Fish Species Composition, Distribution, and Biotic Integrity in Johnson Creek, a Tributary to the Willamette 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 Johnson Creek. The results will also serve as a baseline to allow evaluation of future restoration projects within Johnson Creek. This study complements a similar study undertaken by Wild Fish Conservancy (WFC 2011) in Beaver Creek, Multnomah County, OR as well as previous studies by the 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). The early studies by ODFW and the City of Portland included the lower portions of Johnson Creek below the confines of this study.

Wild Fish Conservancy (WFC) conducted a stratified-random single-pass electrofishing survey within 9 distinct reaches of mainstem Johnson Creek and major tributaries in September 2011; fish species composition at select locations within headwater reaches was also investigated in during higher flows in March and April 2012. 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*), cutthroat trout (*O. clarkii clarkii*), and rainbow trout/steelhead (*O. mykiss*) brought to hand.

During the course of the September 2011 electrofishing surveys, a total of 4643 fish were netted, identified, and released, and an additional 127 were handled in supplemental spring 2012 surveys. WFC documented 10 native fish species and four non-native fish species during fall surveys and one additional non-native fish species during spring surveys. FIBI scores for the nine Johnson Creek reaches ranged from 46 (severely impaired) to 73 (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.
Johnson Creek is no exception. Water quality impacts for the stream are documented in the Total Maximum Daily Load for the Lower Willamette River. Habitat and water quality impacts include high summer water temperatures, sedimentation, bacterial and chemical pollution, introduction of nonnative species, channel simplification, bank armoring, removal of riparian vegetation, and creation of artificial migration barriers (e.g. road crossings). These impacts originate from poorly-planned development, urbanization, agriculture, and road construction

leading to excessive stormwater runoff and loss or degradation of riparian areas. Despite these threats, the watershed is known to support a variety of native fishes, including wild salmon and trout, as well as native 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 the biological condition in lower Johnson Creek is known from previous studies conducted by ODFW, much less is known about the upper mainstem and tributaries. Prior to this effort, no quantitative data of fish species diversity and distribution existed for the upper Johnson Creek watershed.

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

Johnson Creek flows through rural and urban areas of north Clackamas and south Multnomah counties, draining to the Willamette River at Milwaukie, Oregon, southeast of Portland (Figure 1). The watershed occupies 54 square miles and flows for 25 miles through an area of mixed land use ranging from densely developed urban areas, to suburban, agricultural and forested areas in the eastern watershed. Mean annual discharge in Johnson Creek is 78 cubic feet per second. Discharge in Johnson Creek follows the typical hydrological pattern of lowland rain-dominated streams west of the Cascades Mountains, with higher flows in the winter, gradually declining through spring and summer to the low flow period in late summer and early fall.

Johnson Creek harbors several salmon populations listed as threatened under the federal Endangered Species Act (ESA): steelhead (*Oncorhynchus mykiss*), Chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), and chum salmon (*O. keta*), all of which are part of larger Lower Willamette/Lower Columbia 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

September 2011 Sampling: We conducted electrofishing surveys of the upper mainstem of Johnson Creek and its major tributaries during the late-summer baseflow season in order to characterize fish species composition and distribution and calculate a Fish Index of Biotic Integrity. A geographic information system (GIS) was used to identify distinct reaches within the Johnson Creek watershed (n=9), including three in the mainstem, two in Sunshine Creek, and one each in Badger, Butler, North Fork Johnson, and Hogan creeks (all upper watershed tributaries, Table 1, Figure 1). Prioritization of survey reaches was based on the presumed distribution of ESA-listed salmonids. Reach breaks were delineated at tributary junctions, and at distinct changes in stream gradient or land use. Reaches were further divided into one-to-eight representative 200 m segments for field sampling. Segments (n=40) were delineated based on accessibility (e.g., major road crossings and land ownership), but were spatially stratified to represent habitat conditions within the larger reach. Continuous surveys of consecutive habitat units within these 200 m segments were conducted working upstream, rather than sampling every fifth habitat unit as in similar previous studies in Portland area streams (e.g., Van Dyke and Storch 2009). Physical stream habitat units identified in the field were grouped for data summarization into three categories: pools, riffles, and mixed or intermediate habitats (including glides).

Beginning at each segment start location, instream habitat units were sampled using single-pass electrofish removal without block-nets. Survey start and endpoints were recorded on a GPS unit. Surveys were performed between September 13 and September 27, 2011. Stream discharge was at late summer base flow prior to and during the three days of sampling but increased after the first fall freshet, which occurred on September 17, based on discharge recorded in Johnson Creek (USGS 14211400 Johnson Creek at Regner Road at Gresham, OR).

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. Fork length (to nearest 1mm) was measured for all salmonids. Electrofishing time for discrete habitat units was recorded in seconds. Water temperature and conductivity data were collected and recorded each morning, and above significant tributary confluences.

March-April 2012 Headwater Sampling:

We conducted electrofishing surveys of small tributaries and seasonal headwater reaches of Johnson Creek during the high flow spring season in order to characterize fish species composition and distribution and gather additional information on the upstream extent of fish habitat within the watershed. Spring surveys were timed to occur during higher flows in spring when fish distribution is typically at its maximum extent and most ephemeral streams, including several that were dry during the summer surveys, were flowing. The survey team sampled headwater tributary segments upstream from the fall study reaches, and expanded the headwater survey, between March 27th and April 3, 2011. Single-pass electrofish removal with no block nets was used to document fish species composition. Less access to survey reaches in headwater reaches surveyed in the spring meant that selection of survey reaches was more opportunistic in nature, however, efforts were made to spatially stratify the surveys to maintain spatial coverage of small tributaries. As in fall surveys, fish were identified and enumerated, and salmonids measured, but fish species composition was characterized for individual stream segments and not at the resolution of habitat units for each segment (as in the fall mainstem surveys). These data were primarily intended to determine presence or absence of fish during the high flow season in perennial and seasonal headwater stream reaches. The high flow data were not used to estimate the F-IBI scores in those reaches.

Data Analysis

Qualitative, quantitative, and spatial analyses were used to describe fish community composition and distribution within Johnson Creek. In order to describe fish community composition and distribution we constructed bar charts showing the proportions of fish of each species in Johnson Creek as well as each of the nine study reaches (combining all segments within a reach) during the main sampling effort in the fall. We also constructed bar charts showing the proportion of fish grouped by family and grouped as native and non-native. These fall data as well as the spring species composition were also presented in tables.

Lengths of salmonids from all reaches were pooled, separately for each season, 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 Johnson 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 Johnson 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 are more susceptible to capture in all habitat types. 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 of the metrics were summed for each site (stream reach) and then multiplied by (10/ the total number of metrics) 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 Johnson Creek was assigned to one of three qualitative impairment categories: ≤ 50, severely impaired; 51 to 74, marginally impaired; and ≥75, minimally impaired.

Results

Summer-Fall Low Flow Species Composition and Distribution

Over the course of our fall single pass electrofish survey in Johnson Creek we captured 4,643 fish comprising 14 species (10 native species and 4 non-native) and representing 7 distinct families (Tables 2-3, Figures 2-4). Native reticulate sculpin *Cottus perplexus* (72%), redside shiner *Richardsonius balteatus* (11 %), speckled dace *Rhinichthys osculus* (10%), cutthroat trout *O. clarkii clarkii* (4%), and coho salmon *O. kisutch* (2%) were the most abundant species in Johnson Creek, with all other species constituting less than 1% of the total fish assemblage (Table 2, Figure 2). By families, native cottids, cyprinids, and salmonids were most abundant, comprising 72%, 22%, and 6% of fish sampled, respectively, all other families constituting less than 1% of total fish abundance (Figure 3). Overall, 99.8% of fish sampled were native species, while 0.2% were non-native species (Figure 4).

Species composition varied between reaches and species richness (the number of species) appeared to be a function of stream size, declining in an upstream direction and in tributaries. (Table 2, Figure 5). In the mainstem reaches (A, B, C) of Johnson Creek, between 9 and 11 species were present, with reticulate sculpin, speckled dace, cutthroat trout, and redside shiner the most abundant species (Table 2). All non-native species were captured in mainstem reaches, with the exception of pumpkinseed found in Butler Creek (F) (Figure 6).

In contrast to the non-native species, salmonid density was highest in the upper mainstem reaches (B, C), Badger (H), and upper Sunshine (E) creeks. Coho salmon were found in just over half of the study reaches (5/9), but were not found in the uppermost mainstem reach (C), upper Sunshine (E), North Fork Johnson (G), or Butler (F) creeks. Cutthroat trout were more widely distributed, present in all reaches except for North Fork Johnson (G), the only reach where no salmonids were found. (Table 2, Figure 6). Although fish densities were low, coho salmon and cutthroat trout represented a greater proportion of the fish assemblage in Hogan Creek (I) and upper Sunshine creek. Native cyprinids, sculpin, and lamprey were also found at high densities in reaches where native salmonids were abundant. One exception to this pattern was in Sunshine Creek, where high densities of non-salmonids were found in downstream but not upstream reaches (Table 2, Figure 6). Fish were observed within all fall sample reaches, and in most cases the upper extent of fish likely extended well above the uppermost reaches sampled (Figure 7).

Spring Headwater Fish Species Composition and Distribution

Small tributary and headwater surveys during March and April 2012 revealed many of the same species found in the fall 2011-surveyed mainstem reaches. However, total sampling effort and the number of fish sampled (n=130), were considerably less than in more intensive fall surveys (Table 3, Figure 8). One additional non-native species, common carp, was found in an ornamental pond on an unnamed headwater tributary at Cotrell Rd. As in the fall mainstem surveys, reticulate sculpin (48%) was the most frequently encountered species, with salmonids, including cutthroat trout (30%) and coho salmon (7%) as the next most common fish species encountered in the spring surveys. Non-native species were limited in their distribution to two sites in the spring, consistent with fall results (Figure 8). No other species constituted more than 3% of the fish encountered in the spring.

Salmonid Size and Age

Lengths of coho salmon had uni-modal distributions in both the fall (n=74) and the spring (n=8), indicative of a single age class (0+ in the fall, and age 1 in the spring), while cutthroat trout lengths had a distinct tri-modal distribution suggesting three age classes (0+, 1+, and 2+) in both the fall (n=165) and spring (n=38) (Figures 9 and 10). Coho salmon lengths ranged from 40-95 mm (mean = 71 mm) in the fall and from 80-120 mm (mean = 103 mm) in the spring. Based upon clear modes and troughs in fork length distributions, we differentiated three distinct cutthroat trout cohorts in the fall. Age 0+ cutthroat trout (n = 88) lengths ranged from 46-100 mm (mean = 71 mm), age 1+ cutthroat trout (n = 61) lengths ranged from 100-180 mm (mean = 132 mm), and age 2 and older cutthroat trout (n = 13) were greater than 180 mm (mean = 239 mm, max = 366). Less clear modes in spring precluded assignment of cutthroat trout to age classes, but size distributions suggested multiple age classes were present (min = 70 mm, max = 250 mm). Only two rainbow trout/steelhead were captured during the study (70 and 201 mm, respectively), precluding identification of age classes. (Figures 9 and 10)

Fish Index of Biotic Integrity
Fish index of biotic integrity calculations in the nine reaches surveyed in Johnson Creek generated FIBI scores 46-73, with marginal levels of impairment (50< FIBI<75) in 6 out of 9 reaches; all Johnson Creek mainstem, lower Sunshine, Butler, and Hogan creek reaches (A, B, C, D, H, I). Three reaches showed severe impairment (FIBI<50): upper Sunshine, Badger, and North Fork Johnson reaches (E, F, G). No reaches had minimally or non-impaired scores (>75). (Table 4, Figure 11).

Discussion

Species Composition and Distribution
Fish species occurrence in the upper Johnson Creek watershed is typical of small urbanized watersheds in the Pacific Northwest and other urban streams in the Portland, OR area (e.g. Van Dyke and Storch 2009, Titus et al. 2003). Small stream fish assemblages in the Pacific Northwest are often dominated by sculpins (*Cottus* sp.), stream-rearing salmonids (coho salmon, rainbow / steelhead, and cutthroat trout), with native cyprinids found in warmer and lower gradient streams. In urbanized and urbanizing watersheds, non-native species may be present, and are frequently associated with warmer and low-gradient reaches or channel-adjacent ponds, which may facilitate colonization.

Many of the typical Pacific Northwest stream-rearing salmonids were present in Johnson Creek, but were found in reduced abundances and distribution relative to healthy watersheds. Cutthroat trout dominated the salmonid species composition and were more abundant than coho salmon and considerably more abundant than rainbow trout/steelhead. In a healthy watershed with similar physical habitat, we would expect coho salmon to be more abundant. Previous research in developed watersheds suggests that cutthroat trout populations may fare better than other salmonids in response to watershed changes from urbanization (Scott et al. 1986). In urbanized watersheds coho salmon adults may suffer premature mortality prior to spawning, while trout may be less affected. Coho salmon appear especially sensitive to degraded water quality and acute toxicity arising from urbanization (Feist et al. 2011), which may have deleterious population-scale impacts on the species (Spromberg and Scholz 2011). Pre-spawn mortality in coho salmon has been observed in other Portland, OR watersheds (WFC 2011) and may also be occurring in Johnson Creek, accounting for the low abundance of coho relative to cutthroat trout.

Although fish abundances were not quantified in this study, the densities of native salmonids encountered in intensive study reaches appeared lower than would be expected in similar non-degraded streams. Although many of the observed watershed changes in Johnson Creek are likely irreversible, restoration efforts that address degraded water quality and habitat may help ameliorate ongoing human land and water impacts. Efforts to restore natural watershed hydrology, revegetate riparian areas, remove development from floodprone lands, and improve fish passage at road crossings would all help improve the status of native fish in Johnson Creek watershed.

The general pattern of lower species richness moving in an upstream direction observed in this study is consistent with patterns observed in other watersheds worldwide (Reeves et al. 1998), and does not indicate that Johnson Creek headwater streams are degraded. This pattern is likely a reflection of distance from the Willamette River (a source of species), cumulative effects of multiple partial fish passage barriers, and a reduced diversity of habitat moving upstream in Johnson Creek associated with the seasonally-wetted headwaters.

Non-native species were generally more common in mainstem reaches of Johnson Creek, with fewer numbers observed in tributaries. However, in certain tributaries, agricultural and rural residential farm ponds appeared to represent important vectors for introduction of exotic fishes to the watershed. Migration of non-native fishes from ponds into the stream network, and from downstream receiving waters like the Willamette or Columbia Rivers represents a difficult challenge for the long term management of the biological integrity of Johnson Creek. Although, non-native species currently represent a small portion of the total biomass present in Johnson Creek, new introductions and altered watershed conditions (like rising stream temperatures, streamflow depletion, etc.) could favor non-native species populations with unknown consequences for native fishes.

We observed native salmonids at a number of notable locations, and some of these are the first-ever documented observations of these priority fish species at these locations. We found coho salmon in Meadow, Brick, Cedar, and Thom creeks. We found cutthroat trout in Meadow, Nechacokee, Heiney, Brigman, Botefur, Thom, and Upper Johnson creeks (upstream of Cottrell Road), as well as in an unnamed tributary along Wheeler Rd. In addition, we documented cutthroat in an unnamed right-bank tributary to Johnson Creek at SE 282nd and Stone, unnamed tributaries to upper Badger Creek (at 282nd and Kathy Lane and at Telford Road), and unnamed tributaries to upper Sunshine Creek (at Sunshine Valley Rd, at SE Williams Place, at Hideaway Lane, and at Ladera Drive). Most notably, we captured coho and cutthroat trout in Thom Creek, upstream of two partial fish passage barriers at Springwater Trail and Roberts Road crossings.

We failed to detect fish at a number of notable locations where we expected to find fish due to favorable stream habitat (>3 ft BFW and <8% gradient). This included EF Butler upstream of Willow Parkway, Heiney Creek upstream of SW 17th St, Chastain Creek upstream of 14th Court, Highland Creek upstream of the Powerlines crossing, Badger Creek headwaters upstream of SE Haley Rd, McNutt Creek at McNutt Rd, as well as upper Meadow, Nechacokee, Brigman, and several unnamed headwater tributaries to Badger and Sunshine creeks. At many of these locations we identified downstream fish passage barriers that may prevent fish from accessing and recolonizing these environments.

Salmonid Size and Age

Size distributions of coho salmon, cutthroat trout, and rainbow trout / steelhead captured in Johnson Creek were typical of Pacific Northwest streams. The presence of only one age class of coho salmon in both the fall and spring 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 fall in Johnson Creek were likely completing their first summer of life (age 0) and were preparing to migrate to the ocean during the spring sampling period (age 1). The lack of a second smaller length mode of coho in the spring suggests that the young of year had not emerged yet in spring 2012, or that abundance in that cohort was substantially lower. The presence of at least three age classes of cutthroat trout was also consistent with their life history which may include a combination of resident, potamodromous, and anadromous individuals (Trotter 1989). Notably for coho salmon, the mean size appeared to increase between fall 2011 (71 mm) sampling and spring 2012 sampling (103 mm), consistent with growth and or size-selective mortality.

Fish Index of Biotic Integrity (F-IBI)

Fish index of biotic integrity results suggest that upper Johnson Creek and its tributaries are experiencing moderate to severe environmental impairment. Marginal and severe impairment scores were also obtained in surveys of reaches of lower Johnson Creek in 2001, 2002, and 2008, suggesting that the impaired conditions as measured by FIBI have existed for some time but do not appear to be worsening (Van Dyke and Storch 2009, Tinus et al. 2003). F-IBI results for upper Johnson Creek also appear to be similar to those obtained in other Portland, OR area streams (e.g., WFC 2011; Beaver Creek, 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, 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.

It is important to interpret the F-IBI scores for upriver reaches and tributaries with caution. Species diversity typically declines in upstream reaches and small tributaries, since these settings typically show lower habitat diversity as compared to downstream reaches. Fewer fish species means lower F-IBI scores, but this does not necessarily imply degraded ecological conditions. In fact, some of the most ecologically intact stream habitats in upper Johnson Creek are found in tributary streams like Hogan, Kelly, and Wheeler creeks.

F-IBI 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 (which affects the available species pool and subsequent colonization of habitats), natural migration barriers, temperature, or physical habitat constraints, all of which could bias an index value. Naturally low quality or species depauperate habitats may be rated as impaired despite little human influence (e.g. tributaries). 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 effects on both sampling efficiency related to discharge and temperature, as well as habitat use by various species) may affect results and introduce unknown biases in the value of F-IBI in assessing ecosystem health. The F-IBI is best utilized in concert with other data on benthic invertebrates (BIBI), water quality, and habitat to provide a summary and comparison of stream health among comparable reaches (King Co 2004).

Conclusions and Future Research Needs

Conclusions

Fish populations in upper Johnson 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, cutthroat trout, rainbow trout / steelhead. The fish community also contained native resident species including dace, lamprey, and sculpins, suggesting most, if not all of the historically present species remain. However, a total of five non-native species were found in Johnson Creek, though they were not widely distributed and were apparently less abundant than native species. The tributaries in the upper watershed appear to be a refuge from invasives for native species. These fish occurrence data resulted in ratings of moderately to severely impaired (46-63), as measured by the F-IBI, 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 Johnson 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 Johnson Creek. Additional studies are needed to identify factors limiting native fish populations and ecosystem health in Johnson Creek. Some potential areas of future research are described below.

Future Research and Restoration 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 Johnson 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 trout / steelhead, and potentially anadromous cutthroat trout were identified in Johnson 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 Johnson Creek for non-natal rearing.
- 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 Johnson Creek.
- Exotic Fish Control and Management Improvements
    - Non-native fishes were present in Johnson 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.
    - Identification of and outreach to headwater farms with ponds is needed to improve management practices, in order to reduce potential 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 Johnson 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 Johnson 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 Johnson Creek and establish a baseline for future monitoring.

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Tables and Figures

Tables

Table 1. Summary of mainstem Johnson Creek single pass electrofishing sampling during September 2011. Habitat types are (P, pools, R, riffles, and M, mixed water velocity).

					Habitat Units Sampled			
Reach	Stream	Segments	Dates	Length(m)	M	R	P	Total
A	Mainstem	7	9/19, 20	4249	17	8	5	30
B	Mainstem	8	9/20, 21, 22, 26	5099	20	21	18	59
C	Mainstem	6	9/15, 27	2298	13	15	7	35
D	Lower Sunshine	5	9/13, 14, 26, 27	2563	6	7	9	22
E	Upper Sunshine	6	9/13, 27	522	9	1	9	19
F	Butler Creek	2	9/22	1071	6	1	7	14
G	North Fork	3	9/14	920	6	1	6	13
H	Badger Creek	2	9/14	579	4	2	6	12
I	Hogan Creek	1	9/22	900	5	2	3	10
Totals		40	9/13-9/27	18201	86	58	70	214

Table 2. Number and (percent) of each species captured in each study reach in Johnson Creek, OR in September, 2011.

	Major Study Reach								
Species	A	B	C	D	E	F	G	H	I
Bluegill	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Bullfrog larva	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Coho Salmon	5 (0)	32 (2)	0 (0)	11 (1)	0 (0)	0 (0)	0 (0)	5 (1)	21 (21)
Crayfish	4 (0)	0 (0)	41 (5)	26 (4)	0 (0)	0 (0)	0 (0)	11 (3)	0 (0)
Cutthroat trout	14 (1)	57 (3)	26 (3)	11 (1)	36 (16)	6 (2)	0 (0)	7 (2)	11 (11)
Largemouth bass	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)
Largescale suckr	10 (1)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pumpkinseed	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (1)	0 (0)	0 (0)	0 (0)
Rainbow Trt.	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)
Redside Shiner	155 (18)	156 (10)	14 (2)	98 (15)	38 (17)	2 (0)	9 (5)	44 (15)	4 (4)
Reticulate Sculpin	552 (66)	1164 (74)	556 (80)	424 (67)	114 (53)	220 (82)	75 (44)	201 (70)	43 (43)
Speckled Dace	90 (10)	131 (8)	41 (5)	50 (7)	23 (10)	33 (12)	86 (50)	13 (4)	20 (20)
Unk. Cottid	0 (0)	0 (0)	0 (0)	4 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Unk. Trout	1 (0)	6 (0)	4 (0)	1 (0)	0 (0)	0 (0)	0 (0)	2 (0)	0 (0)
W. Br. Lamprey	3 (0)	4 (0)	1 (0)	3 (0)	0 (0)	0 (0)	0 (0)	3 (1)	0 (0)
Yellow Bullhead	0 (0)	0 (0)	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Totals	834 (100)	1553 (100)	692 (100)	628 (100)	212 (100)	266 (100)	170 (100)	287 (100)	99 (100)

Table 3. Number and (percent) of each species captured in each study reach in Johnson Creek, OR in March, 2012.

Species	Count (Percent)
Bluegill	5 (4)
Coho Salmon	9 (7)
Common Carp	2 (2)
Crayfish	2 (2)
Cutthroat trout	39 (30)
Largemouth bass	1 (1)
Pacific Giant Salamander	1 (1)
Redside Shiner	2 (2)
Reticulate Sculpin	63 (48)
Speckled Dace	4 (3)
Unk. trout	2 (2)
Totals	130 (100)

Table 4. Fish index of biotic integrity (F-IBI) scores and associated impairment levels (≤ 50, severely impaired; 51 to 74, marginally impaired; and ≥ 75, minimally impaired) in Johnson Creek, OR in September 2011.

Reach	Stream	F-IBI Score	Condition
A	Mainstem	72	Marginally Impaired
B	Mainstem	73	Marginally Impaired
C	Mainstem	62	Marginally Impaired
D	Lower Sunshine	69	Marginally Impaired
E	Upper Sunshine	49	Severely Impaired
F	Butler Creek	47	Severely Impaired
G	North Fork	46	Severely Impaired
H	Badger Creek	62	Marginally Impaired
I	Hogan Creek	57	Marginally Impaired

Figures

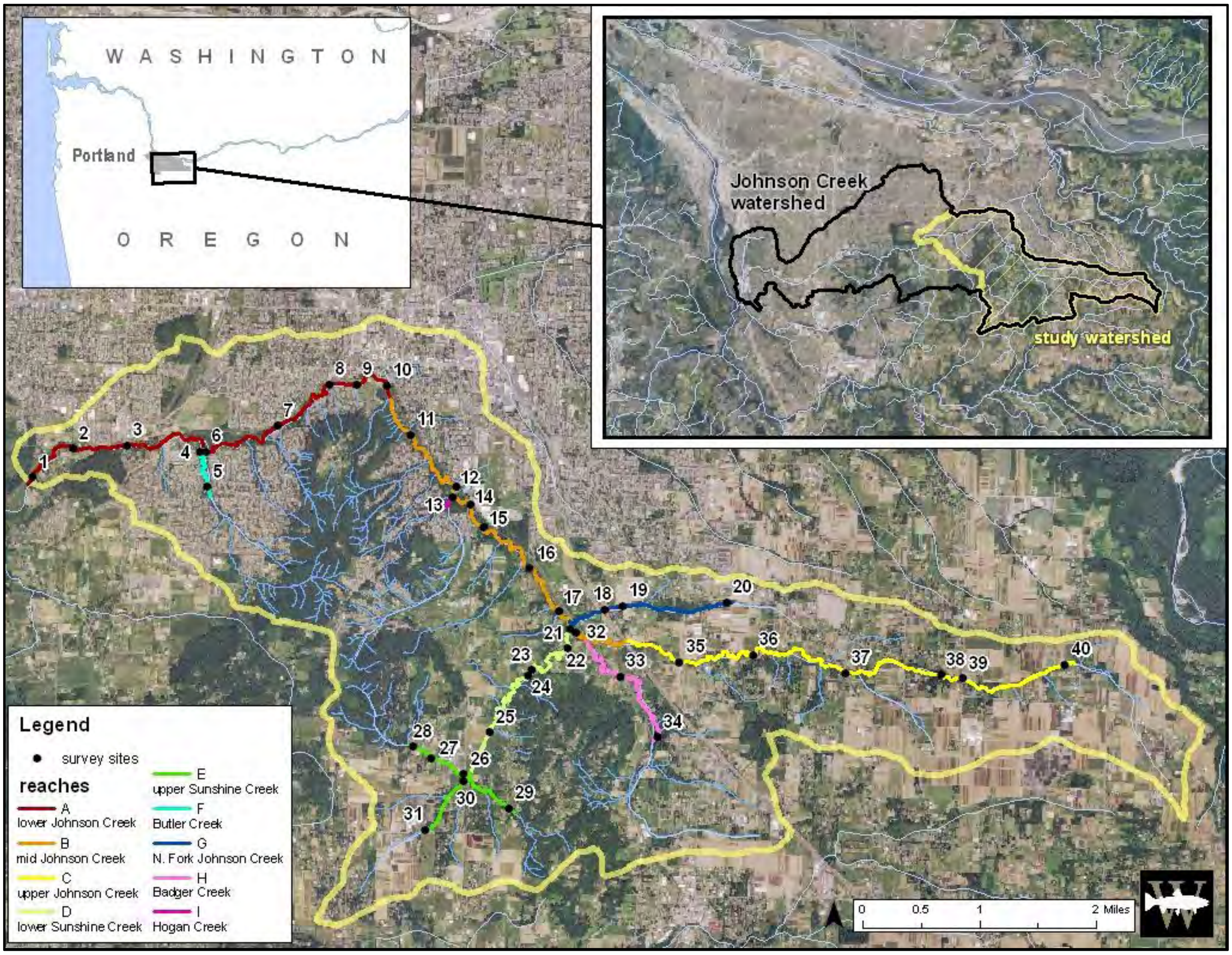


Figure 1. Site map showing Fall 2011 major study reaches A-I and survey segments (numbers corresponding to Appendix 4) within those reaches in the Johnson Creek watershed, tributary to the Willamette River south of Portland, OR.

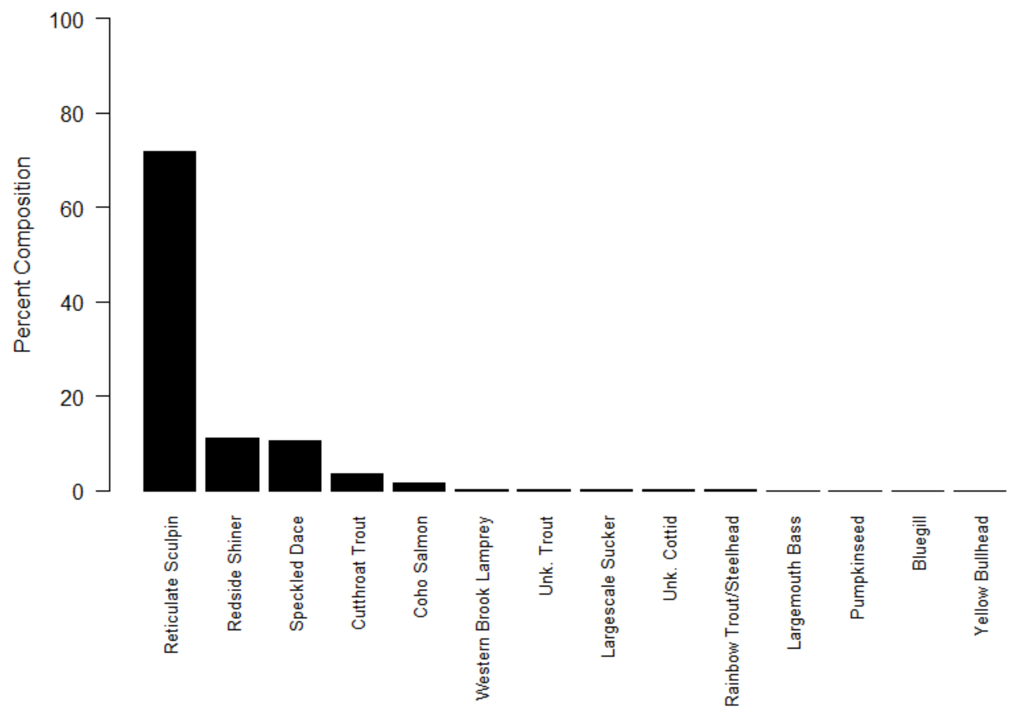


Figure 2. Relative abundance of fish species (n =4643) occurring in all reaches combined in Johnson Creek, OR in September 2011.

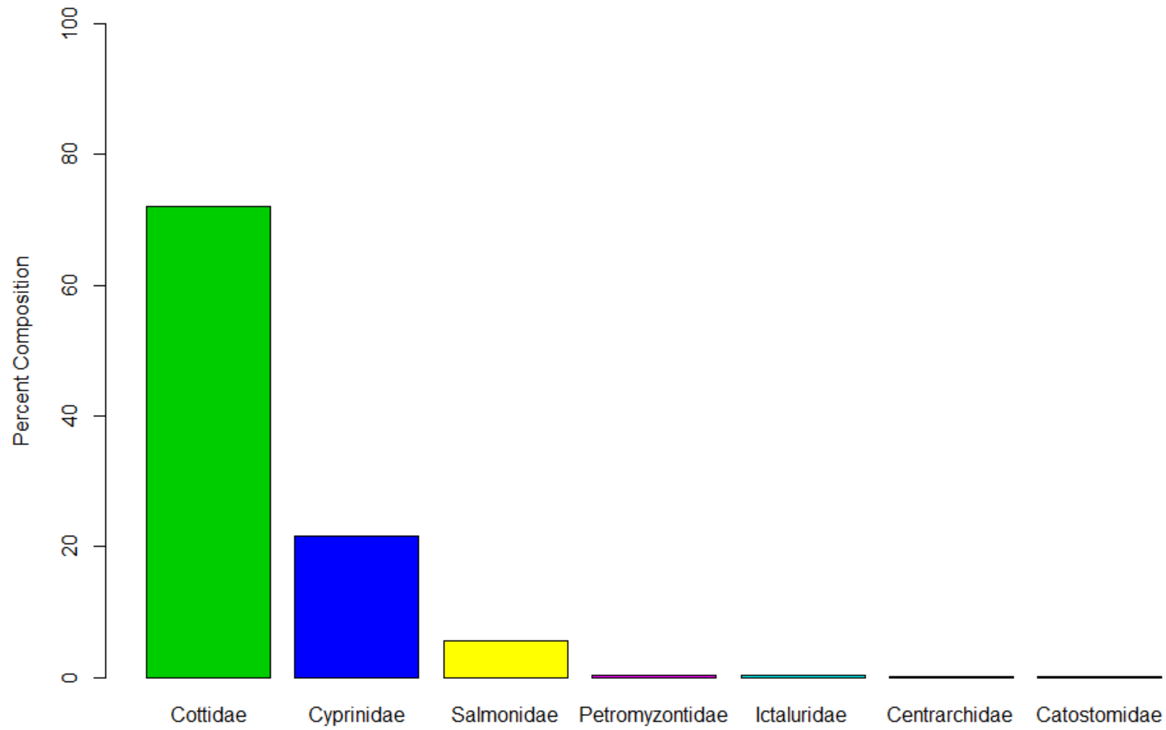


Figure 3. Relative abundance of fish organized by families (n =4643) occurring in all reaches combined in Johnson Creek, OR in September 2011.

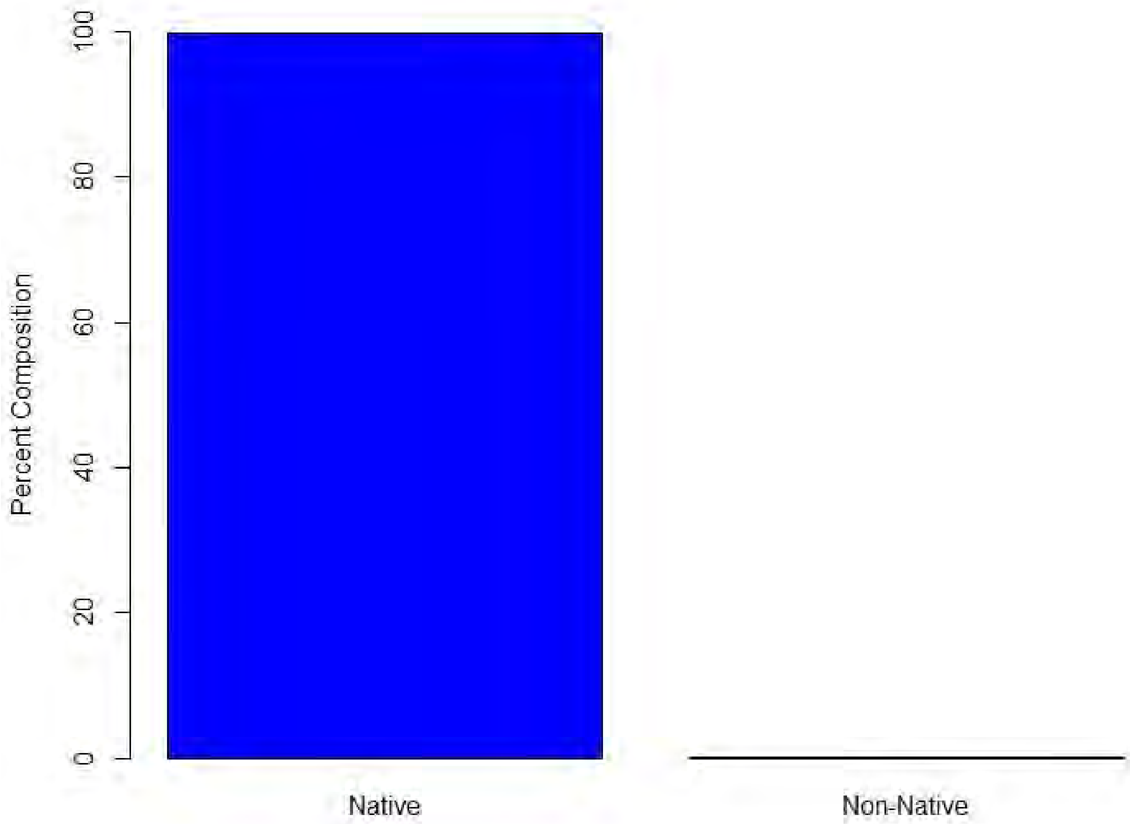
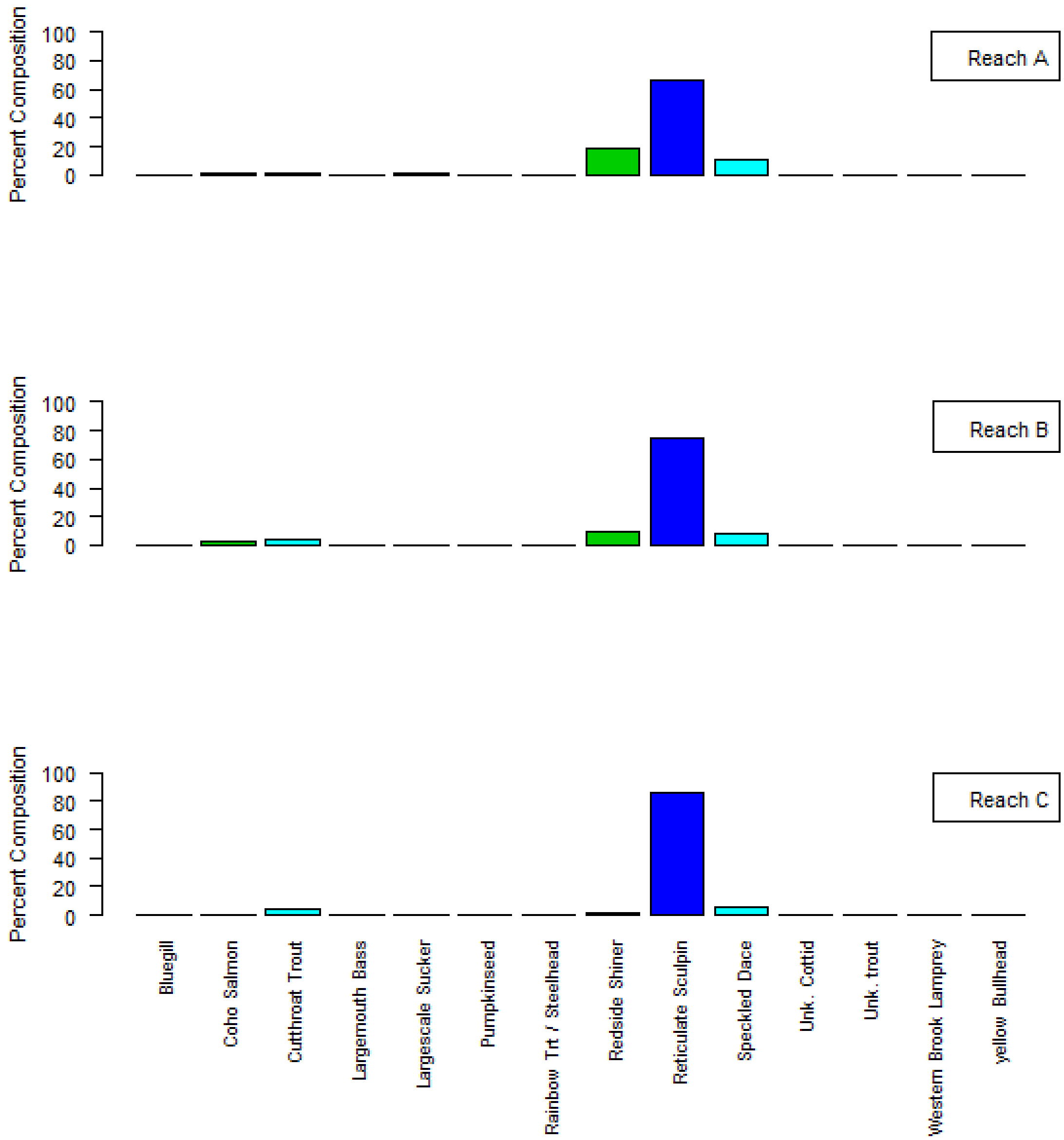
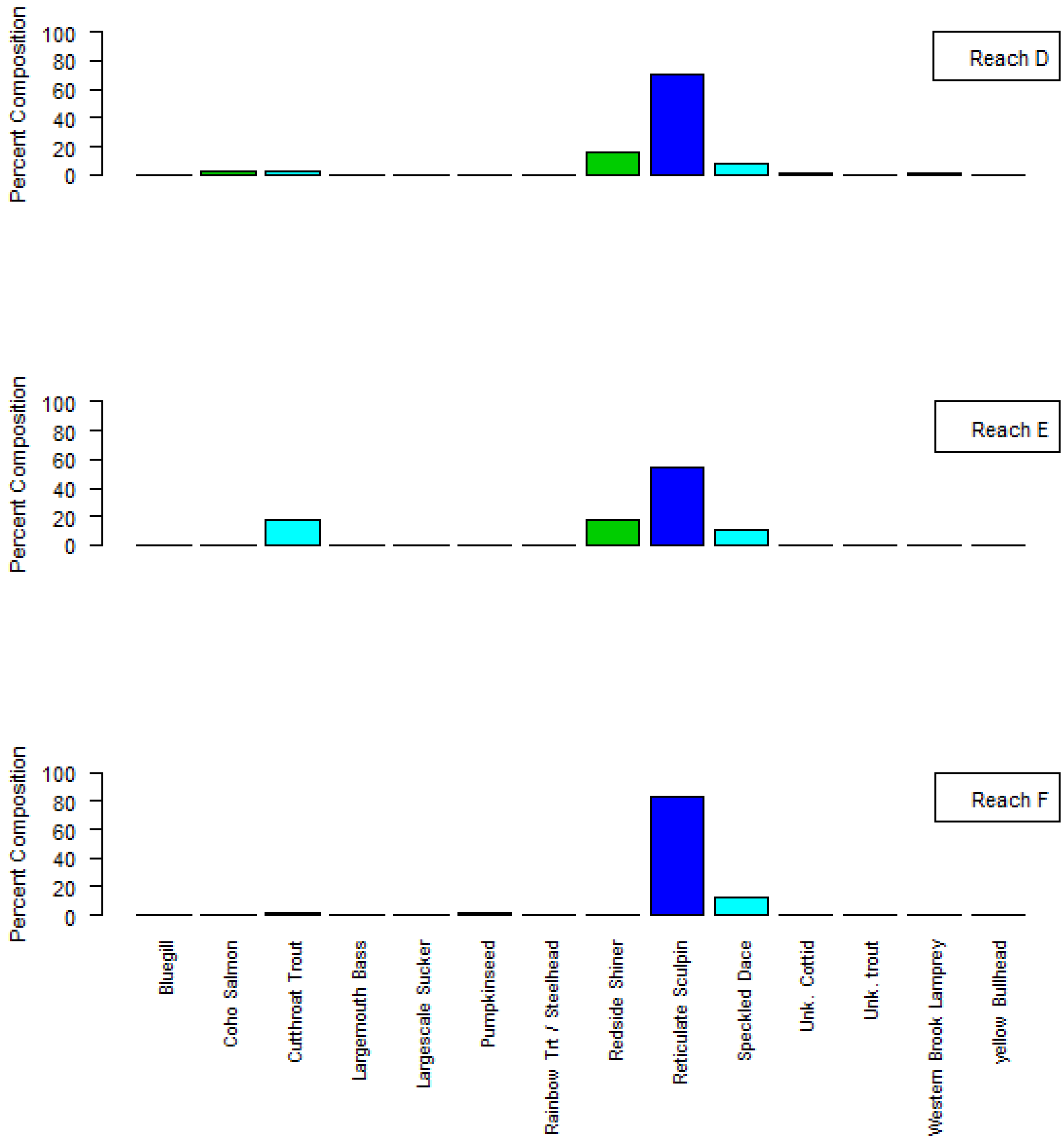


Figure 4. Relative abundance of native (99.8%) and non-native fishes (0.2%) occurring in all reaches combined in Johnson Creek, OR in September 2011 (n= 4643).


Percent Composition
100
80
60
40
20
0
Reach A
Reach B
Reach C
Bluegill
Coho Salmon
Cutthroat Trout
Largemouth Bass
Largescale Sucker
Pumpkinseed
Rainbow Trt / Steelhead
Redside Shiner
Reticulate Sculpin
Speckled Dace
Unk. Cottid
Unk. trout
Western Brook Lamprey
yellow Bullhead


Percent Composition
100
80
60
40
20
0
Reach D
Percent Composition
100
80
60
40
20
0
Reach E
Percent Composition
100
80
60
40
20
0
Reach F
Bluegill
Coho Salmon
Cutthroat Trout
Largemouth Bass
Largescale Sucker
Pumpkinseed
Rainbow Trt / Steelhead
Redside Shiner
Reticulate Sculpin
Speckled Dace
Unk. Cottid
Unk. trout
Western Brook Lamprey
yellow Bullhead

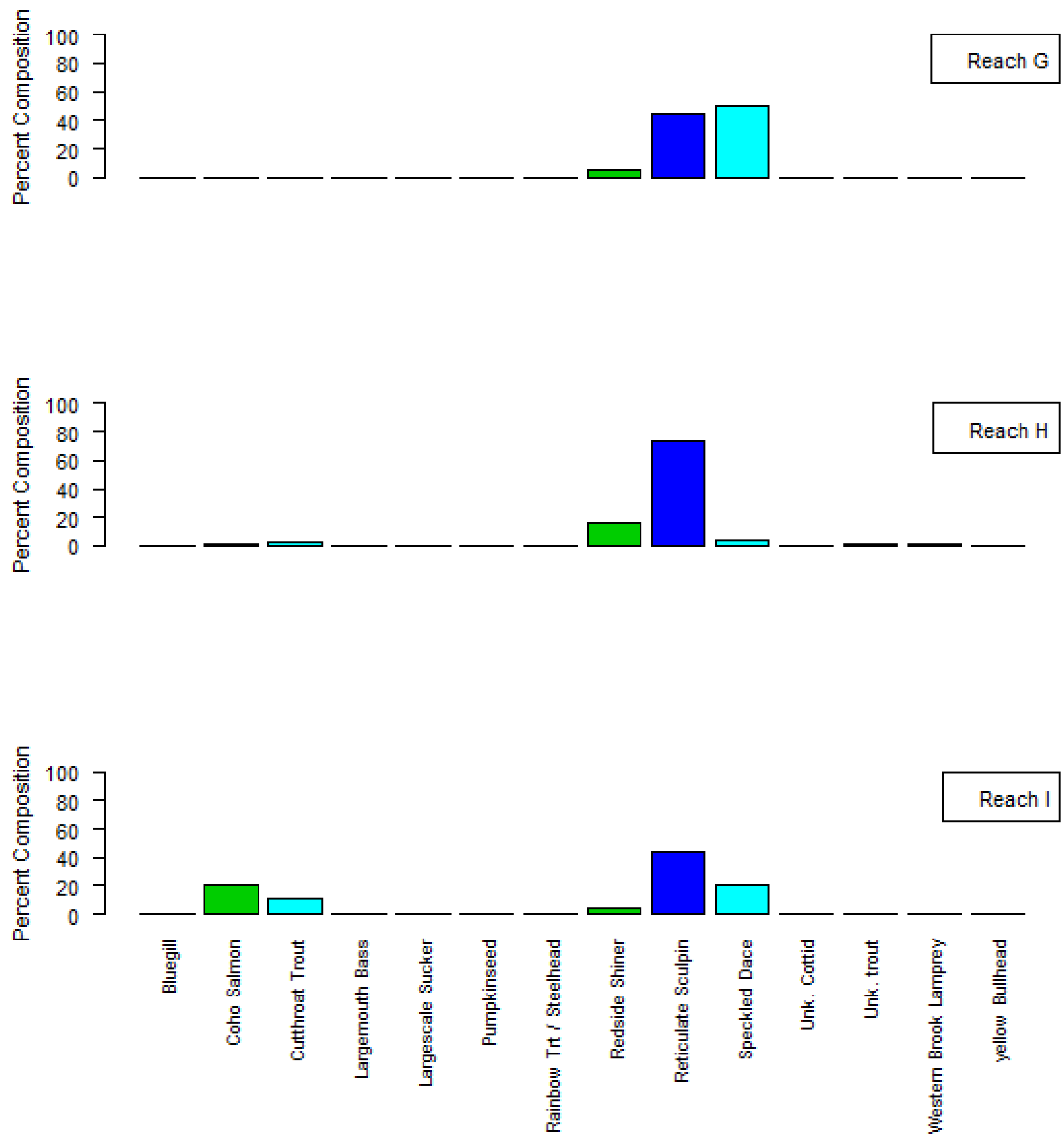


Figure 5. The species composition of fish captured in study reaches of Johnson Creek, OR in September, 2011.

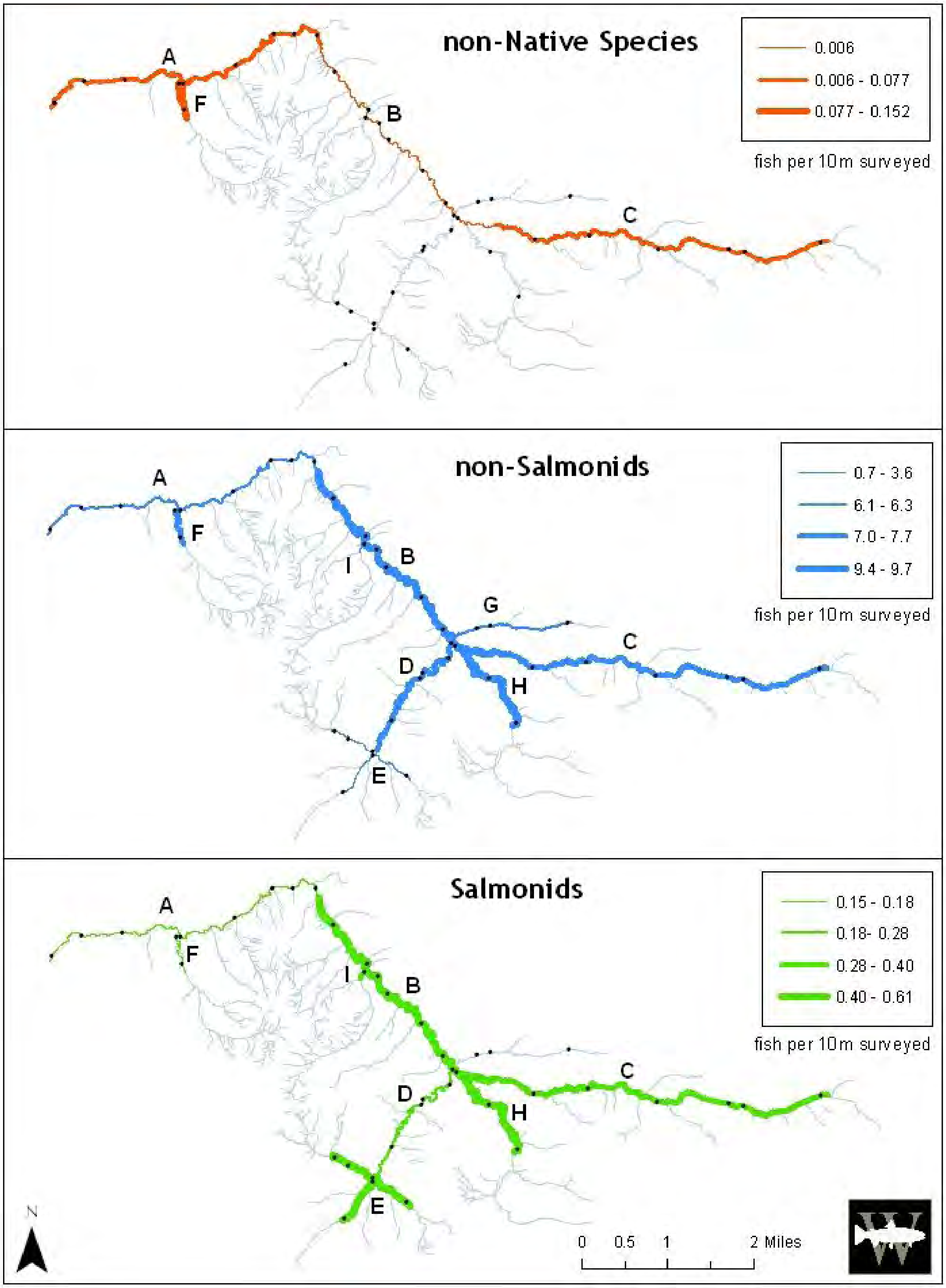


Figure 6. Maps of fish occurrence and catch per 10 meters sampled during single pass electrofishing in reaches of Johnson Creek, OR in September, 2011. Dots show the downstream starting point of the segments of each reach that were sampled and used to characterize fish populations throughout the reach. Line thickness represents differences in catch per 10 m among major reaches (note differences in scales for each species group). Raw catch data corresponding to site numbers are listed in Appendix 4.

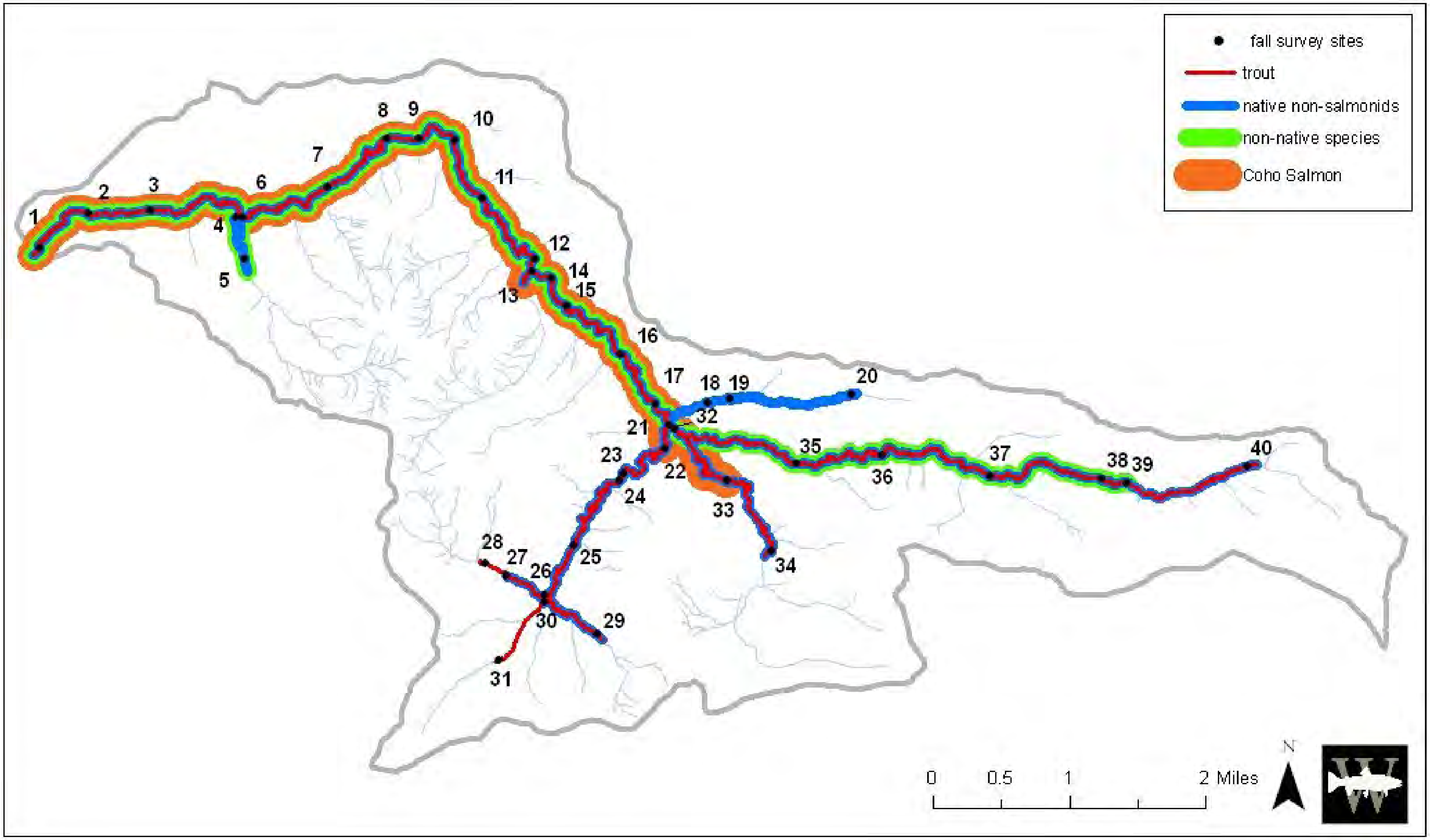


Figure 7. Map of minimum observed upstream fish extent in Johnson Creek and tributaries in Fall 2011 (trout = red, native non-salmonids = blue, non-native species = green, coho salmon = orange). Fish distribution likely extends further upstream beyond the extent of the fall survey sites. Raw catch data corresponding to site numbers are listed in Appendix 4.

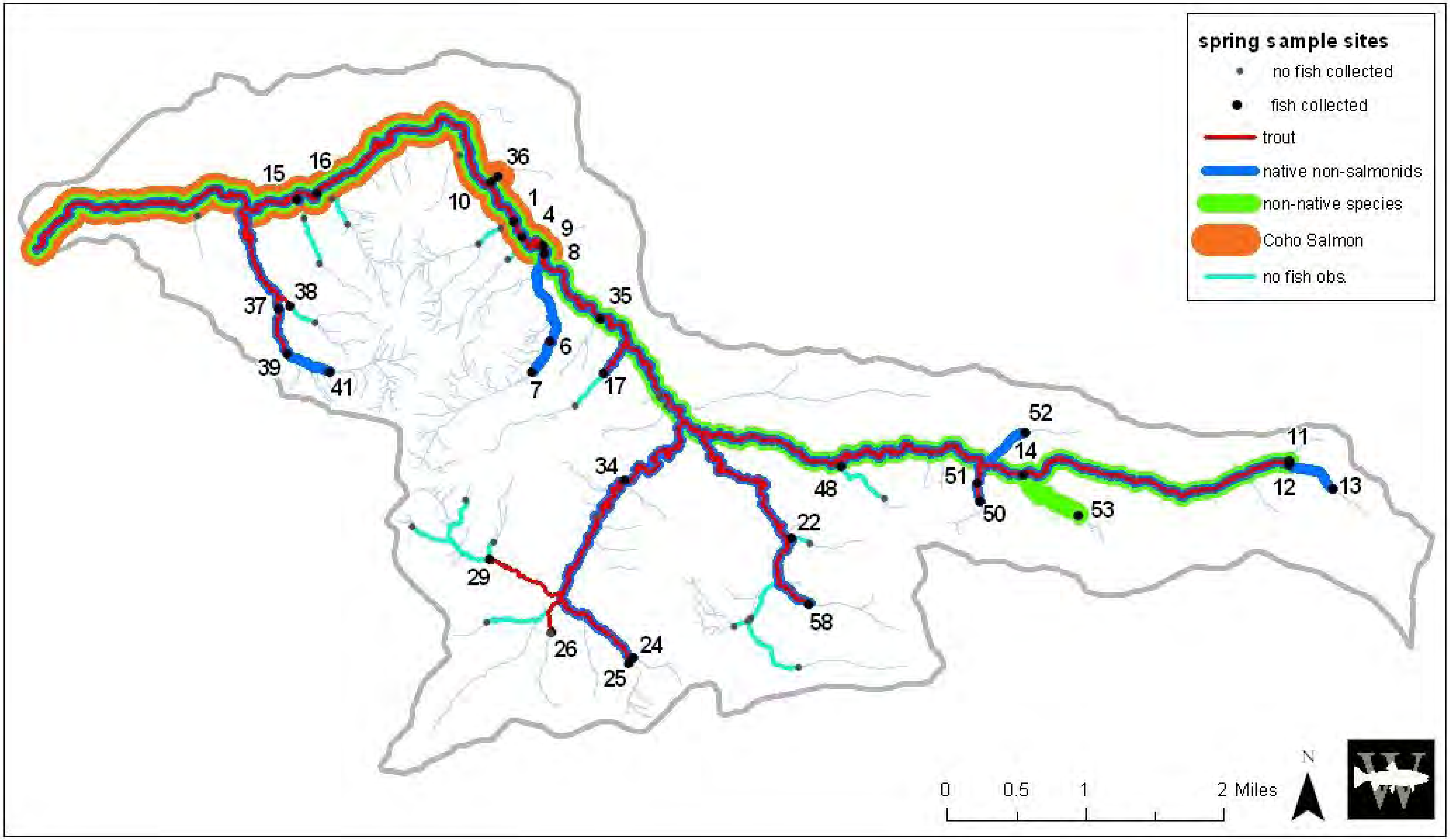


Figure 8. Map of minimum observed upstream fish extent in Johnson Creek and tributaries in Spring 2012 (trout = red, native non-salmonids = blue, non-native species = green, coho salmon = orange) and survey extent (survey extent = teal, survey sites = black dots, with big dots at sites where fish were captured). Fish distribution likely extends upstream from survey reaches where surveys terminated before sites with no fish had been encountered. Raw catch data corresponding to site numbers are listed in Appendix 5.

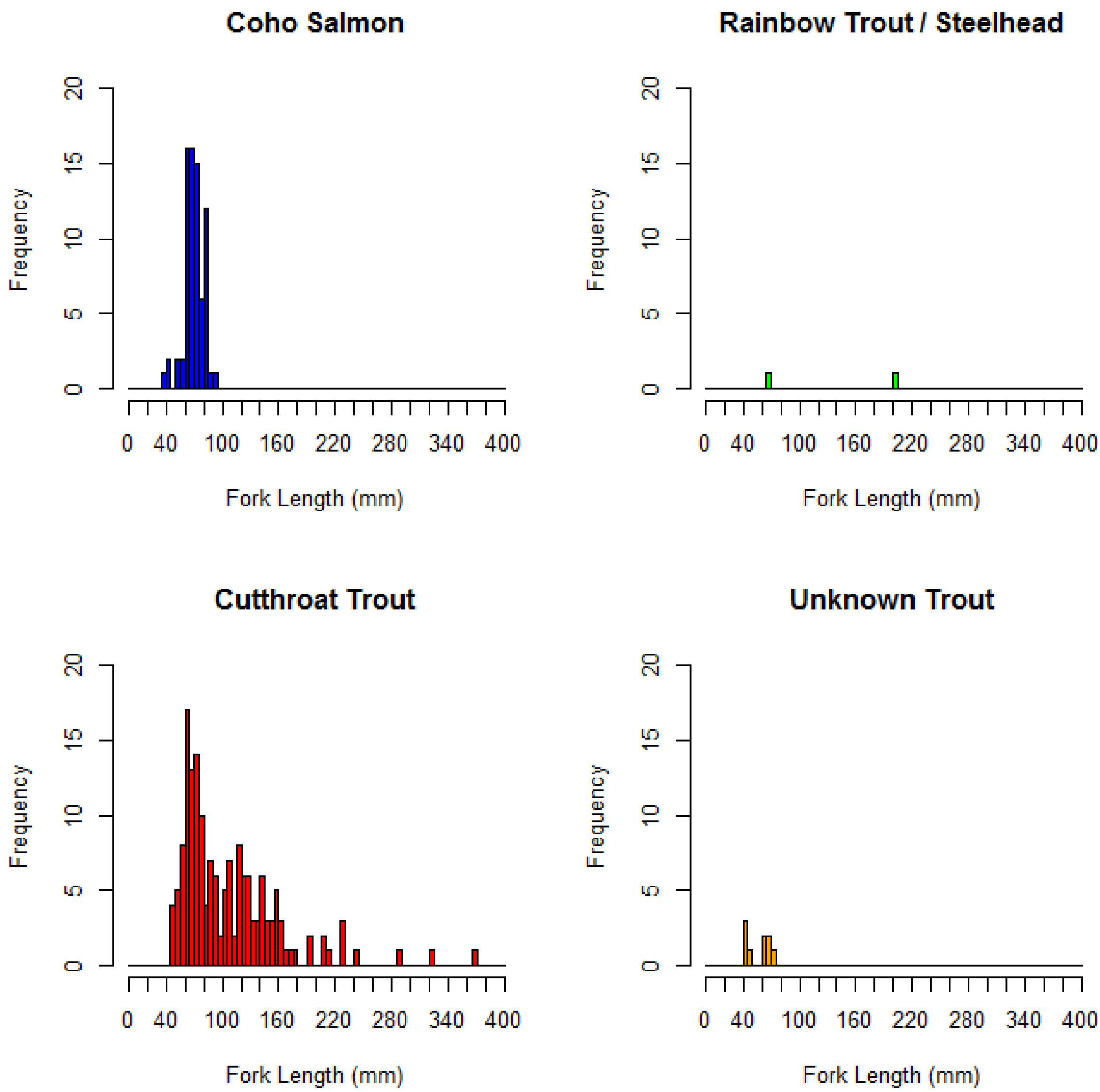


Figure 9. Length frequency distribution for juvenile coho salmon (n= 74), rainbow trout/steelhead (n= 2), cutthroat trout (n= 165), and unknown trout (n= 9) in Johnson Creek, OR, September 2011.

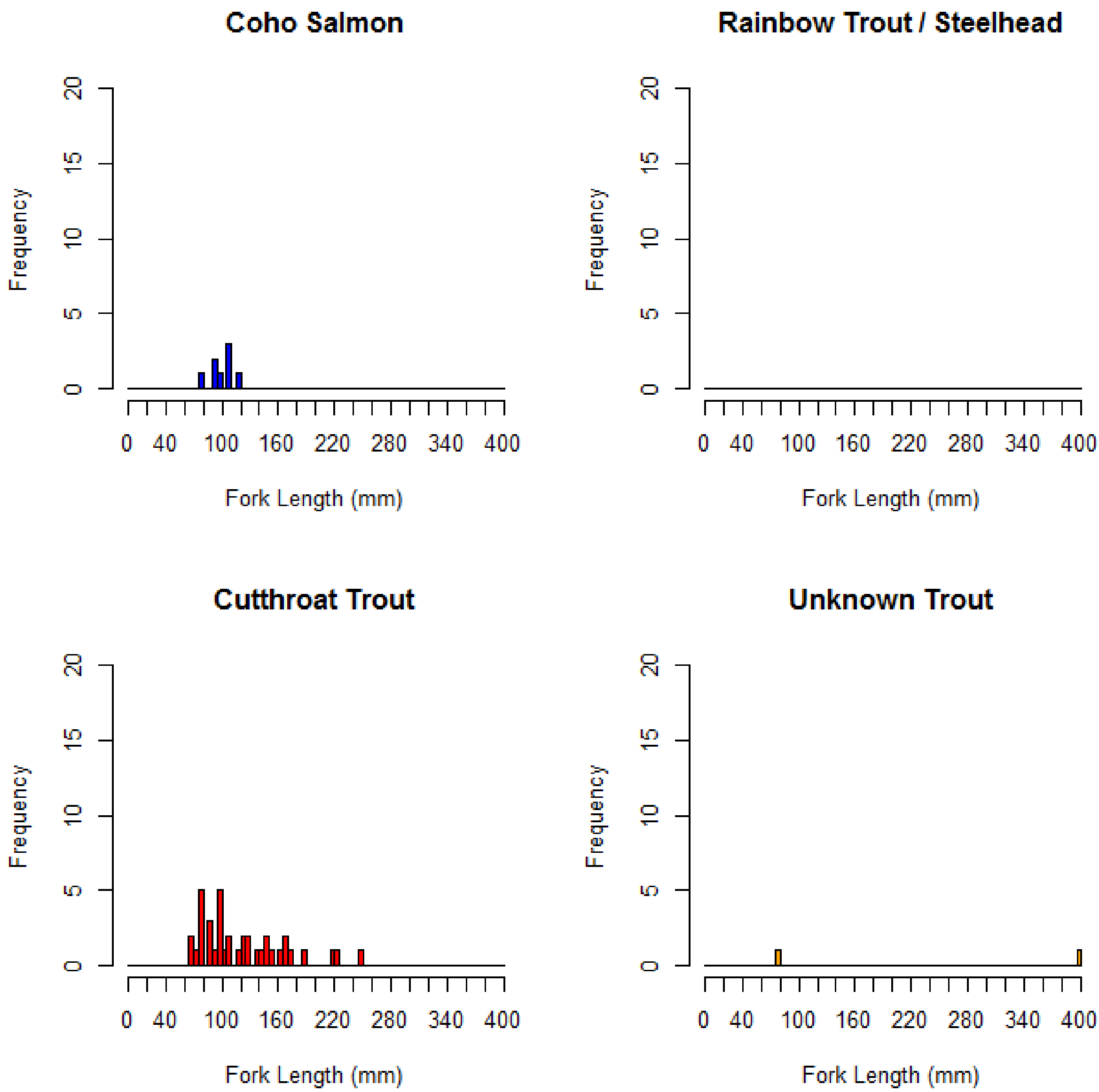


Figure 10. Length frequency distribution for juvenile coho salmon (n= 8), rainbow trout / steelhead, cutthroat trout (n= 38), and unknown trout (n= 2) in Johnson Creek, OR, March and April, 2012. Rainbow trout/steelhead were not encountered during spring surveys

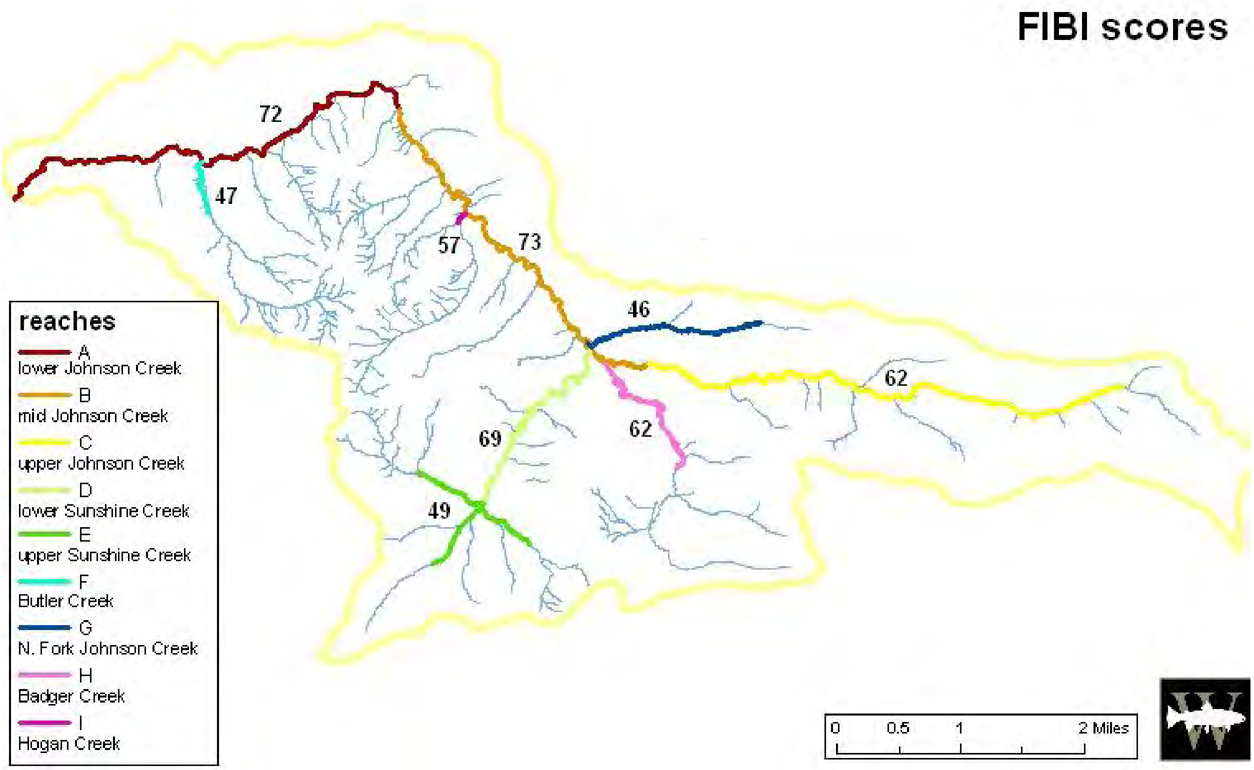


Figure 11. Fish Index of Biotic Integrity (F-IBI) scores calculated for reaches in Johnson Creek, OR, based on fish community data collected in fall 2011.

Appendix

Appendix 1. Index of biotic integrity metrics used to score stream condition to three impairment levels for second and third order steams (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	10 – 0
Trophic Guilds:	
9) Percent filter-feeding individuals	0 – 10
10) Percent omnivores	10 – 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 used in calculations of Fish Index of Biotic Integrity (F-IBI) in Johnson Creek, OR, September 2011. Tolerance categories are: S, sensitive, T, tolerant, and Iintermediate.

Species	Family	Native	Tolerance (S,I,T)	Benthic	Water Col.	Hider	Ng. Lith. Nester	Filter Feeders	Omnivore
Bluegill (*Lepomis macrochirus*)	Centrarchidae	Alien	T		X				
Coho, juvenile (*Oncorhynchus kisutch*)	Salmonidae	Native	S		X		X		
Cutthroat Trout (*Oncorhynchus clarkii clarkii*)	Salmonidae	Native	S		X	X	X		
Largemouth Bass (*Micropterus salmoides*)	Centrarchidae	Alien	T		X				
Largescale Sucker (*Catostomus macrocheilus*)	Catostomidae	Native	I	X					X
Pumpkinseed (*Lepomis gibbosus*)	Centrarchidae	Alien	T		X				
Rainbow / Steelhead *(Oncorhynchus mykiss)*	Salmonidae	Native	S		X	X	X		
Redside Shiner (*Richardsonius balteatus*)	Cyprinidae	Native	I		X				
Reticulate Sculpin (*C. perplexus*)	Cottidae	Native	I	X		X			
Speckled Dace (*Rhinichthys osculus*)	Cyprinidae	Native	I	X		X			
Yellow Bullhead (*Ameirus natalis)*	Ictaluridae	Alien	T	X		X			X
Western Brook Lamprey (*Lampetra richardsoni*)	Petromyzontidae	Native	S	X		X	X	X	

Appendix 3. Standardized (0-10 with greater scores indicating better ecological function) Scores for each F-IBI metric (corresponding to Appendix 1) in reaches of Johnson Creek, OR in September 2011.

	F-IBI Metric (Numbers from Appendix 1)												
Reach	1	2	3	4	5	6	7	8	9	10	11	12	Total FIBI
A	7.1	6.4	5.7	7.5	10.0	6.0	10.0	10.0	0.4	8.8	NA	NA	72
B	7.1	6.4	5.7	7.5	10.0	6.0	10.0	10.0	0.3	9.9	NA	NA	73
C	5.7	5.5	4.3	7.5	4.0	6.0	10.0	10.0	0.2	9.1	NA	NA	62
D	5.7	5.5	4.3	7.5	10.0	6.0	10.0	10.0	0.5	10.0	NA	NA	69
E	4.3	3.6	2.9	5.0	7.5	2.0	3.3	10.0	0.0	10.0	NA	NA	49
F	4.3	3.6	2.9	5.0	7.5	2.0	3.3	10.0	0.0	8.1	NA	NA	47
G	2.9	2.7	2.9	2.5	5.0	0.0	10.0	10.0	0.0	10.0	NA	NA	46
H	5.7	6.4	4.3	10.0	4.0	8.0	3.0	10.0	1.1	10.0	NA	NA	62
I	4.3	4.5	2.9	7.5	7.5	4.0	6.7	10.0	0.0	10.0	NA	NA	57

Appendix 4. Raw counts of each fish species captured at each subreach (corresponding to Figure 6) sorted by major reach in Fall 2011.

Major Reach	Subreach Number	Bluegill	Bullfrog larva	Coho Salmon	Crayfish	Cutthroat trout	Largemouth bass	Largescale Sucker	Pumpkinseed	Rainbow Trt / Steelhead	Redside Shiner	Reticulate Sculpin	Speckled Dace	Unk_ Cottid	Unk_ trout	Western Brook Lamprey	Yellow Bullhead
A	1				4	1		4				55	97	21			2
A	2											3	24	3		1	
A	3							3				4	27				
A	6					2						12	34	12			
A	7					6		2				34	187	28			
A	8			2		5		1				38	109	22			1
A	9			3								9	74	4			
B	10					3		1				8	81	5			
B	11			6		4						27	222	42			
B	12			3		5						36	144	14			
B	14			4		14						10	114	21			1
B	15			1		4						5	61	4			
B	16			10		10						29	111	21		6	
B	17		2	4		11						26	270	18			2
B	32			4		6						15	161	6			1
C	35				19	4					1	5	144	8			1
C	36	3				2						9	66	2			
C	37				20	3							126	1			
C	38				2	8							50	2		3	
C	39					7	1				2		109	1		1	
C	40					2							61	27			
D	21			10		8						4	155	9			
D	22			1	26							57	161	14	4		2
D	23					1						6	37	5			
D	24					2						9	43	4			1
D	25											22	28	18		1	
E	26												3				
E	27					6							64				
E	28					12											

E	29			7							16				
E	30			8						38	31	23	1		
E	31			3			0								
F	4			6						2	132	32			
F	5				2		3			88	1				
G	18										57	66			
G	19									1	18	20			
G	20						0			8					
H	33	5	7	4			0		1	15	61	4			1
H	34		4	3						29	140	9		2	2
I	13	21		11						4	43	20			

Appendix 5. Raw counts of each fish species captured at each spring 2012 site.

Site Number	Bluegill	Coho Salmon	Common Carp	Crayfish	Cutthroat trout	Largemouth bass	No Fish	Pacific Giant Salamander	Redside Shiner	Reticulate Sculpin	Speckled Dace	Unk_ trout
1		3			2					3		
2							0					
3							0					
4					2					3		
5							0					
6				1						3		
7				1						3		
8		2							2	3		
9		2										
10		1								2		
11	1		2							3		
12					2					3		
13										3		
14					1					1		
15					6					3	3	
16											1	
17					2					3		
18							0					
19							0					
20							0					
21							0					
22					5					3		
23							0					
24										1		
25					2			1				
26												1
27							0					
28							0					
29					3							
30							0					
31							0					

32					0		
33					0		
34			1			1	
35			1				
36		1	1				
37			4				
38			2			2	
39			1			1	
40					0		
41						7	
42					0		
43					0		
44					0		
45					0		
46					0		
47					0		
48			1			3	
49					0		
50			1			3	
51						3	1
52						3	
53	4			1			
54					0		
55					0		
56					0		
57					0		
58			2			3	