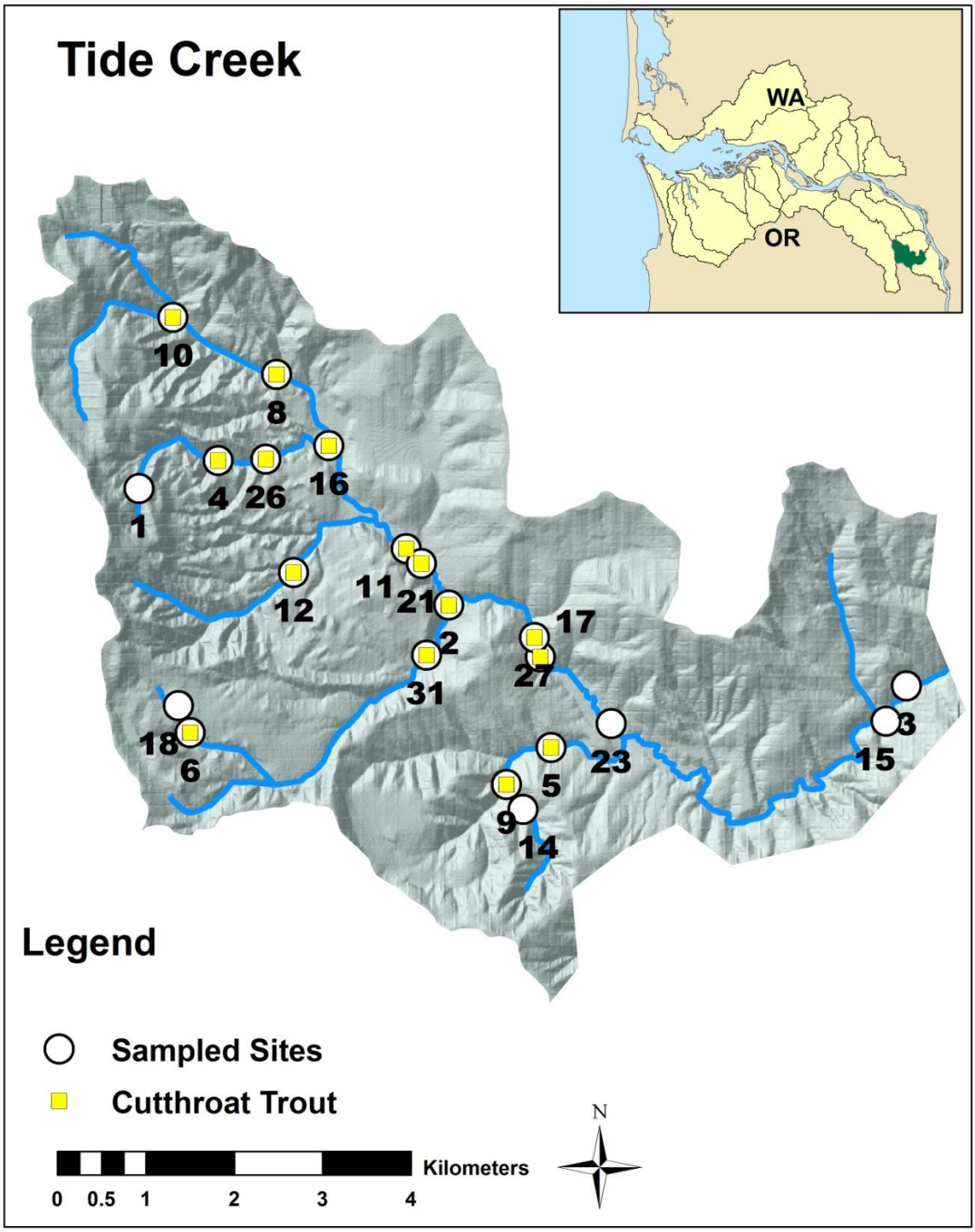


Figure 10. Reaches sampled in Tide Creek 2010. Barrier waterfall is approximately 1 km downstream of reach 3.

Coastal Cutthroat Trout and Juvenile Coho Salmon Movement and Residency

Merrill Creek: 2010 – A total of 66 coastal cutthroat trout ranging in length from 101 to 291 mm (average 141 mm) were tagged in Merrill Creek (Table 2). A total of 333 juvenile coho salmon ranging in length from 47 to 105 mm (average 73 mm) were captured in Merrill Creek. Of the total, 265 coho salmon were subsequently marked with PIT tags. The remaining 68 juvenile coho salmon were not marked with PIT tags due to their small size (64 fish) or poor condition (e.g., fish with black spot). No adipose fin clipped coho salmon were captured in Merrill Creek. Coincidentally, coho salmon coexisted with coastal cutthroat trout at 11 GRTS reaches and were the only salmonid found at 2 reaches, all downstream of the barrier waterfall (see Table 1 and Figure 7).

Table 2. Total number of coho salmon and coastal cutthroat trout tagged in each GRTS reach and supplemental sample reach in Merrill Creek, 2010.

Date	GRTS Reach	Tagged Coho	Tagged Cutthroat	Date	Supplemental Sample Reach	Tagged Coho	Tagged Cutthroat
9/8/10	6	0	1	9/17/10	1	14	3
9/8/10	21	2	0	9/20/10	2	18	4
9/9/10	11	0	0	9/20/10	3	10	1
9/9/10	17	0	0	9/20/10	4	13	6
9/9/10	19	0	7	9/20/10	5	9	2
9/10/10	5	4	0	9/21/10	6	16	4
9/10/10	7	7	0	9/21/10	7	24	2
9/10/10	10	0	2	9/22/10	8	19	4
9/13/10	1	6	1	9/22/10	9	22	4
9/13/10	15	6	1	9/22/10	10	28	3
9/13/10	20	0	1	9/23/10	11	20	3
9/14/10	2	3	2	9/23/10	12	26	10
9/14/10	4	7	2	---	---	---	
9/14/10	9	4	1	---	---	---	
9/15/10	3	0	1	---	---	---	
9/15/10	13	0	0	---	---	---	
9/15/10	14	0	0	---	---	---	
9/16/10	12	0	1	---	---	---	
9/16/10	18	0	0	---	---	---	
9/17/10	8	0	0	---	---	---	
9/17/10	16	7	0	---	---	---	

Tide Creek: 2010 – A total of 175 coastal cutthroat trout ranging in length from 74 to 253 mm (average 131 mm) were tagged in Tide Creek (Table 3). No coho salmon were captured within 21 GRTS reaches or supplemental reaches in Tide Creek. All reaches were upstream of the barrier waterfall (Figure 10).

Table 3. Total number of coho salmon and coastal cutthroat trout tagged in each GRTS reach and supplemental sample reach in Tide Creek, 2010.

Date	GRTS Reach	Tagged Coho	Tagged Cutthroat	Date	Supplemental Sample Reach	Tagged Coho	Tagged Cutthroat
9/24/10	20	0	3	10/25/10	1	0	6
9/27/10	3	0	0	10/25/10	2	0	8
9/27/10	15	0	0	10/25/10	3	0	2
9/27/10	17	0	0	10/26/10	4	0	9
9/28/10	5	0	2	10/26/10	5	0	5
9/28/10	9	0	3	10/26/10	6	0	7
9/28/10	14	0	0	10/29/10	7	0	15
9/29/10	11	0	1	10/29/10	8	0	20
9/29/10	12	0	1	10/29/10	9	0	13
9/30/10	2	0	2	11/1/10	10	0	15
9/30/10	6	0	2	11/1/10	11	0	20
9/30/10	18	0	0	11/3/10	12	0	15
9/30/10	22	0	0	11/3/10	13	0	9
10/1/10	1	0	0	---	---	---	---
10/1/10	4	0	1	---	---	---	---
10/1/10	16	0	1	---	---	---	---
10/4/10	8	0	5	---	---	---	---
10/4/10	10	0	0	---	---	---	---
10/5/10	25	0	4	---	---	---	---
10/5/10	26	0	1	---	---	---	---
10/5/10	27	0	5	---	---	---	---

Movement and residency: Cutthroat trout and coho salmon tagged in 2010 – As of 31 December 2010, a total of six PIT-tagged juvenile coho salmon and one coastal cutthroat trout were detected from the 2010 field season at the Merrill Creek antenna array (Table 4). Tag detections occurred from 3 December through 21 December 2010. Tagged coho salmon originated from six different sampling locations and were detected at the Merrill Creek array a total of 77-92 days after their initial capture (average 85 days). The coastal cutthroat trout originated from a different sampling location than the coho salmon and was detected 78 days after its initial capture.

Table 4. Detection date, tagging date, site of capture (GRTS reach or supplemental sample reach), fork length when tagged, and days since tagged of seven PIT-tagged juvenile coho salmon and a coastal cutthroat trout at Merrill Creek and SDS antenna arrays.

Detection Date	PIT Array	Tag Date	Tag #	GRTS reach	Supplemental sample reach	FL (mm)	Days Since Tagged*
			Coho salmon				
12/3/10	Merrill Creek	9/17/10	SS10258	1	---	73	77
12/9/10	Merrill Creek	9/10/10	SS10210	---	5	77	90
12/10/10	Merrill Creek	9/22/10	SS10407	10	---	71	79
12/11/10	Merrill Creek	9/21/10	SS10337	7	---	71	81
12/13/10	SDS	9/21/10	SS10314	6	---	77	83
12/14/10	SDS	9/22/10	SS10407	10	---	71	83
12/19/10	Merrill Creek	9/20/10	SS10286	3	---	71	90
12/21/10	Merrill Creek	9/20/10	SS10271	2	---	81	92
			Coastal cutthroat trout				
12/9/10	Merrill Creek	9/22/10	SS10657	---	8	125	78

* Number of days between date tagged and detection date.

A total of two coho salmon have been detected at the South Deer Island Slough antenna array as of 31 December 2010. Tag detections occurred on 13 and 14 December 2010. Detection data indicate these fish were tagged in reaches 6 and 10, both 83 days prior to their detection at the South Deer Island Slough antenna array (Table 4). One fish was not detected leaving Merrill Creek, whereas the second fish resided in South Deer Island Slough for four days before it was detected at the SDS array.

Movement and residency: Coho salmon tagged in fall 2009 – The Merrill Creek PIT antenna array was not in operation for a five week period during the months of December 2009 and early January 2010, and during the months of July-October 2010 due to a power source failure. Of the 279 juvenile coho salmon PIT-tagged in Merrill Creek during the 2009 field season (see Poirier et al. 2010), 138 fish (49.5%) were detected at the Merrill Creek antenna array from 25 November 2009 through 19 May 2010 (Figure 11). Coho salmon were detected at the Merrill Creek antenna array 49 to 230 days (average 193 and median 206 days) after tagging.

The South Deer Island Slough PIT antenna array was inoperable during the months of August-October 2010, also due to a power source failure. A total of 56 PIT tags were detected by the South Deer Island slough antennas from 17 April through 20 May 2010 (Figure 11). Of these

detections, 87.5% (49 fish) originated from Merrill Creek, 1.8% (1Chinook salmon) originated from Spring Creek National Fish Hatchery (Rkm 269) and 10.7% (6 fish) were of unknown origin (i.e., orphan tags in PTAGIS or not found in the database). The juvenile Chinook salmon was released from the hatchery on 12 April. It was detected once at the antenna array on 29 April, and subsequently detected at three different antennas of the array over the course of about 40 minutes on 13 June. Thus, the individual is assumed to have resided in Deer Island Slough for at least 45 days. Median residence time of 49 coho salmon in the South Deer Island Slough was 6 days (range 1-162, average 16 days) (Figure 12). Of these fish, 6% (3 fish) entered South Deer Island Slough prior to 31 December 2009 and remained for a median of 156 days (range 150-162, average 156 days); 84% (41 fish) entered the slough during 15 March to 15 May and remained a median of 7 days (range 1-21, average 7 days); and 10% (5 fish) entered after 15 May and remained a median of 1 day (range 1-2, average 1 day).

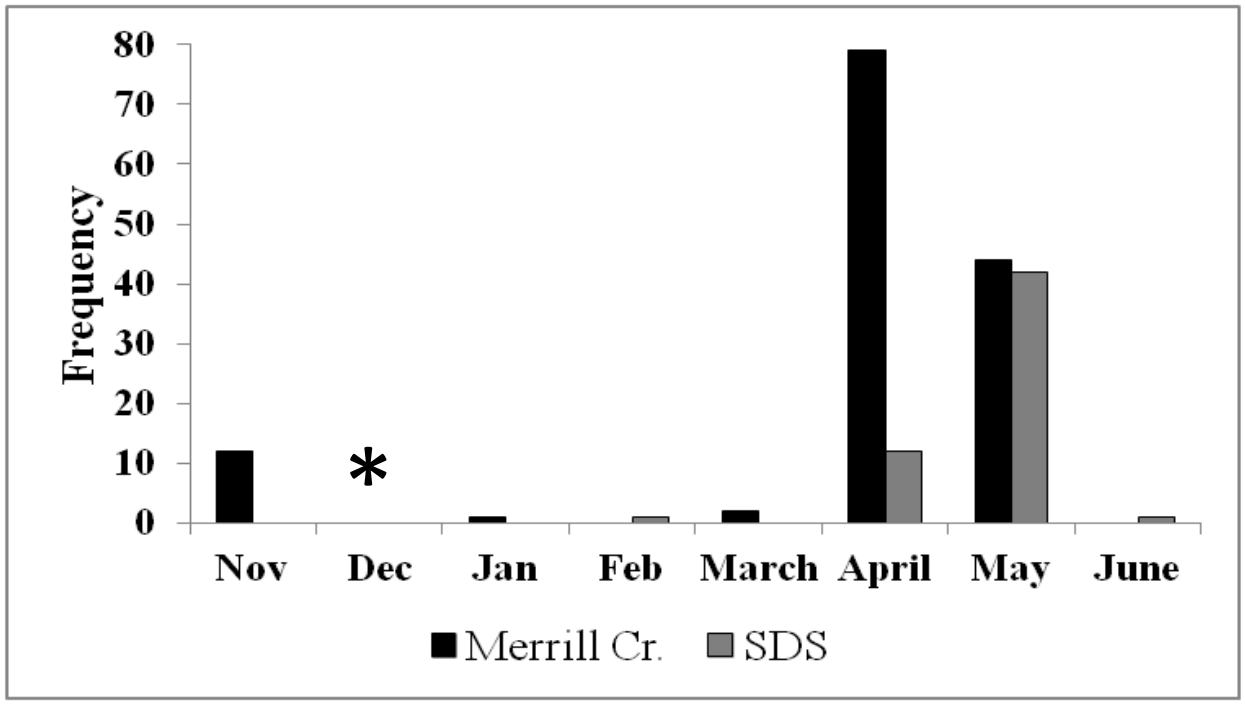


Figure 11. Number of coho salmon detected at Merrill Creek (black bars) and South Deer Island Slough (SDS, grey bars) antenna arrays, November 2009 through June 2010. Merrill Creek array began operating on November 19, 2009 and South Deer Island Slough array began operating on February 18, 2010. *Asterisk denotes time when Merrill Creek array was inoperable due to power failure.

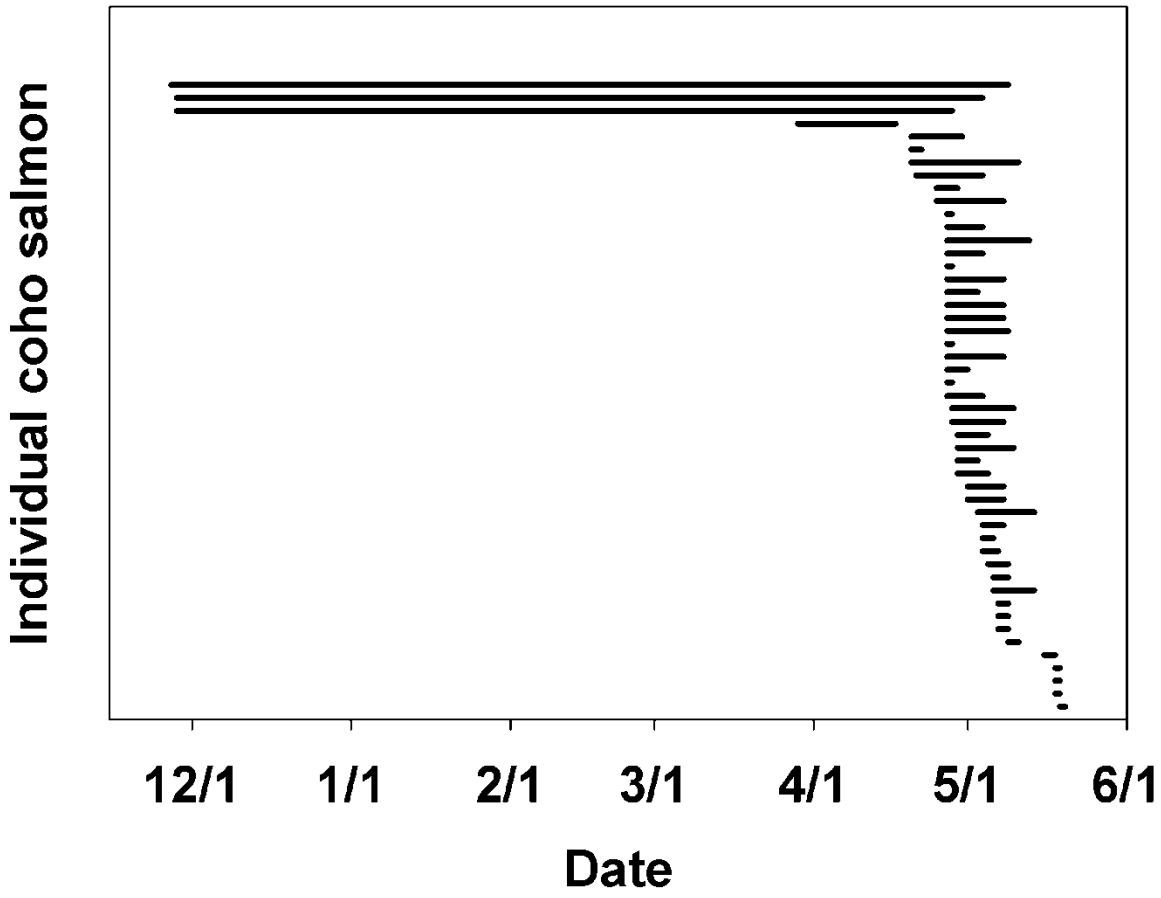


Figure 12. Deer Island Slough residence timing of individual juvenile coho salmon tagged (fall) 2009 in Merrill Creek. Each line represents an individual fish detected at both the Merrill Creek PIT antenna array and the South Deer Slough antenna array at the tide gates. Each line begins on the last date an individual was detected at Merrill Creek and continues to the last date that it was detected at the tide gate array.

Conclusions

Lamprey Spawning

- Larval lamprey were observed in both Tide and Merrill creeks, but no individuals were confirmed to be a Pacific lamprey. No evidence of Pacific lamprey spawning activity (i.e., nests or carcasses) was observed in three non-contiguous reaches (4.2 km total) of Merrill Creek during two days in June 2010. Earlier observations of adult Pacific lamprey suggest that opportunity for spawning may occasionally occur in the watershed.

Coastal Cutthroat Trout Occupancy and Distribution

- Coastal cutthroat trout were distributed in this area of the lower Columbia River basin.
- Sampling confirmed that coastal cutthroat trout occupy both the Merrill Creek and Tide Creek watersheds.
- Coastal cutthroat trout were widely distributed in Merrill Creek and Tide Creek, suggesting that fish utilize a variety of habitats and elevations during their life cycle, and resident and migratory forms may exist in the watersheds.
- Watershed unit analysis is an effective way to document occupancy and distribution of coastal cutthroat trout in the lower Columbia River basin, and may be used to identify trends. Evidence documenting distribution will be useful in making informed management decisions regarding coastal cutthroat trout status as a species of concern.

Coastal Cutthroat Trout and Coho Salmon Movement and Residency

- Juvenile coho salmon occupy and are distributed throughout much of Merrill Creek downstream of the barrier waterfall in the uppermost portion of the watershed.
- In Merrill Creek, coho salmon were detected in 13 of the 18 GRTS reaches, which yielded a 0.72 SSDP.
- No coho salmon were detected in Tide Creek above the falls. Assuming a 0.72 SSDP, this suggests we can be > 99% certain that coho salmon do not occupy Tide Creek above the waterfall. Thus, the waterfall is a barrier to coho salmon.
- Juvenile coho salmon move from Merrill Creek into Deer Island Slough during at least five months of the year. The majority of movement into the slough was detected in April and May.
- Juvenile coho salmon were found to reside days to months in Deer Island Slough. PIT tag evidence suggests that juvenile coho salmon may be found in the slough most months of the year (fall, winter, spring). It is unclear if juvenile coho salmon do or are able to reside in the slough over the summer months.
- Not all juvenile coho salmon detected entering the slough were detected leaving the slough. This could be due to mortality of the fish, antenna detection efficiency, or fish may be rearing in lower Tide Creek or South Deer Island Slough for an additional year before moving out to the Columbia River.
- PIT tag detection evidence indicates that fish from outside the watershed utilize the slough. A total of seven PIT tags were detected at the South Deer Island Slough antenna array originated from locations outside of Merrill Creek. One tag was applied to a juvenile fall Chinook salmon released from Spring Creek National Fish Hatchery that appeared to reside in Deer Island Slough for at least 45 days. The other six tags were of unknown origin.
- Juvenile coho salmon tagged in Merrill Creek during 2009 would be expected to be returning as adults by fall 2012.

Western pearlshell mussel

- Allard et al. (2012) inspected 208 mussels from a bed estimated to consist of 2,390 individuals to investigate timing of reproduction in Merrill Creek.
- No signs of reproduction were observed in any individual inspected.

- Evidence of reproduction (conglutinates at the beds and glochidia in drift samples) was observed from 5 May through 16 June 2010, and corresponding water temperatures were recorded.

Implementation of SHC

Activities of the CRFPO during 2010 generated information contributing to a better understanding of lamprey, WPM, and juvenile coho salmon and coastal cutthroat trout presence, distribution, and use among various areas of Tide and Merrill creeks and South Deer Island Slough. This, and additional information being collected by our partners concerning conditions in South Deer Island Slough (i.e., water temperature, water surface elevations inside and outside tide gates), primarily supports the biological planning and conservation design elements of SHC. The association of each objective addressed in 2010 with elements and sub-elements of SHC, including examples of potential results of biological information and resulting decisions and conservation actions that could be influenced by the information are illustrated in Table 5.

The goal of the partners' draft restoration plan focuses on salmon. Our work is providing information on salmon, as well as other species. In the context of sub-elements of biological planning and conservation design, we are assessing the current state of species populations (i.e., coho salmon and cutthroat trout populations are present and spawn in the watershed, whereas Pacific lamprey may occasionally spawn there and juvenile Chinook salmon rear in the slough), and identifying limiting factors (e.g., thermal conditions likely stressful to salmonids in summer and passage restriction between the slough and Columbia River at the tide gates). This information also supports the conservation design element of SHC, namely the sub-elements of developing species-habitat relations (e.g., juvenile coho salmon appear to use slough habitat during several months) and identifying priority areas (e.g., residency and timing of juvenile coho salmon movement among stream, slough, and river habitats suggest possible life-history strategies, which highlight temporal variability in the relative importance of some areas for coho salmon). An improved understanding of coho salmon and coastal cutthroat trout movement and residency between stream and slough habitats as well as passage at the tide gates, which is being addressed by this study, ultimately will assist our partners in making informed decisions concerning conservation delivery. For instance, our partners are considering several types of conservation actions, ranging from expanding fish access to adjacent slough habitat to replacing the tide gates between the slough and the Columbia River. Our information will help them decide on the types, locations, and relative importance of potential habitat restoration actions at Deer Island to pursue. Incidentally, we found juvenile coho salmon rearing in the 8.2-km reach between the confluence and barrier in Merrill Creek. With this information and increased interest in the creek by some landowners, our partners decided to restore a reach of stream habitat in Merrill Creek (Oregon Watershed Enhancement Board 2010). Continued monitoring and assessment efforts in the future will inform the development of additional conservation delivery actions, including the exploration of improving stream habitat, slough habitat, and tide gate passage.

Furthermore, information gained from our work should be highly transferrable to other local watersheds. The overall physical and biological conditions, as well as aquatic habitat issues, at the Deer Island complex are not unique to the area, and are expected to be representative of numerous relatively small watersheds in the lower Columbia River and north Oregon coast. Thus, after a cursory assessment of a new watershed (e.g., for species composition, general habitat categories, and factors affecting habitat), information (e.g., fish

spawning, occupancy, distribution, movement, residency) generated at Deer Island likely could be applied to inform (i.e., identify and prioritize) biological planning and conservation design and delivery elsewhere.

Table 5. Each objective addressed in 2010 with associated elements and sub-elements of SHC, potential results of biological information, and resulting decisions or conservation actions.

Objective	SHC element/primary sub-element	Potential result	Potential decision/action
1) Evaluate whether Pacific lamprey and western brook lamprey spawn in Tide and Merrill creeks.	Biological Planning —assess current state of species —identify limiting factors Conservation Design —identify priority areas	Evidence suggests that Pacific lamprey do not spawn at the Deer Island Complex.	Evaluate tide gates operation relative to Pacific lamprey passage needs (timing, physical constraints). Determine necessary modifications if passage conditions appear limiting.
2) Determine coastal cutthroat trout occupancy within the two streams and distribution relative to barriers thought to prevent upstream movement.	Biological Planning —assess current state of species —identify limiting factors Conservation Design —identify priority areas	Coastal cutthroat trout occupy watersheds of both streams and are widely distributed above barriers thought to prevent upstream movement (i.e., waterfall in upper Merrill Creek and lower Tide Creek).	Consider effects on cutthroat trout in evaluating proposed actions (e.g., roads, development) that may affect aquatic habitat in areas upstream of the barriers. Additional habitat evaluation may indicate opportunities for restoration actions.
3) Determine if and when juvenile coho salmon and coastal cutthroat trout move among habitats in Merrill Creek, Tide Creek, and Deer Island Slough, and the Columbia River. 4) Determine how long juvenile coho salmon and coastal cutthroat trout reside in areas of the Deer Island Complex.	Biological Planning —identify priority species —assess current state of species —identify limiting factors Conservation Design —describe species-habitat relations —identify priority areas	a) Most fish exhibit extensive residency in Merrill Creek and very little time in the slough. b) Most fish exhibit extensive residency in the slough during times that tide gate operation provides opportunity for fish passage to the Columbia River. c) Most fish exhibit extensive residency in the slough during times that water surface elevations indicate that the tide gates are closed for extended periods.	a) Focus on conservation delivery actions to protect and restore quality and quantity of stream habitat (e.g., riparian plantings, reducing sediment input where appropriate). b) Focus on conservation delivery actions to protect and restore quality and quantity of slough habitat (e.g., expand connective with blocked areas of the slough). c) Focus on conservation delivery actions that increase time that tide gates are open (e.g., hold gates open, install side-hinged self-restraining gate).

Table 5. Continued.

Objective	SHC element/primary sub-element	Potential result	Potential decision/action
5) Explore whether we can assess the adult return rates of coho salmon and cutthroat trout (relative to their use of Deer Island Slough).	Biological Planning —identify priority species —assess current state of species —identify limiting factors Conservation Design —describe species-habitat relations —identify priority areas	May allow evaluation of survival relative to timing and duration of residency in Merrill Creek and Deer Island Slough.	Survival-residency relations may indicate priority areas (e.g., stream or slough habitats) on which to focus for protection and opportunities for habitat restoration actions.
6) Investigate the reproductive timing of western pearlshell mussel.	Biological Planning —assess current state of species —identify limiting factors Monitoring and Research —assumption-driven research	Location and extent of WPM bed under study has been documented, and investigation of reproductive timing is ongoing, for which assumptions about factors influencing timing may be developed.	Consider effect on WPM in evaluating proposed actions (development) that may affect the location of the WPM bed and factors likely influencing reproduction.

Acknowledgements

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Appendix A: Habitat data Merrill and Tide creeks.

Date	9/13/2010	9/14/2010	9/15/2010	9/14/2010	9/10/2010	9/8/2010	9/10/2010	9/17/2010
Watershed Unit	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek
Site ID	1	2	3	4	5	6	7	8
Sampling Crew	SC,JP,BPS	SC,JP,BPS	SC, JP	SC,JP,BPS	JP, BPS, HS, MH	SC, JP, BPS	JP, BPS, HS, MH	SC, JP, BPS
Elevation (m)	61	61	122	61	55	132	61	183
% Gradient	1	1	1	0.5	0.5	2	1.75	2
% Canopy Cover	0	85	95	25	40	90	40	85
CCT Present?	Y	Y	Y	Y	N	Y	Y	Y
# CCT	1	2	4	5	0	3	1	1
E-Fisher Volts	400	400	400	400	400	350	350	400
E-Fisher Duty Cycle (%)	12	12	12	12	12	12	12	12
E-Fisher Hz	28	28	28	28	28	24	28	28
E-Fisher Seconds	698	214	297	541	401	175	408	242
Temperature (°C)	13	13	12	13	14	12	13	10.5
Conductivity (µs)	63.2	38.2	26.3	46.6	61.4	42.7	45.1	45.1
Time Start	9:50	12:25	10:10	9:58	14:10	13:05	11:08	9:33
Time End	11:10	13:10	11:09	10:58	14:50	14:02	12:32	10:03
Reach Length (m)	50	50	50	50	50	50	50	50
# Pools in Reach	2	0	1	2	0	2	3	1
#LWD >3 m and > 10 cm	1	7	8	5	2	13	4	6
# LWD Piles	0	0	0	0	0	4	2	0
# Large LWD Pieces	0	0	1	0	0	0	0	0
# Root Wads	1	0	0	1	0	1	0	0
Mean Depth (m)	0.8225	0.02	0.025	0.4575	0.26	0.11	0.1075	0.025
Mean Wetted Width (m)	6.8	2.4	1	3.6	6.4	1.9	3.4	0.75
Mean Bankfull Width (m)	9.7	3.9	2.6	5.2	6.7	3.5	3.7	0.8
% Undercut Banks	72	23	15	29	50	12	47	10
Shannon-Wiener Index (H)	0.09	0.14	0.22	0.25	NA	0.19	0.09	0.09

Date	9/14/2010	9/10/2010	9/9/2010	9/16/2010	9/15/2010	9/15/2010	9/13/2010	9/17/2010
Watershed Unit	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek
Site ID	9	10	11	12	13	14	15	16
Sampling Crew	SC,JP,BPS	JP, BPS, HS, MH	SC, JP, BPS	SC, JP, BPS, DA	SC, JP	SC, JP	SC,JP,BPS	SC, JP, BPS
Elevation (m)	99	61	183	183	112	122	61	55
% Gradient	3	3	11	1	4	8.5	1	1
% Canopy Cover	75	70	25	95	50	60	50	20
CCT Present?	Y	Y	N	Y	Y	Y	Y	Y
# CCT	1	3	0	1	2	6	1	1
E-Fisher Volts	400	350	375	400	400	400	400	400
E-Fisher Duty Cycle (%)	12	12	14	12	12	12	12	12
E-Fisher Hz	28	26	25	28	28	28	28	28
E-Fisher Seconds	148	324	556	112	238	261	531	481
Temperature (°C)	12.5	12.5	12.5	12.5	11.5	12	13.5	15.5
Conductivity (µs)	36.7	43.4	47.6	32.4	37.3	26.3	56.7	67.1
Time Start	13:30	9:43	11:44	11:25	8:47	11:52	11:25	11:12
Time End	14:29	10:30	12:38	12:00	9:37	12:44	12:24	12:09
Reach Length (m)	50	50	50	50	50	50	50	50
# Pools in Reach	0	2	2	1	0	1	2	1
#LWD >3 m and > 10 cm	8	3	6	4	3	6	5	20
# LWD Piles	0	3	0	0	3	0	0	1
# Large LWD Pieces	2	0	0	0	0	0	0	0
# Root Wads	0	0	2	0	0	0	0	0
Mean Depth (m)	0.115	0.07	0.625	0.0825	0.15	0.015	0.2825	0.2225
Mean Wetted Width (m)	2.8	2.3	4.8	1.3	2.2	1	4.9	3.7
Mean Bankfull Width (m)	4.4	4.2	4.8	1.75	3.8	4.2	5	8.2
% Undercut Banks	14	20	3	14	7	13	18	15
Shannon-Wiener Index (H)	0.09	0.19	NA	0.09	0.14	0.27	0.09	0.09

Date	9/9/2010	9/16/2010	9/9/2010	9/8/2010
Watershed Unit	Merrill Creek	Merrill Creek	Merrill Creek	Merrill Creek
Site ID	17	18	19	21
Sampling Crew	SC, JP, BPS	SC, JP, BPS, DA	SC, JP, BPS	SC, JP, BPS
Elevation (m)	183	122	149	61
% Gradient	1	1	1.5	3
% Canopy Cover	25	5	60	90
CCT Present?	Y	N	Y	N
# CCT	3	0	7	0
E-Fisher Volts	375	400	375	350
E-Fisher Duty Cycle (%)	12	12	14	12
E-Fisher Hz	25	28	25	24
E-Fisher Seconds	162	213	271	212
Temperature (°C)	12.5	13.5	12	12
Conductivity (µs)	49	45.3	44	42.8
Time Start	10:49	9:40	9:00	9:59
Time End	11:30	10:14	9:57	11:05
Reach Length (m)	50	50	50	50
# Pools in Reach	2	1	2	2
#LWD >3 m and > 10 cm	6	0	5	9
# LWD Piles	0	1	0	0
# Large LWD Pieces	1	0	0	1
# Root Wads	0	2	1	0
Mean Depth (m)	0.2425	0.45	0.0275	0.1175
Mean Wetted Width (m)	1.7	9	1.1	3.1
Mean Bankfull Width (m)	1.9	9	3	3.7
% Undercut Banks	25	5	41	13
Shannon-Wiener Index (H)	0.19	NA	0.30	NA

Date	10/1/2010	9/30/2010	9/27/2010	10/1/2010	9/28/2010	9/30/2010	10/4/2010	9/28/2010
Watershed Unit	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek
Site ID	1	2	3	4	5	6	8	9
Sampling Crew	AH, MH, BPS	BPS, JJ, AH	JJ, MH, BS	AH, MH, BPS	SL, JJ, BPS	BPS, JJ, AH	SC, BPS	JJ, SL, BPS
Elevation (m)	301	122	61	183	61	283	122	61
% Gradient	5	0.5	0	5.5	1	5.2	2	1
% Canopy Cover	50	50	40	80	20	90	5	10
CCT Present?	N	Y	N	Y	Y	Y	Y	Y
# CCT	0	4	0	4	2	7	7	5
E-Fisher Volts	350	350	400	300	400	350	350	350
E-Fisher Duty Cycle (%)	16	16	12	16	16	16	16	16
E-Fisher Hz	28	28	28	28	28	28	28	28
E-Fisher Seconds	131	351	280	199	397	253	312	389
Temperature (°C)	12.5	13	14	12	15	12.5	11	15
Conductivity (µs)	80.8	88.8	118.7	123	N/A	82.7	89.5	N/A
Time Start	13:10	9:16	9:23	10:43	9:10	12:37	11:38	12:58
Time End	13:59	10:15	9:54	11:30	9:58	13:53	12:35	14:03
Reach Length (m)	50	50	50	50	50	50	50	50
# Pools in Reach	6	2	0	1	0	4	2	2
#LWD >3 m and > 10 cm	10	1	5	17	11	10	6	4
# LWD Piles	0	0	0	1	0	1	1	0
# Large LWD Pieces	5	0	0	3	0	5	0	5
# Root Wads	2	0	0	1	0	0	0	2
Mean Depth (m)	0.0875	0.125	0.225	0.0125	0.835	0.0175	0.15	0.3975
Mean Wetted Width (m)	1.4	1.05	10.4	1.25	4.35	1.15	2.3	3.25
Mean Bankfull Width (m)	2.44	6.62	11.5	2.04	4.35	1.7	2.3	3.25
% Undercut Banks	3	44	28	21	16	42	30	27
Shannon-Wiener Index (H)	NA	0.155	NA	0.155	0.096	0.220	0.220	0.179

Date	10/4/2010	9/29/2010	9/29/2010	9/28/2010	9/27/2010	10/1/2010	9/27/2010	9/30/2010
Watershed Unit	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek
Site ID	10	11	12	14	15	16	17	18
Sampling Crew	SC, BPS	SL, MK, BPS	BPS, SL, MK	JJ, SL, BPS	JJ, MH, BPS	BPS, MH, AH	JJ, MH, BPS	BPS, JJ, AH
Elevation (m)	185	122	141	62	61	122	62	282
% Gradient	3.5	1.5	5	3	0	0	2	6.3
% Canopy Cover	60	80	75	30	25	20	40	10
CCT Present?	Y	Y	Y	N	N	Y	Y	N
# CCT	4	1	2	0	0	1	5	0
E-Fisher Volts	350	350	350	350	400	400	350	350
E-Fisher Duty Cycle (%)	16	16	16	16	16	16	16	16
E-Fisher Hz	28	28	28	28	28	28	28	28
E-Fisher Seconds	123	257	170	163	337	285	384	208
Temperature (°C)	10	13	12	13	14.5	11.5	15	13.5
Conductivity (µs)	87.3	117.2	120	NA	116.4	94.4	125.6	114.5
Time Start	10:13	12:20	10:17	11:15	10:51	9:07	12:50	11:15
Time End	10:51	13:29	11:18	12:21	11:25	9:40	13:30	11:56
Reach Length (m)	50	50	50	50	50	50	50	50
# Pools in Reach	1	1	2	0	0	0	1	3
#LWD >3 m and > 10 cm	5	1	11	12	9	2	2	4
# LWD Piles	0	0	1	0	1	0	0	0
# Large LWD Pieces	2	1	2	0	2	0	2	1
# Root Wads	0	1	3	1	2	2	0	3
Mean Depth (m)	0.11	0.0825	0.035	0.0625	0.33	0.2675	0.365	0.1825
Mean Wetted Width (m)	1.1	6.05	1.7	1.1	5.5	6.1	5.1	1.33
Mean Bankfull Width (m)	3.7	5.6	5.35	1.15	6.1	6.1	8.8	1.5
% Undercut Banks	15	26	24	29	21	75	2	3
Shannon-Wiener Index (H)	0.155	0.057	0.096	NA	NA	0.057	0.179	NA

Date	9/24/2010	9/30/2010	10/5/2010	10/5/2010	10/5/2010
Watershed Unit	Tide Creek	Tide Creek	Tide Creek	Tide Creek	Tide Creek
Site ID	20	22	25	26	27
Sampling Crew	SC, BPS, JP	BPS, JJ, AH	SC, BPS	SC, BPS	SC, BPS
Elevation (m)	244	305	61	142	62
% Gradient	6	2	1.5	1.5	1
% Canopy Cover	80	75	30	60	25
CCT Present?	Y	N	Y	Y	Y
# CCT	10	0	4	11	9
E-Fisher Volts	350	350	350	350	350
E-Fisher Duty Cycle (%)	12	16	16	16	16
E-Fisher Hz	28	28	28	28	28
E-Fisher Seconds	163	77	401	228	264
Temperature (°C)	11.6	13	11.5	10	11
Conductivity (µs)	80.1	45.6	NA	NA	NA
Time Start	12:21	15:05	9:00	12:32	10:42
Time End	13:15	15:38	9:38	13:37	11:32
Reach Length (m)	50	50	50	50	50
# Pools in Reach	2	2	1	1	1
#LWD >3 m and > 10 cm	2	7	5	15	1
# LWD Piles	0	0	0	2	0
# Large LWD Pieces	1	1	0	4	0
# Root Wads	0	0	0	1	1
Mean Depth (m)	0.0275	0	0.31	0.0375	0.2125
Mean Wetted Width (m)	2.8	0	4.6	2.2	2.9
Mean Bankfull Width (m)	4.9	1.2	5.8	3.4	6.2
% Undercut Banks	4	15	22	47	5
Shannon-Wiener Index (H)	0.267	NA	0.155	0.280	0.253

Appendix B: Habitat comments.

Watershed	Site	Comments
Merrill Creek	11	Beaver activity in sample site.
	18	Habitat is marshy, flat and wide.
	19	Clear Cut Area with beaver activity.
Tide Creek	5	Beaver Dams within sampling site.
	13	Not sampled, Dry.
	22	Intermittent spring fed creek.

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