Fish Species Composition, Distribution, and Biotic Integrity in Beaver Creek, a Tributary to the Sandy River in Multnomah County, Oregon

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Summary

This investigation of fish species composition and distribution, and the resultant calculation of Fish Index of Biotic Integrity (FIBI) scores, allow assessment of within and between-reach changes in stream health and fish assemblages over time and can be used to guide land use planning and prioritization of fish habitat restoration and protection projects within Beaver Creek. The results will also serve as a baseline to allow evaluation of future restoration projects within Beaver Creek, including but not limited to proposed fish passage improvements at several road crossings. This study complements a similar study previously undertaken by Oregon Department of Fish and Wildlife (ODFW) and the City of Portland in four City of Portland watersheds (Van Dyke and Storch, 2009) and earlier investigations in urban streams of the lower Willamette River watershed (Ward 1995; Friesen and Zimmerman 1999; Tinus et al. 2003).

Wild Fish Conservancy (WFC) conducted a stratified-random single-pass electrofishing survey within four distinct reaches of mainstem Beaver Creek in September 2010; fish species composition at select locations within headwater reaches was also investigated in September 2010 and again during higher flows in April 2011. In addition to identifying to species and enumerating the fish brought to hand, staff recorded the habitat types from which fish were sampled, photographed representatives of each species encountered, and measured the fork-length of the salmonids (juvenile coho salmon (*Onorhynchus kisutch*) and rainbow trout/steelhead (*O. mykiss*) brought to hand.

During the course of the September 2010 electrofishing surveys, a total of 1189 fish were netted, identified, and released. WFC documented twelve native fish species and four non-native fish species. An additional three non-native species were documented in the headwaters survey. FIBI scores for the four mainstem Beaver Creek reaches ranged from 47 (severely impaired) to 64 (marginally impaired), out of a possible score of 100.

Introduction

Low-elevation watersheds are often at the interface of urban and rural areas, have a long history of agricultural land use, and continue to face pressure from urban development.
Beaver Creek is no exception. Water quality impacts for the stream are documented in the Total Maximum Daily Load for the Sandy River, as wells as through monitoring from the Multnomah County Stormwater Program. Water quality impacts include: exceedances of fecal bacteria and temperature standards, stormwater runoff from both agricultural and urban areas, sedimentation, reduced summer low-flows, erosion, and flooding. Additional detrimental ecological impacts include: the presence of introduced fish and vegetation species, simplified instream physical habitat, and removal of riparian vegetation. Despite these threats, the watershed is known to support a variety of native fishes and invertebrates, and opportunities exist to protect and restore

portions of the watershed so it can continue to provide ecosystem services to its residents and those downstream.

While information on water quality is available from previous studies, much less is known about the biological condition in Beaver Creek. Prior to this effort, no quantitative data of fish species diversity and distribution existed for the Beaver Creek watershed. The only known quantitative fish data from Beaver Creek originate from annual but limited ODFW and Mt. Hood Community College salmon spawning surveys, and an outmigrant (smolt) trap operated near the mouth of Beaver Creek by the City of Portland.

A biotic health assessment, including both fish and macro-invertebrate metrics, is needed to identify and prioritize opportunities for habitat restoration and to evaluate the effectiveness of state and local government environmental management programs. Short and long term planning efforts also need environmental data to make more informed decisions about future growth and infrastructure needs. Baseline fish data provide a long term indicator of the biotic health of the watershed, and provide a benchmark against which habitat protection and restoration efforts can be measured. Specific objectives of this study included determining the seasonal (spring and late summer) occurrence and distributions of fish species during high and low flow periods, respectively, and calculating a Fish Index of Biotic Integrity to serve as a quantitative fish community measure of ecosystem health.

Study Area

Beaver Creek flows into the Sandy River east of Troutdale, OR (Figure 1). The watershed occupies 13.5 square miles including three principle tributaries (South Fork Beaver Creek, Arrow Creek, and Kelly Creek) and is the downstream-most tributary to the Sandy River. This study excluded Kelly Creek because of the presence of a complete barrier to fish passage at the Mt. Hood Community College reservoir. Mean annual discharge in Beaver Creek ranged from 11.6-25.8 cfs during water years 2000-2011. Discharge in Beaver Creek follows the typical hydrological pattern of lowland rain-dominated streams west of the cascades, with higher flows in the winter (winter mean daily flow 32-60 cubic feet per second, peak 361-1080 cfs), gradually declining through spring and summer to the low flow period in late summer and early fall (late summer mean daily flow 1-3 cfs). During the September 2010 (low flow) survey period, the creek had contiguous surface flow downstream from the vicinity of the SE Division Dr. and S. Troutdale Rd. intersection; above that location we observed intermittent surface flow and disconnected residual pools during the survey period.

Land use in the watershed is split between urban uses (6.7 square miles) and forest / farms (5.6 square miles), with the balance (1.2 square miles) in parks and open space. The watershed is home for 62,000 people, with the majority residing within the metropolitan Portland urban growth area at the western fringe of the watershed. Although a small proportion of the watershed area is publicly owned, portions of the lower creek mainstem riparian areas are owned by the City of Troutdale and Portland Metro regional government.

Beaver Creek harbors several salmon populations listed as threatened under the federal Endangered Species Act: steelhead (*Oncorhynchus mykiss*), Chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), and chum salmon (*O. keta*), all of which are part of larger Sandy River populations. In addition the stream supports other native and non-native resident fishes, as well as a diversity of wildlife species including a still-thriving population of American beaver (*Castor canadensis*). Information on fish species occurrence, distribution, and abundance was not available, prompting our work.

Methods

Field Data Collection

<u>September 2010 Mainstem Sampling</u>: A geographic information system (GIS) was used to identify four distinct reaches within mainstem Beaver Creek - Reaches A, B, C, and D (Figure 12). Prioritization of survey reaches was based on the presumed distribution of ESA listed salmonids. Reach breaks were defined where changes in fish passage at road crossings, valley confinement and/or channel gradient were identified. Surveyors had contiguous access to the four reaches, which were surveyed working upstream. Three categories of instream habitats were identified: pools, glides, and fast water. In reaches A-C, every fifth pool, glide and fast water habitat were surveyed, whereas in reach D every tenth habitat unit of each type was surveyed (Table 1). Beginning each reach at randomized start locations, instream habitat units were sampled using single-pass electrofish removal without block-nets. Surveys were performed between September 20 and September 23, 2010 after a period of moderate rainfall. During the week prior streamflow had risen to over 20 cfs before receding to 3-4 cfs at the time of the surveys – a level more typical of late summer baseflow conditions. In addition to the mainstem surveys, the field team performed limited electrofishing at headwater tributary road crossings upstream from Reach D. This headwater spot check data was not included in the FIBI analysis, but was used to characterize the uppermost extent of fish surveyed in the watershed.

<u>April-May 2011 Headwater Sampling:</u>
The survey team revisited headwater tributary road crossings upstream from Reach D, and expanded the headwater survey, on April 29th and May 2, 2011. Access was generally limited to County road right-of-ways. Single-pass electrofish removal with no block nets was used to document fish species composition.

A three-person team consisting of one electrofisher operator and two dip-netters conducted all fish sampling. A Smith Root LR-24 backpack electrofishing unit was used throughout the study.

Fish brought to hand were identified to species, enumerated, and released unharmed. Forklength (to nearest 1mm) was measured for all salmonids. The number of seconds the electrofishing unit was used at each sampling unit was recorded. Water temperature and conductivity data were collected and recorded each morning, and whenever significant tributaries were encountered.

Data Analysis

Qualitative, quantitative, and spatial analyses were used to describe fish community composition and distribution within Beaver Creek. In order to describe fish community composition and distribution we constructed pie charts showing the proportions of fish of each species in Beaver Creek as well as each of the four study reaches. We also constructed pie charts showing the proportion of fish grouped by family and grouped as native and non-native.

Lengths of salmonids from all reaches were pooled in order to calculate descriptive statistics and construct length frequency distributions, which we then used to assign ages to fish.

In order to assess the ecological integrity of Beaver Creek, we applied a fish index of biotic integrity (FIBI) to the fish species composition data collected during summer single-pass electrofishing surveys. The FIBI is a measure of ecological integrity and one means of assessing stream conditions and the degree to which they are affected by anthropogenic disturbances within the Beaver Creek watershed. Changes in stream discharge, temperature, water quality, and important biological life history events seasonally influence species occurrence and distribution. Though these factors may influence the FIBI score, the measure is calibrated to low-flow end-of-summer conditions, when fish are concentrated in pool habitats and more susceptible to capture. To improve consistency with previous regional work, we employed the same 12 metrics (Appendix 1) and scoring criteria for the FIBI reported in Van Dyke and Storch (2009). The index reliably predicts stream condition to three levels of impairment. Fish species and their characteristics used in the calculation of FIBI are presented in Appendix 2.

Individual metric scores were calculated using linear interpolation as described by Van Dyke and Storch (2009). The maximum score each metric can receive is 10, which is obtained when the metric value is equal to the high end of the range listed in Appendix 1. Conversely, the lowest score a metric can receive is 0, which is obtained when the metric value is equal to the low end of the range listed in Appendix 1. Raw values between the low and high values were scored by interpolating between 0 and 10. For example, where the number of native families sampled in a reach is 5 and the total number of families potentially encountered in the watershed is 7, the score for this metric is calculated as $(5/7) = 0.71*10 = 7.1$.

The total score for a site is the sum of the scores for each of the twelve metrics. By convention, the maximum total score a site can attain is constrained to equal 100. Since there are 12 metrics each with a maximum possible value of 10, the values of all 12 metrics were summed for each site (stream reach) and then multiplied by (10/12) = 0.833 to constrain the maximum possible total for a site to score of 100. Based on the final score, each of the four sites (reaches) in Beaver Creek was assigned to one of three qualitative impairment categories: ≤ 50, severely impaired; 51 to 74, marginally impaired; and ≥75, minimally impaired.

Results

Species Composition and Distribution

Over the course of our single pass electrofish survey in Beaver Creek we captured 1189 fish comprising 16 species (12 native species and 4 non-native) and representing 8 distinct families (Table 2, Figure 2). Native reticulate sculpin (31%) and speckled dace (25%) were the most abundant species in Beaver Creek followed by non-native western mosquitofish (11%), native coho salmon (9%), redside shiner (7%), and rainbow trout / steelhead (5%) (Figure 2). By families, native cottids, cyprinids, and salmonids were most abundant, comprising 38%, 35%, and 14% of fish sampled, respectively. Non-native Gambusia (or western mosquitofish), family Poecilidae (11%), was the only other family constituting greater than 1% of total fish abundance (Figure 3). Overall, 88% of fish sampled were native species, while 12% were non-native species (Figure 4). In addition to fish captured by electrofishing, surveyors observed a live adult chum salmon and a dead adult female coho salmon with completely intact ovaries (unspawned) that had no attributable signs of death, and may have been a pre-spawn mortality, a phenomena that has been documented in similar urban watersheds (Feist et al. 2011).

Species composition varied between reaches, with species richness (the number of species) declining in an upstream direction (Table 2). In the downstream-most reach (A), located immediately above the mouth, 14 species were present, with redside shiner, speckled dace and prickly sculpin as the most abundant species, comprising 35%, 27%, and 16% of the community, respectively (Figure 5). In the second reach upstream (B), 11 species were present, with speckled dace (24%), reticulate sculpin (24%), coho salmon (22%), rainbow trout / steelhead (11%), and longnose dace (11%) as the most abundant species (Figure 6). Farther upstream in reach C only 9 species were present and native reticulate sculpin (39%) and speckled dace (27%) were most abundant, followed by non-native western mosquitofish (23%) (Figure 7). In the farthest upstream reach, only 4 species were present with reticulate sculpin constituting the majority of fish captured (64%), followed by speckled dace (16%), coho salmon (16%), and rainbow trout / steelhead (4%) (Figure 8).

In addition to the four mainstem study reaches, spot surveys during September 2010 and April 2011 in the upper watershed revealed new species not found in the lower mainstem Beaver Creek, including non-native pumpkinseed, largemouth bass and crappie. The upstream-most salmon observed, a juvenile coho, was found at the westernmost NE Division Street crossing on the mainstem. In April 2011, many fewer and in some cases no fish were encountered in the upper mainstem and tributary locations as compared to September 2010 surveys. In April 2011, no fish were found at nine out of fifteen stream crossings sampled. Seven of these no-fish sites were downstream of reaches where we did encounter fish and where fish had been previously sampled in September 2010. Of the six headwater spot locations with fish, three sites harbored only reticulate sculpin, three sites harbored 1 species of non-native centrachid, and only one site (SF Beaver Creek at NE 302nd St crossing) harbored 3 species (steelhead/rainbow, reticulate sculpin, and pumpkinseed). (Figure 9).

Salmonid Size and Age
Lengths of coho salmon (n = 109) had a uni-modal distribution indicative of a single age class (0+), while rainbow / steelhead (n = 59) lengths had a very distinct tri-modal distribution suggesting three age classes (0+, 1+, and 2+) (Figures 10 and 11). Coho salmon lengths ranged from 68-118 mm (mean = 90 mm). Age 0+ rainbow trout /steelhead (n = 55) lengths ranged from 58-110 mm (mean = 85 mm), age 1+ rainbow trout /steelhead (n = 3) lengths ranged from 148-160 mm (mean = 151 mm), and the single age 2+ rainbow trout /steelhead was 227 mm. The large gaps between modes in the rainbow trout / steelhead length distribution allowed reasonable confidence in aging individuals based upon length (Figures 9 and 10).

Fish Index of Biotic Integrity
Fish index of biotic integrity calculations in the four reaches surveyed in Beaver Creek generated FIBI scores 47-64, with moderate levels of impairment (50< FIBI<75) in reaches A, B, and D, and severe impairment in reach C (FIBI<50) (Table 3, Figure 12).

Discussion

Species Composition and Distribution
Fish species occurrence in Beaver Creek is typical of small urbanized watersheds in the Pacific Northwest and other urban streams in the Portland, OR area (e.g. Van Dyke 2009). Small stream fish assemblages in the Pacific Northwest are often dominated by sculpins (*Cottus* sp.), stream-rearing salmonids (coho salmon, rainbow / steelhead, cutthroat trout, and to a lesser extent Chinook salmon), and native cyprinids in warmer and lower gradient streams. In urbanized watersheds, non-native species are frequently encountered and are often associated with warmer streams.

Beaver Creek contained all of the typical native species, with the notable exception of cutthroat trout, which were not encountered. Cutthroat trout typically use smaller headwater streams for spawning and rearing than coho and Chinook salmon, and steelhead (Trotter 1989), and require access to these habitats. The apparent absence of cutthroat trout from the watershed may indicate degraded habitat connectivity within the Beaver Creek watershed (anthropogenic fish passage barriers), though cutthroat trout populations frequently fare better than other salmonids in urbanized and degraded habitat (Scott et al. 1986), and an abundant source population is located in the nearby Sandy River. During fish surveys in this study, we noted that several road crossings appeared to be partial or full fish passage barriers, supporting this possibility. Alternatively, lower sampling intensity of the headwater reaches may have simply missed resident cutthroat trout, since this species is sometimes confined to headwater areas. However, if they are indeed present, it would be unlikely to not encounter a single cutthroat in all our sampling.

Although fish abundances were not quantified in this study, the densities of native salmonids encountered in intensive study reaches appeared to be lower than would be expected in similar non-degraded streams. This observation was also supported by the patchy occurrence of native salmonids in spot surveys in the upper watershed in fall 2010, and their absence in spring 2011. Together, these observations suggest that despite extensive intact riparian corridors and numerous beaver dams that create and maintain excellent salmonid rearing habitat (Pollock et al 2004), salmon and trout populations in Beaver Creek are likely reduced relative to their historic abundance. Continued habitat restoration efforts, including improved fish passage at road crossings and efforts to address degraded water quality and hydrology, would likely improve their status. Fish passage improvement projects at the Troutdale Road, Stark Street, and Cochran Road culverts would likely improve fish access to the upper watershed. The lack of salmonids observed in the upper watershed in spring 2011 despite their presence in the fall also suggests that environmental problems, such as water quality issues associated with fall and winter storms (Feist et al. 2011) may be affecting salmonid populations in Beaver Creek. Another possible explanation is a lack of suitable high flow refuge habitats for salmonids to survive high winter flows—a condition that occurs frequently in streams with drastically simplified physical habitat and cover. Alternatively, it is possible that dispersal of salmonids at the reach-scale from their summer concentration in the few watered pools, and their use of interstitial spaces for cover during colder, higher flow conditions rendered them less susceptible to sampling in spring than fall.

The general pattern of lower species richness moving in an upstream direction observed in this study is consistent with patterns observed in other areas (Reeves et al. 1998), and is likely a reflection of distance from the Sandy River (a source of species), cumulative effects of multiple partial fish passage barriers, and a reduced quantity and diversity of habitat moving upstream in Beaver Creek associated with the seasonally-wetted headwaters. One notable exception to this pattern was the presence of non-native largemouth bass, crappie, pumpkinseed in headwater areas that had not been encountered downstream. In agricultural areas, headwater farm irrigation ponds may have current or historic stocking of non-native species that may volitionally pass downstream, as well as bridge crossings that offer easy access for anthropogenic introductions;

both offer additional pathways for non-native fish to colonize watersheds in addition to moving upstream from receiving bodies of water. In addition to headwater introduction vectors, the proximity of the Columbia River – with a large pool of invasive species – may serve as another potential source. Such numerous avenues for invasion makes control of nonnative species particularly difficult due to the bidirectional nature of potential sources within the stream.

Another interesting pattern observed was the presence of extensive beaver ponds in the mainstem within reach C. Across North America, beaver ponds frequently harbor higher species richness as compared to adjacent, undammed stream channels. In our investigation, this reach harbored western mosquitofish, a lentic fish not found elsewhere in the watershed, but not any other species or fish life history stages not encountered in adjacent reaches.

Finally, the headwater September 2010 and April 2011 headwater spot surveys revealed fish presence and absence patterns that pose questions for follow up investigation. Coho salmon were found at the westernmost NE Division St crossing on mainstem Beaver Creek, indicating that at least some anadromous fish can penetrate this far upstream at certain flow conditions. Farther upstream on the mainstem, steelhead/rainbow trout and non-native centrachids were found, with an apparent absence of small-bodied native fish (like the ever-present reticulate sculpin). Reticulate sculpin were only found at the uppermost section of this stream during the April 2011 survey. In the headwater tributaries, similar patterns were observed (low densities of native fish, with widely-distributed non-native centrachids), except that we observed more sites with reticulate sculpin.

Salmonid Size and Age

Size distributions of coho salmon and rainbow trout/ steelhead captured in Beaver Creek were typical of Pacific Northwest streams. The presence of only age 0 coho salmon is consistent with their life history, which involves fall spawning and spring emergence from gravels, a year of freshwater rearing, and subsequent emigration to marine waters in their second spring (Quinn 2005). Coho observed in Beaver Creek were likely completing their first summer of life and would migrate to the ocean the following spring.

The presence of three age classes of rainbow trout/ steelhead (*O. mykiss*) was also consistent with expectations for the anadromous reaches of small streams. Rainbow trout/steelhead, of which the anadromous form (steelhead) predominate in coastal streams with access to saltwater, typically rear in streams for 2-3 years before migrating to marine waters. The lack of larger adult rainbow trout suggests that the *O. mykiss* encountered were likely pre-smolt steelhead.

Fish Index of Biotic Integrity

Fish index of biotic integrity results suggest that Beaver Creek is experiencing moderate to severe environmental impairment similar to other Portland, OR area streams (e.g. Van Dyke

2009; 10 out of 15 reaches were marginally impaired with FIBI scores between 50 and 75, and 5 were severely impaired with scores between 25 and 50). This finding is not surprising given the numerous invasive species, the presence of anthropogenic impediments to fish passage, apparent low densities of native salmonids observed in this study, potential water quality issues, and the large proportion of the watershed that has been developed or is in agricultural production and is no longer forested. FIBI results should also be interpreted with other biological, physical and chemical data, because it is difficult to assess the health of a stream with a single index. Fish species occurrence and relative abundance may be naturally limited by geological history, including natural migration barriers, temperature, or physical habitat constraints, all of which may bias an index value. Naturally low quality habitats may be rated as impaired despite little human influence. Conversely, intrinsically high quality habitats which have been considerably impaired, may rate highly due to their naturally high starting point. Finally, unavoidable variability in sampling efficiency across space (e.g. variable numbers of habitats sampled with different electrofishing characteristics), and across time (e.g. seasonal changes in sampling efficiency related to discharge and temperature) may affect results and introduce unknown biases in assessing ecosystem health.

Conclusion and Future Research Needs

Fish populations in Beaver Creek are indicative of considerable ecosystem degradation yet they retain some characteristics of those found in less disturbed areas. The fish community contained the native salmonids typically found in small Pacific Northwest streams, including coho salmon, steelhead, and chum salmon (all ESA listed), however, cutthroat trout were surprisingly absent. The fish community also contained native resident species including dace, lamprey, and sculpin, suggesting most, if not all of the historically present species remain. However, a total of seven non-native species were found in Beaver Creek and were widely distributed, though apparently less abundant than native species, suggesting multiple introduction pathways, and few refuges for native fishes. These fish occurrence data resulted in ratings of moderately to severely impaired (47-64), as measured by a Fish Index of Biotic Integrity (FIBI), for all surveyed stream reaches surveyed. These results are similar to those found in other watersheds in the Portland area, and likely are reflective of degraded watershed conditions that result from a history of urban, suburban, and rural/agricultural development in the region. Although this study did not measure population abundance or the relationship between fish populations and habitat conditions, its results suggest that Beaver Creek still has the capacity to support native fish populations. Efforts to better understand factors limiting native fish capacity and productivity could help decision making and the identification of projects that will protect and restore ecological functions in Beaver Creek. Additional studies are needed to identify factors limiting native fish populations and ecosystem health in Beaver Creek. Some potential areas of future research are described below.

Future Research Needs

As a result of this study, we have identified several future research and monitoring opportunities that would improve the understanding and conservation of the Beaver Creek watershed. Of these projects, those that are already underway should be continued and/or expanded.

- Fish Passage Inventory and Assessment
  - Several partial and potentially full barriers to fish passage were noted, particularly at road crossings. Efforts to systematically identify, assess, prioritize, and remediate these barriers would have immediate benefit for native fishes and stream health.
- Water Quality Monitoring
  - Urban streams often have water quality issues related to the presence of roads and other impervious surfaces in their catchments. Extensive agriculture in the headwaters, often with minimal riparian buffers, likely degrades water quality within and downstream from those reaches.
  - Systematic water quality monitoring can help to identify particular problems in a stream and can also detect ephemeral water quality issues that may be important to fishes (e.g. stormwater runoff). Specific study metrics can include macroinvertebrates (benthic index of biotic integrity) and an evaluation of spawning success to document the potential occurrence of pre-spawning mortality (Spromberg and Scholz 2011).
- Spawning Surveys
  - Anadromous fishes including coho salmon and rainbow/steelhead were identified in Beaver Creek, and in addition to providing abundance and distribution information for adult life stages, systemic spawning surveys would help identify anthropogenic barriers to upstream migration and help determine whether the juveniles observed are of local origin or are simply using Beaver Creek for non-natal rearing.
  - An adult coho carcass observed during the September 2010 survey was unspawned. This observation, and the land-use character of Beaver Creek, warrants additional investigation into the magnitude of pre-spawning mortality within Beaver Creek.
- Salmonid outmigrant ID / Enumeration
  - Although summer stream surveys of fish populations provide much information on stream fish production, winter survival, particularly in habitats with little instream cover, typical of urban streams, may limit production of fishes. Monitoring salmonid outmigration provides a means to integratively assess the success of the whole freshwater portion of salmonid lifecycle, and would improve knowledge of the status of fishes in Beaver Creek.
- Exotic Fish Control / Farm Pond Management Improvements

  - Numerous species and individual nonnative fishes were present in Beaver Creek and the may compete with or prey upon native species. Understanding their origin, in order to stem introductions and efforts to reduce their abundance may benefit native species.
  - Outreach to headwater farms with ponds is needed to improve management practices, in order to reduce apparent downstream water quality and non-native fish invasion impacts.
- Instream / Riparian Habitat Restoration and Protection
  - As a result of current and historic development and other anthropogenic activities, upslope and riparian conditions including the quantity and quality of large woody debris is likely limiting habitat productivity in Beaver Creek. Efforts to protect and restore riparian and upslope processes will likely benefit fish populations by providing more instream cover, moderating water temperatures, and reducing erosion
- Seasonal and annual fish movement patterns – Passive Integrated Transponder (PIT) tag study
  - Understanding within and extra-basin migration patterns of Beaver Creek's salmonid species is necessary to identify factors currently limiting their productivity.
- Freshwater mussel inventory
  - Long-lived freshwater mussels are excellent indicators of watershed integrity. Documenting their distribution, population structure, and abundance would provide valuable baseline information about water quality and the distribution / abundance of the host fish they rely upon.
- Seasonal abundance of fishes
  - Population abundance of fishes has not been quantified in the current study, and in addition to outmigrant trapping, abundance estimation employing multipass electrofishing and an appropriate statistical framework would improve understanding of the abundance of fishes in Beaver Creek and establish a baseline for future monitoring.

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Tables and Figures

Tables

Table 1. Summary of mainstem Beaver Creek single pass electrofishing sampling during September 2010.

			Habitat Units Sampled			
Reach	Date Sampled	Length (km)	Fastwater	Glide	Pool	Total
A	Sept. 20, 2010	1.40	1	2	6	9
B	Sept. 21, 2010	1.83	9	5	9	23
C	Sept. 22, 2010	2.07	9	7	12	28
D	Sept. 23, 2010	2.05	4	4	5	13

Table 2. Number and percent of each species captured in each study reach in Beaver Creek, OR in September, 2010.

Species	Reach A		Reach B		Reach C		Reach D	
	count	percent	count	percent	count	percent	count	percent
Brown bullhead	2	0.9	0	0.0	0	0.0	0	0.0
Coho salmon	4	1.7	65	21.5	20	3.7	20	15.7
Signal Crayfish	1	0.4	1	0.3	4	0.7	0	0.0
Longnose dace	0	0.0	32	10.6	0	0.0	0	0.0
Northern pikeminnow	1	0.4	1	0.3	0	0.0	0	0.0
Peamouth	1	0.4	13	4.3	0	0.0	0	0.0
Prickly sculpin	38	16.4	0	0.0	0	0.0	0	0.0
Pumpkinseed	0	0.0	0	0.0	10	1.9	0	0.0
Rainbow / Steelhead	0	0.0	32	10.6	22	4.1	5	3.9
Redside shiner	80	34.5	1	0.3	0	0.0	0	0.0
Reticulate sculpin	6	2.6	74	24.5	206	38.6	82	64.6
Riffle sculpin	1	0.4	0	0.0	0	0.0	0	0.0
Speckled dace	62	26.7	73	24.2	145	27.2	20	15.7
Unk. sucker	13	5.6	0	0.0	0	0.0	0	0.0
Unknown cottid	18	7.8	8	2.6	0	0.0	0	0.0
Unk. cyprinid	4	1.7	0	0.0	0	0.0	0	0.0
Unk. dace	0	0.0	2	0.7	0	0.0	0	0.0
Western Brook lamprey	0	0.0	0	0.0	1	0.2	0	0.0
Western mosquitofish	0	0.0	0	0.0	125	23.4	0	0.0
Yellow bullhead	1	0.4	0	0.0	1	0.2	0	0.0
Totals	232	100	302	100	534	100	127	100

Table 3. Fish index of biotic integrity scores and associated impairment levels.

Reach (downstream to upstream)	Reach F-IBI Score
Reach A (Mouth to Road 054)	56 (Marginally impaired)
Reach B (Road 054 to Troutdale Road)	64 (Marginally impaired)
Reach C (Troutdale Road to Cochran)	47 (Severely impaired)
Reach D (LMK063 to Triangle)	51 (Marginally impaired)

Figures

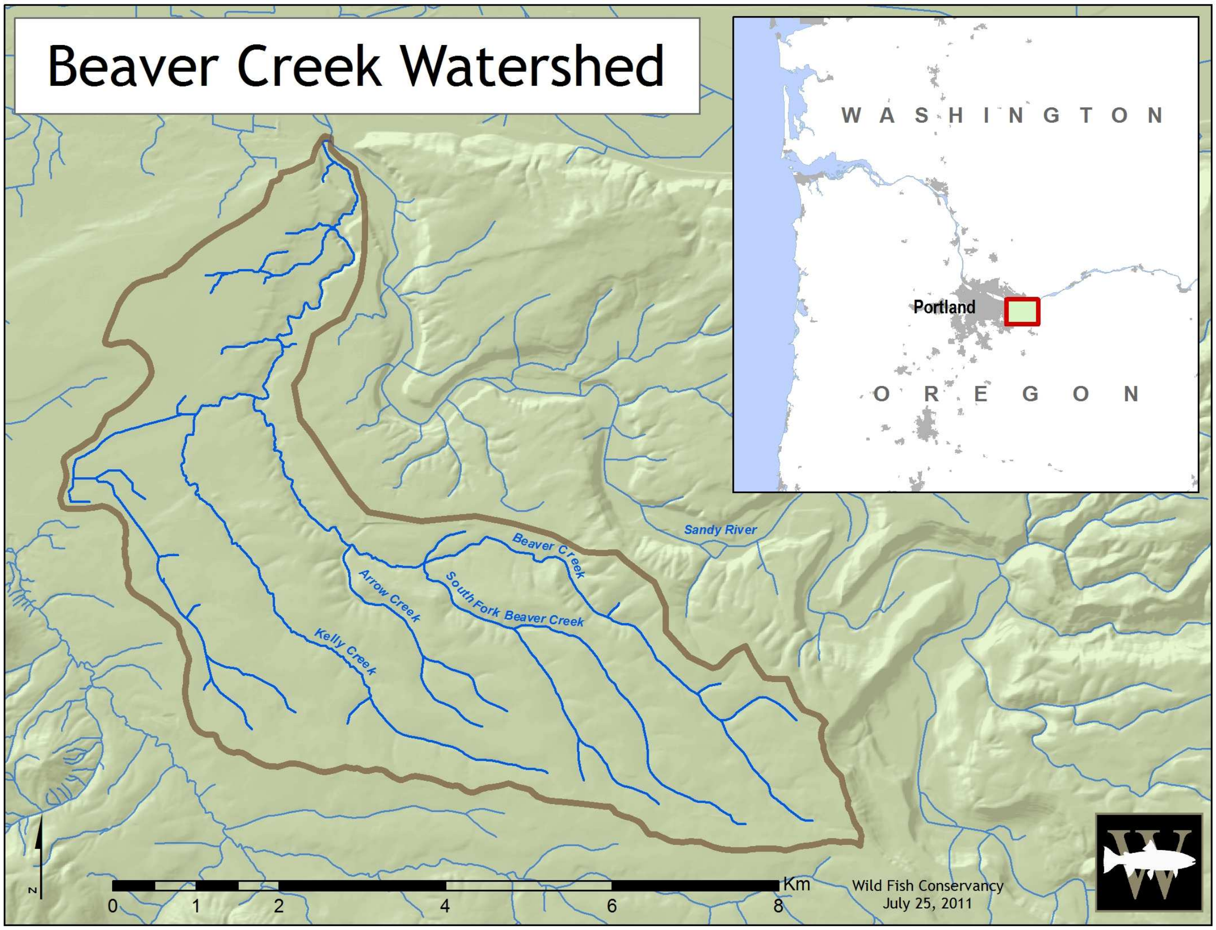

Figure 1. The Beaver Creek watershed flows into the Sandy River east of Portland. Local government jurisdictions include Multnomah County and the cities of Gresham and Troutdale.

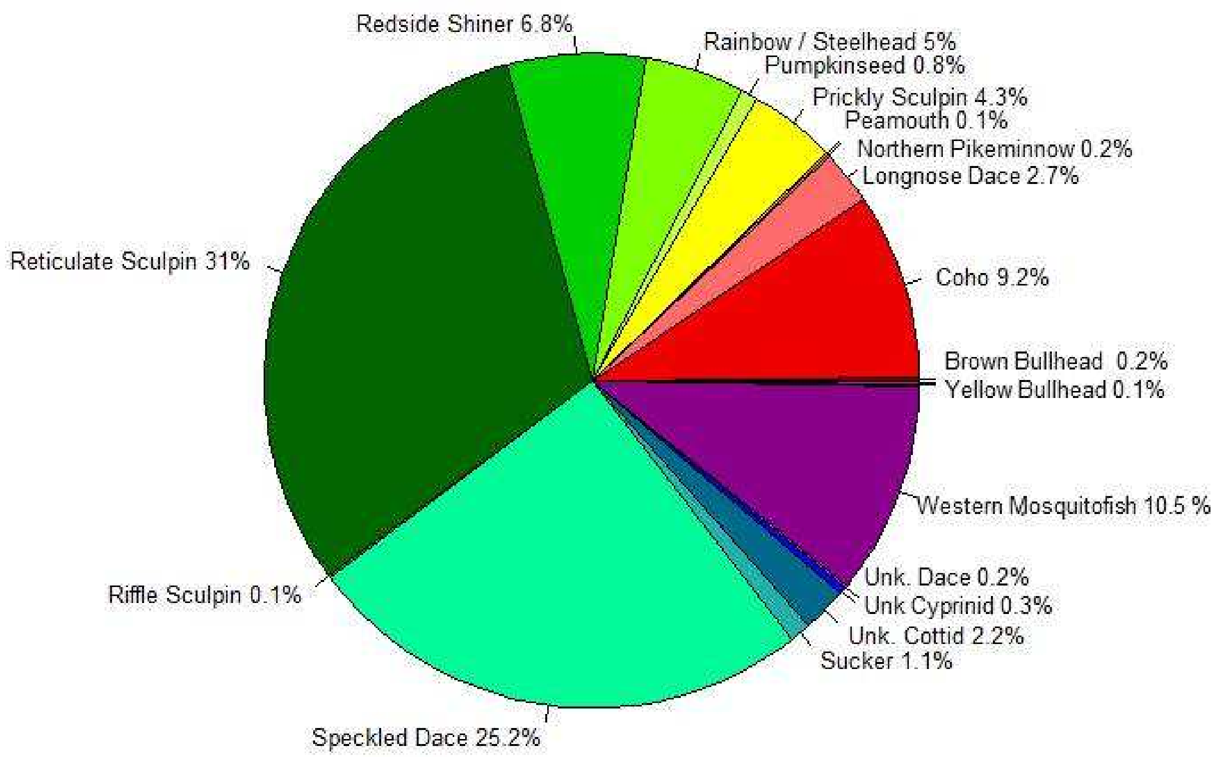

Figure 2. Relative abundance of fish species (n =1189) occurring in all reaches combined in Beaver Creek, OR in September 2010.

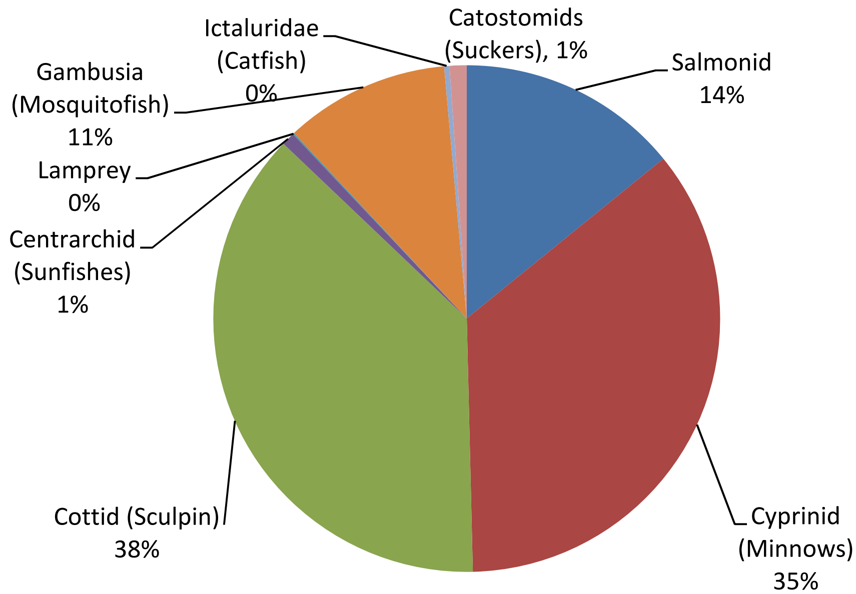

Figure 3. Relative abundance of fish organized by families (n =1189) occurring in all reaches combined in Beaver Creek, OR in September 2010.

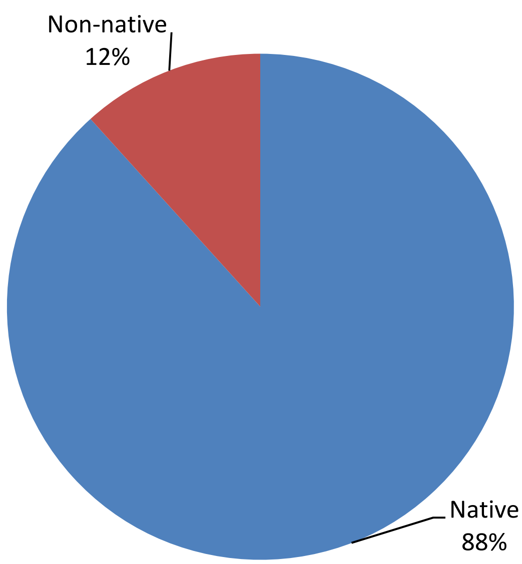

Figure 4. Relative abundance of native and non-native fishes (n= 1189) occurring in all reaches combined in Beaver Creek, OR in September 2010.

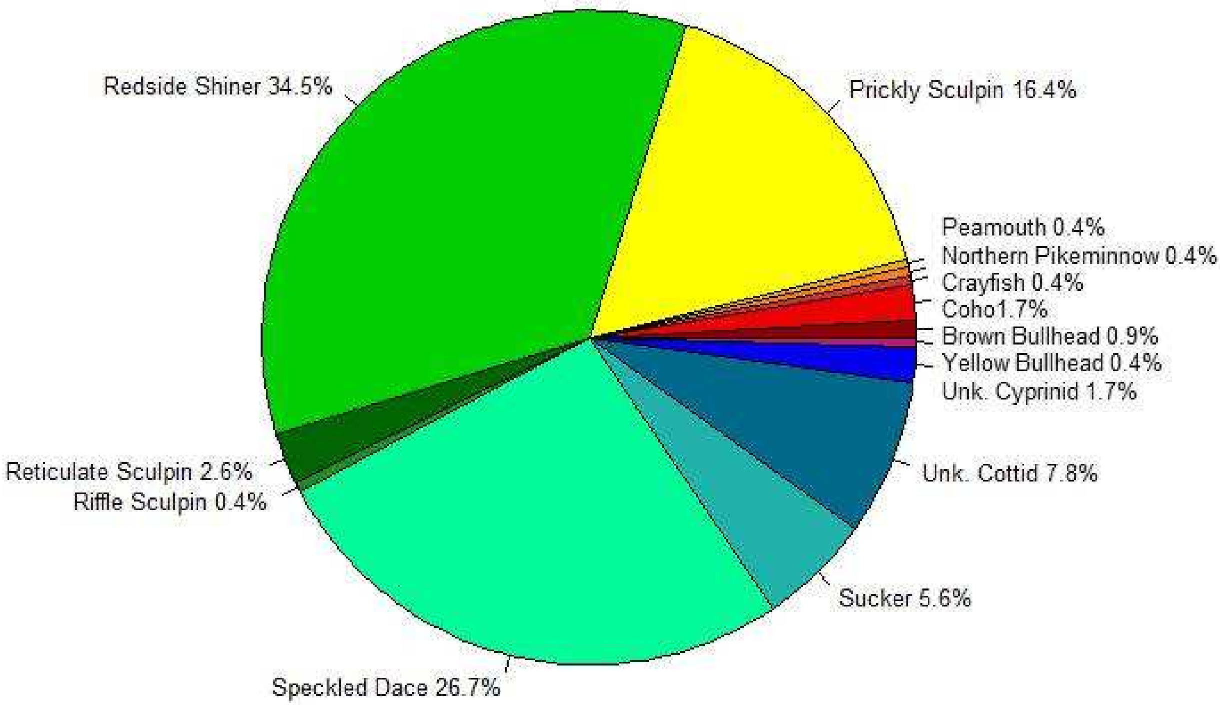

Figure 5. Relative abundance of fish species (n = 232) occurring in Reach A (Mouth to 054) in Beaver Creek, OR in September 2010.

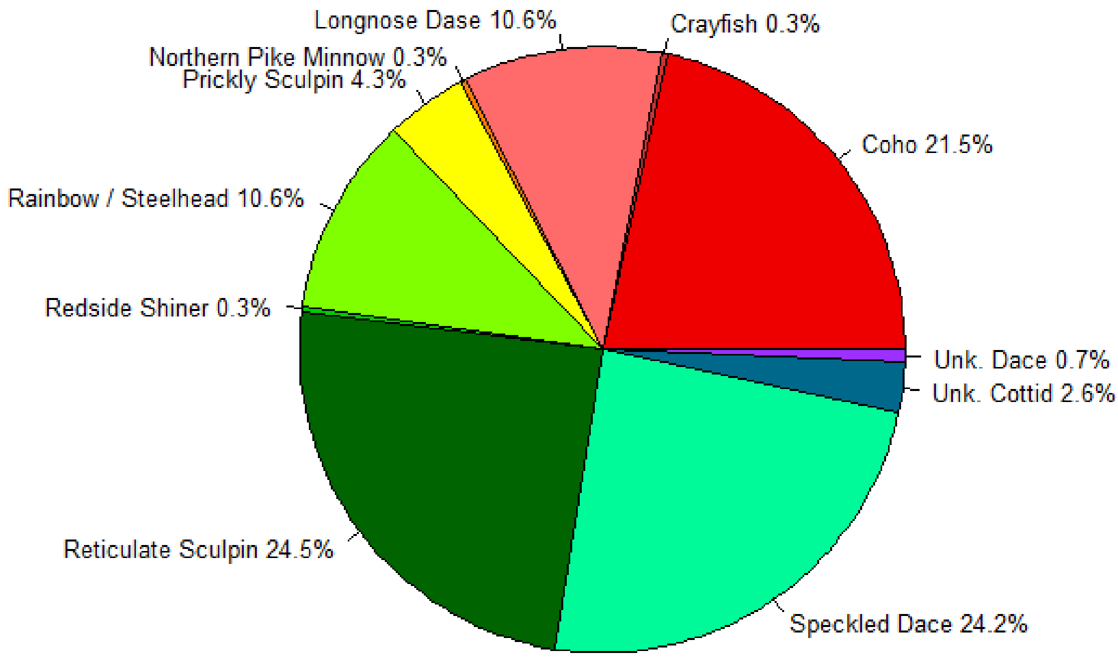

Figure 6. Relative abundance of fish species (n = 302) occurring in Reach B (054 to Troutdale Rd; Canyon) in Beaver Creek, OR in September 2010.

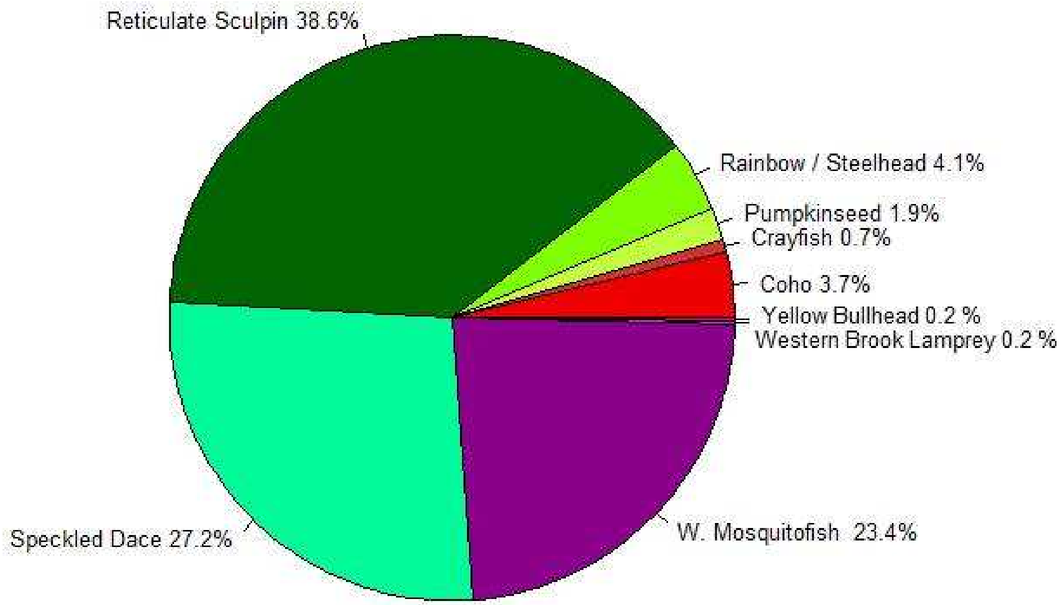

Figure 7. Relative abundance of fish species (n = 534) occurring in Reach C (Troutdale-Cochran) in Beaver Creek, OR in September 2010.

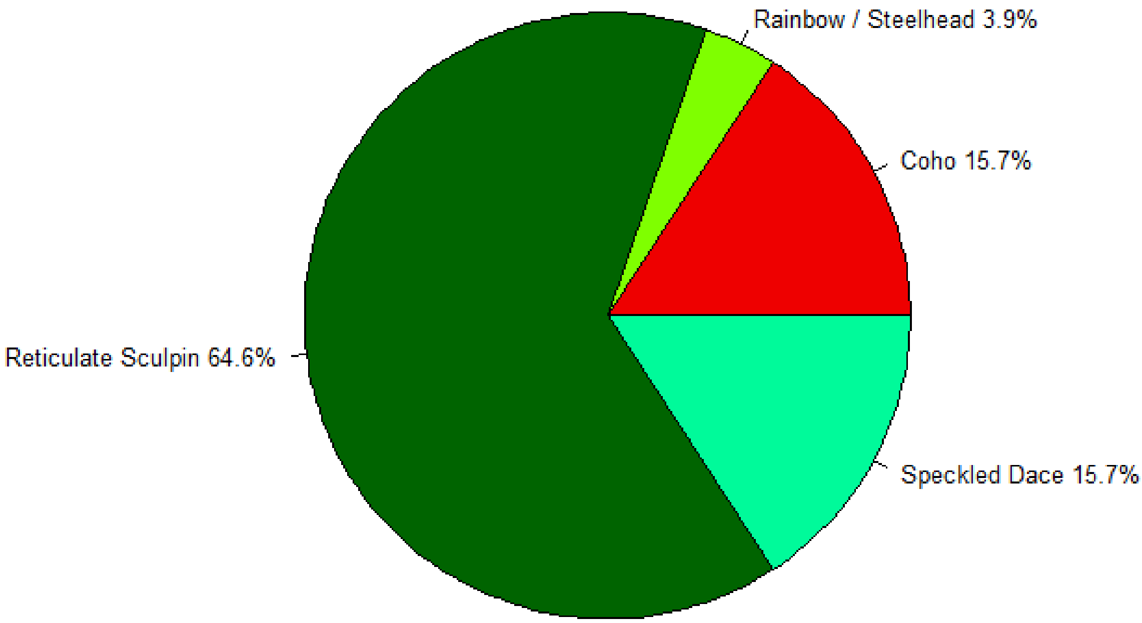

Figure 8. Relative abundance of fish species (n = 127) occurring in Reach D (LMK 063 to Triangle) in Beaver Creek, OR in September 2010.

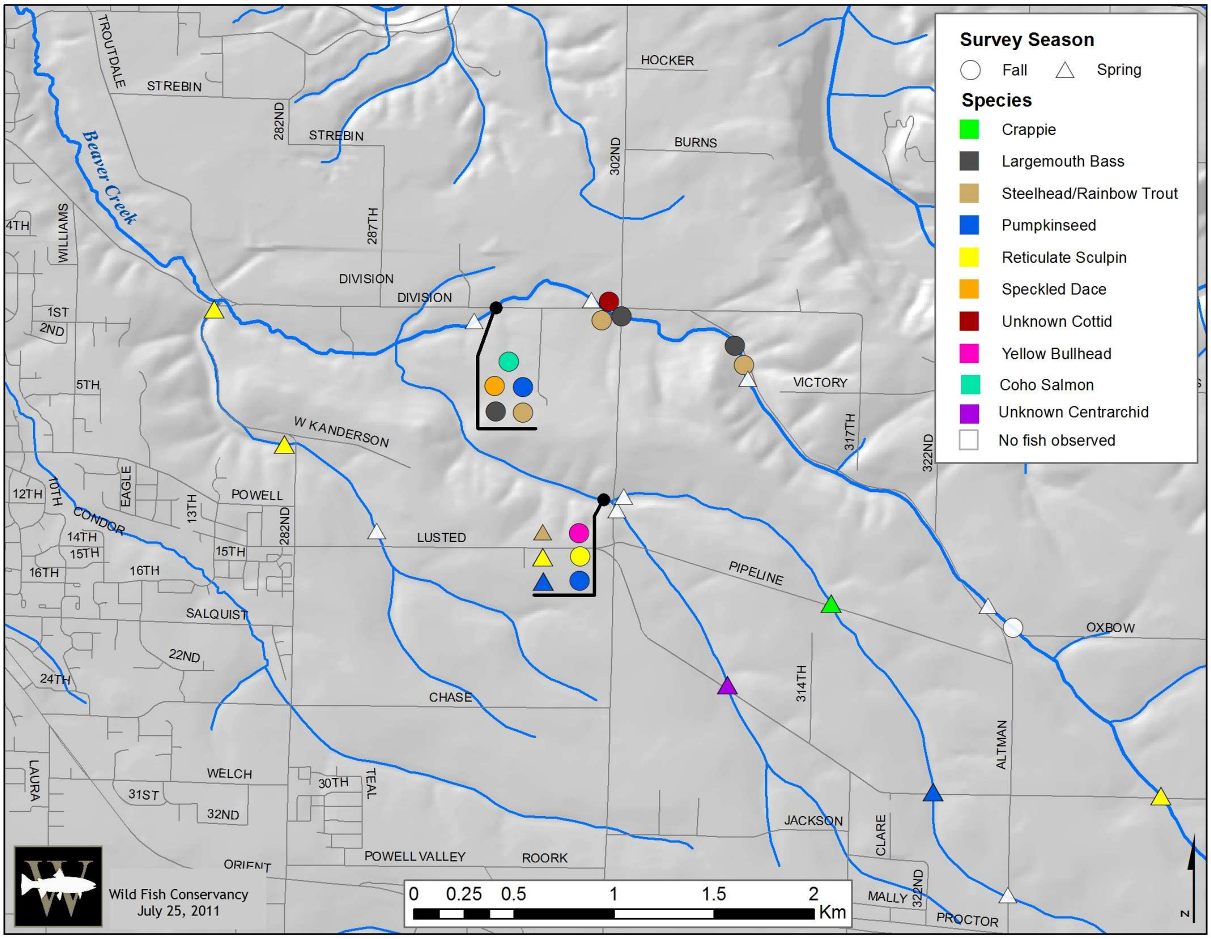

Figure 9. Map of fish species occurrence at spot survey locations in the upper headwaters of Beaver Creek, OR, in September, 2010 and April, 2011.

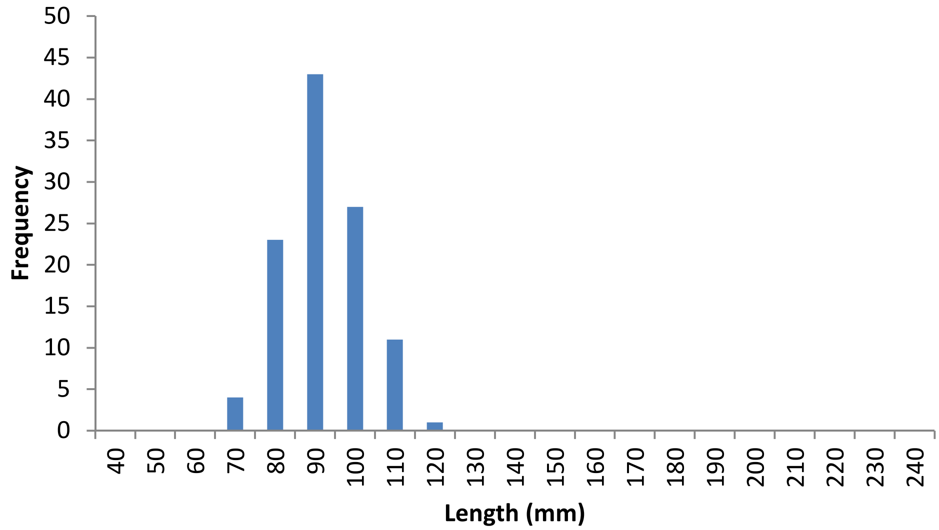

Figure 10. Length frequency distribution for juvenile coho salmon (n=109) in Beaver Creek, OR, September 2010.

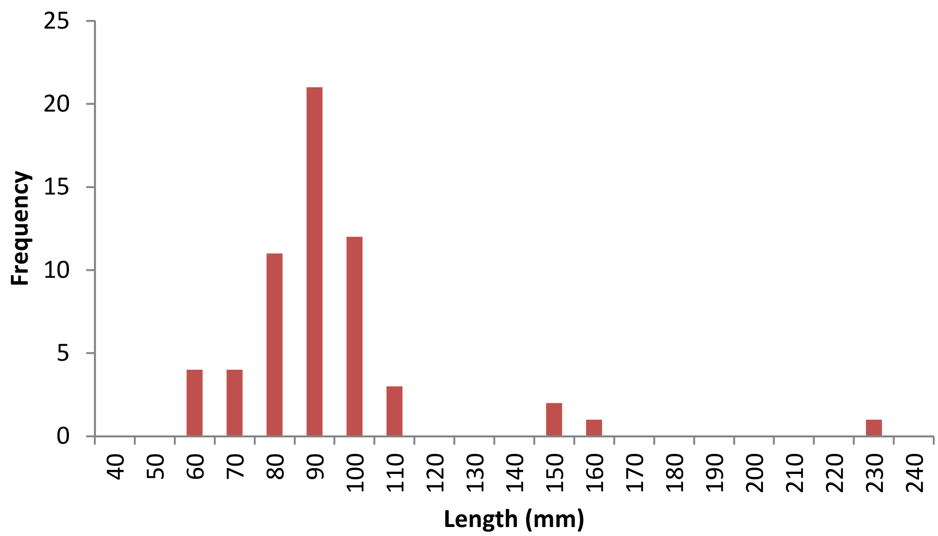

Figure 11. Length frequency distribution for juvenile rainbow trout / steelhead (n=59) in Beaver Creek, OR, September 2010.

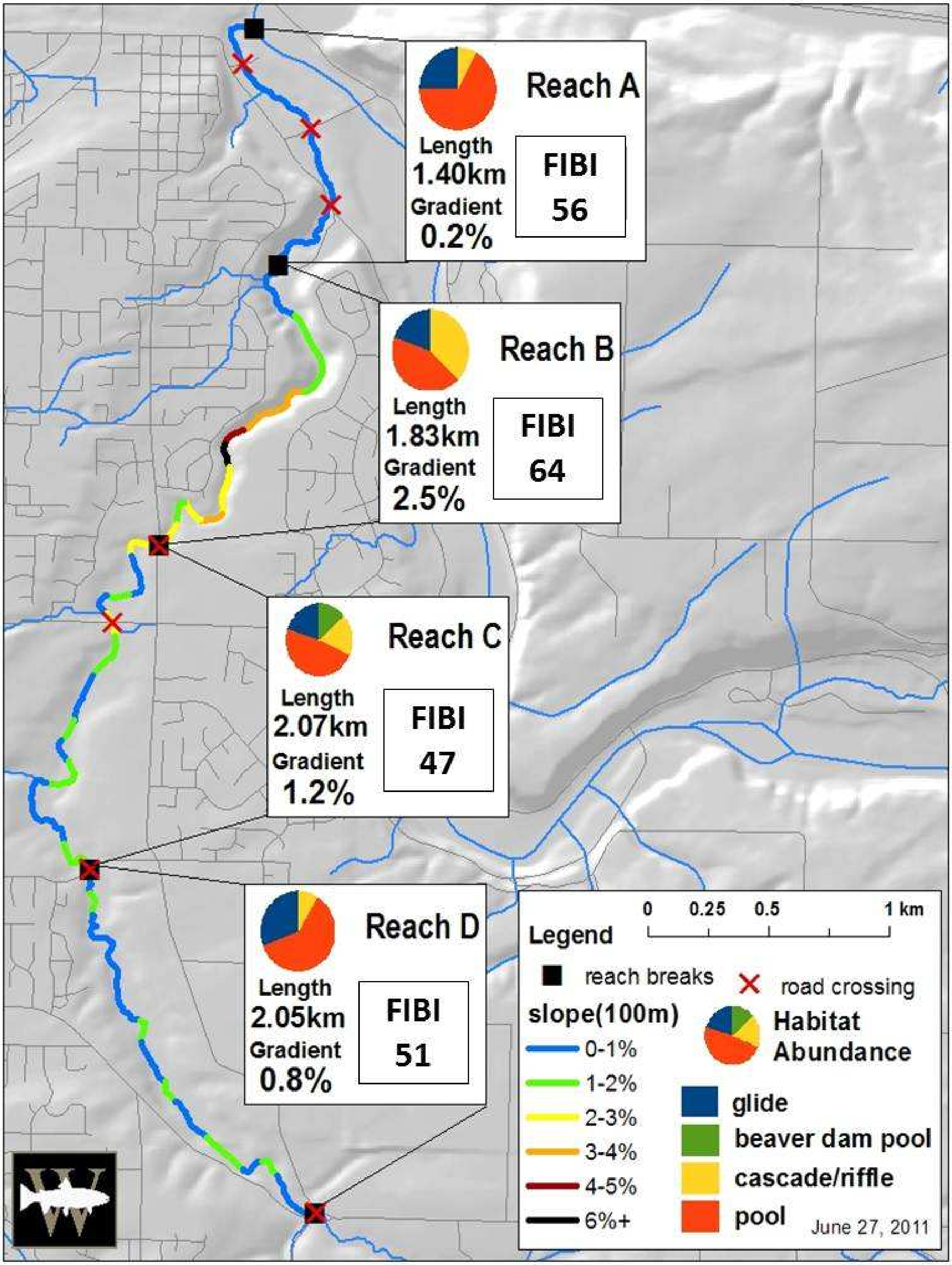

Figure 12. Map of continuous fish survey reaches, stream gradient, habitat type, and reach-scale Fish Index of Biotic Integrity (FIBI) scores on Beaver Creek, OR, in September, 2010.

Appendix

Appendix 1. Index of biotic integrity metrics used to score stream condition to three impairment levels (Hughes et al. 1998).

Category, Metric	Raw Values (low to high)[1]
Taxonomic Richness:	
1) Number of native families	0 – 7
2) Number of native species	0 – 11
Habitat Guilds:	
3) Number of native benthic species	0 – 7
4) Number of native water column species	0 – 4
5) Number of hider species	0 – 4
6) Number of sensitive species	0- 5
7) Number of native nonguarding lithophilic nester species[2]	0 – 3
8) Percent tolerant individuals	100 – 0
Trophic Guilds:	
9) Percent filter-feeding individuals	0 – 100
10) Percent omnivores	100 – 0
Individual health and abundance:	
11) Percent of target species that include lunkers[3]	0 – 100
12) Percent of individuals with anomalies	2 – 0

[1] Values for stream orders 2 and 3
[2] Species that create nests in gravel or smaller substrates to spawn.
[3] Lunkers are relatively large individuals of the following species and sizes: prickly sculpin (100mm), torrent sculpin (100 mm), steelhead (300 mm), cutthroat (250 mm), chiselmouth (300 mm), northern pikeminnow (300 mm), and largescale sucker (300 mm).

Appendix 2. Species of fish and associated characteristics (from Table 1.) used in calculations of Fish Index of Biotic Integrity (FIBI) in Beaver Creek, OR, September 2010.

Species	**Family**	**Native**	**Tolerance (S,I,T)**	**Benthic**	**Water Col.**	**Hider**	**Ng. Lith. Nester**	**Filter Feeders**	**Omnivore**
Brown Bullhead (*Ameirus melas)*	Ictaluridae	Alien	T	X		X			X
Western Mosquitofish *(Gambusia)*	Poecilidae	Alien	T		X	X			X
Yellow Bullhead (*Ameirus natalis)*	Ictaluridae	Alien	T	X		X			X
Pumpkinseed (*Lepomis gibbosus*)	Centrarchidae	Alien	T		X				
Signal Crayfish *(Pacifastacus leniusculus*)	Astacidae	Native	T	X		X			X
Coho, juvenile (*Oncorhynchus kisutch*)	Salmonidae	Native	S		X		X		
Rainbow / Steelhead *(Oncorhynchus mykiss)*	Salmonidae	Native	S		X	X	X		
Western Brook Lamprey (*Lampetra richardsoni*)	Petromyzontidae	Native	S	X		X	X	X	
Sucker (*Catostomus* sp.)	Catostomidae	Native	I	X					X
Longnose Dase (*Rhinichthys cataractae*)	Cyprinidae	Native	I	X		X			
Northern Pike Minnow *(Ptychocheilus oregonensis)*	Cyprinidae	Native	I		X				
Peamouth (*Mylecheilus caurinus*)	Cyprinidae	Native	I		X				
Prickly Sculpin (*Cottus asper*)	Cottidae	Native	I	X					
Redside Shiner (*Richardsonius balteatus*)	Cyprinidae	Native	I		X				
Reticulate Sculpin (*C. perplexus*)	Cottidae	Native	I	X		X			
Riffle Sculpin (*Cottus gulosus*)	Cyprinidae	Native	I	X		X			
Speckled Dace (*Rhinichthys osculus*)	Cyprinidae	Native	I	X		X			