Pudding River
Rapid Bio-Assessment 2014 Final Report

Prepared for the Pudding River Watershed Council
Prepared by Bio-Surveys, LLC.
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Introduction

The 2014 Rapid Bio-Assessment inventory of 4 Pudding River sub-basins covered 91.5 miles of stream habitat. The effort encompassed most of the mainstem and tributary habitats exhibiting the potential for providing functional summer habitat for anadromous salmonids in the Abiqua Cr, Butte Cr, Drift Cr, and Silver Cr sub-basins.

The intent of this project was to quantify the distribution and relative abundance of all juvenile salmonid species during pinch period summer low flow regimes that are known to truncate their summer distribution as a function of elevated stream temperature. The inventory consisted of snorkel surveys that began at select locations (determined by visibility) in each mainstem and at the mouth of each tributary. Surveys continued to at least the end of the current distribution of coho and steelhead and therefore describe the full extent of distribution for these anadromous species in 2014. The surveys did not extend to the end of cutthroat distribution. The surveys are intended to establish base-line distribution and abundance metrics, provide a foundation for long term trend analysis, identify anchor habitats and to guide and prioritize future restoration and management actions.

The juvenile census is a 20% sub-sample of pool rearing habitats only (no riffles or rapids were sampled) using a Rapid Assay technique designed to cover large distances and succeed in describing the distribution patterns and the relative abundance of multiple species of salmonids. Beaver dam abundance and road crossing information was also collected. The juvenile salmonid abundance data presented tabularly in this document has been expanded from the 20% sample to represent an estimate of abundance for all pool habitats within a stream segment. Although estimates have been produced for all existing pool habitats this still does not represent a complete population estimate for each stream because steelhead and cutthroat both utilize fast water habitats for summer rearing. Coho expansions from the pool inventory can be used as a surrogate for a population estimate because coho summer rear almost exclusively in pool habitats. Because juvenile distribution within side channel habitats is not evenly distributed, all side channels were sampled at a 100% rate (every pool).

The abundance estimates for steelhead and cutthroat in this document should only be utilized for inter annual trend analysis and do not represent an estimate of total abundance.

The juvenile abundances documented in the Pudding River sub-basins during the summer of 2014 were the result of an adult escapement of 22,747 wild coho (18,636 adults / 4,111 jacks) and 4,944 winter steelhead (Willamette Falls Fish Count) into the Willamette River for the 2013 brood year.

Several significant observations were made during the field work and subsequent data analysis phase of this assessment that are worth highlighting to set the stage for your review of this assessment;

1) The abundance of anadromous fish fell far short of the current capacity of aquatic habitats in all 4 sub-basins.

2) When steelhead were present they were observed in very low densities. Steelhead were not observed at all in the Drift Cr sub-basin.

3) Coho are by far the most abundant salmonid species and have succeeded in capitalizing on habitat niches not well utilized by other salmonid species.

4) Deep channel entrenchment and inadequate riparian buffers were consistently documented in lower mainstem reaches.

5) Lack of adequate spawning gravel and cover in the form of wood complexity was documented throughout a majority of the inventoried reaches. Where spawning gravel and cover were adequate, temperature limitations often restricted utilization of the aquatic habitats for summer rearing.

6) Invasive non-native and/or introduced fauna were observed in all four sub-basins:
   (a) A naturalized resident rainbow trout population was observed rearing in high densities above anadromous barriers in Abiqua Cr. and Butte Cr.
   (b) Catchable rainbow trout (hatchery progeny) were observed rearing below the reservoir in Silver Cr.
   (c) Bluegill were observed in all four sub-basins
   (d) Bull frogs were observed in all four sub-basins
   (e) Small and largemouth bass were observed in all four sub-basins

The average rearing density for a stream segment is utilized in this document as a metric for comparing productivity between streams and stream reaches. The average has been calculated by dividing the sum of the pool averages by the total number of sampled pools. This is not a weighted average that would divide the total metric surface area of the sampled pools by the total number of fish observed.

The average rearing density for a surveyed reach (fish/Sqm. of pool surface area) is also an excellent measure of trend that can be monitored from year to year. However, it tends to portray only a general description of the current status within a reach. Understanding how each reach is functioning is more accurately interpreted in a review of how the rearing density changes within the reach. The pivot table graphics provided in electronic format with this summary are essential for the proper interpretation of this review. The more refined analysis observed in the pivot table graphics of distribution patterns allows us to get a sense of what the true rearing potential is for the highest quality individual pool habitats. We can then identify the key anchor habitats (stream segments that provide all of the seasonal habitat requirements for sustaining salmonids from incubation through winter rearing) existing within a stream segment. Identifying these key zones of high production potential aids in understanding the unique biological and morphological characteristics that create and maintain exceptional ecosystem function. Anchor habitats may be capable of rearing salmonid juveniles at disproportionately higher densities than non-anchor reaches. In many cases, these unique habitats require special conservation measures to be applied to their management and restoration in order to maintain and enhance their current level of productivity.

It’s important to clarify that two different metrics for location are utilized in this assessment for describing specific fish distributions. This was necessary because the inventories began at points above their actual river mouth. Fish distribution graphics that accompany this document (Pivot Table Workbook) have been described in lineal feet above the survey start points. For management actions, we have frequently transposed this measurement into USGS

River Mile locations. The USGS mapped mileage will be noted as USGS RM XX. The use of USGS RM estimates was not required to georefference any of the tributary inventories because all the tributary surveys began at RM 0.0.

Mainstem surveys required start points above their mouths because in some cases the existing visibility in these lower mainstems was not appropriate for the snorkel methodology.

Methods

Snorkel survey crews conducted RBA surveys between July 7 and August 21 of 2014. Land owner contacts were made for all of the small private, industrial and public ownerships that existed on both sides of every stream reach surveyed. These contacts were conducted by Bio Surveys, LLC. The effort involved personal contacts to describe the survey and request permission for access. The land owner information was recorded (name, contact #, tax lot # and location) and is available as a byproduct of this effort from the Pudding River Watershed Council.

Stream surveys were initiated by selecting the first pool encountered at the beginning of a mainstem or tributary. By not randomly selecting the first sample pool the method was able to identify minor upstream temperature dependent migrations that may not have extended more than a few hundred feet. The identification of this type of migratory pattern in juvenile salmonids is critical for understanding potential limiting factors within the basin (temperature, passage, etc.).

The survey continued sampling at a 20% frequency (every fifth pool) until at least two units without coho and steelhead were observed (the survey does not describe the upper limits of native cutthroat distribution). In addition, pools that were perceived by the surveyor as having good rearing potential (beaver ponds, complex pools, and tributary junctions) were selected as supplemental sample units to insure that the best habitat was not excluded with the random 20 percent sample. This method suggests that the data existing in the database could overestimate average rearing density if these non-random units were not removed prior to a data query (the selected units are flagged as non-random in the database).

In sub-basins with low rearing densities, there were situations where coho and steelhead were not detected for more than two sampled units. These situations were left to the surveyor's discretion, whether to continue or terminate the survey. There is a possibility that very minor, isolated populations of juvenile steelhead could be overlooked in head water reaches of small 2nd order tributaries.

Sample pools had to meet the minimum criteria of being at least as long as the average stream width. They also had to exhibit a scour element (this factor eliminates most glide habitats) and a hydraulic control at the downstream end. There were no minimum criteria established for depth. Only main channel and select side channel pools in the mainstem were sampled. Back waters and alcoves were not incorporated into the surveyed pool habitats. The primary reasons for not including these off channel pools is that they compromise the consistency of measuring, summarizing and reporting lineal stream distances (in addition, off channel habitat types are primarily utilized by salmonids as winter refugia).

Distances reported in the Access database are from the beginning of one sampled unit to the beginning of the next sampled unit. The length of the sampled pool is an independent quantity, which was also measured and not estimated. Total distances represented in the database

are consistently greater than distances generated utilizing a GIS measuring tool on a GIS stream layer (regardless of projection). This is related to the level of sinuosity within the floodplain that is not projected in GIS base map layers. If you are attempting to overlay this database on existing stream layer information there would be a need to justify lineal distances with known tributary junctions (these can be found in the comments column of the Access database). Comparisons of lineal distance have not been made between the RBA field data and a LIDAR base layer. We would expect the differences to be less significant between these two platforms.

Pool widths were generally estimated. Because pool widths vary significantly within a single unit, a visual estimate of the average width was considered adequate. Pool widths were typically measured at intervals throughout the survey to calibrate the surveyor's ability to estimate distance.

The snorkeler entered the pool from the downstream end and proceeded to the transition from pool to riffle at the head of the pool. In pools with large numbers of juveniles of different species, multiple passes were completed to enumerate by species. (coho first pass, 0+ trout second pass, etc.). This allowed the surveyor to concentrate on a single species and is important to the collection of an accurate value. In addition, older age class steelhead and cutthroat were often easier to enumerate on the second pass because they were concentrating on locating food items stirred up during the surveyor's first pass and appeared to exhibit less of their initial avoidance behavior.

In large order stream corridors two snorkelers surveyed parallel to each other, splitting the difference to the center from each bank.

A cover/complexity rating was attributed to each pool sampled. This rating was an attempt to qualify the habitat sampled within the reach. The 1 - 5 rating is based on the abundance of multiple cover components within a sampled unit (wood, large substrate, undercut bank, overhanging vegetation). Excessive depth (>3 ft) was not considered a significant cover component.

The following criteria were utilized:

1	0 cover present
2	1-25 % of the pool surface area is associated with cover
3	26-50 % of the pool surface area is associated with cover
4	51-75 % of the pool surface area is associated with cover
5	> 75 % of the pool surface area is associated with cover

A point to consider here is that the frequency of higher complexity pools increases with a decrease in stream order. This inverse relationship is primarily a function of average channel width and the resultant ability of narrow channels to retain higher densities of migratory wood. Channel morphology begins to play a much more significant role in this relationship during winter flow regimes where increases in floodplain interaction and the abundance of low velocity habitat may become as significant as wood complexity.

A numerical rating was given to each sampled unit for the surveyor's estimate of visibility. The following criteria were utilized:

Visibility

1 excellent
2 moderate
3 poor

This variable delivers a measure of confidence to the collected data. Survey segments with a visibility ranking of 1 can assume normal probabilities of detection (the observed abundance is within 20 percent of the actual abundance of coho). Segments with a visibility of 2 suggest that less confidence can be applied to the observed number (uncalibrated) and segments with a visibility rating of 3 suggest that the observation can probably be used to determine presence or absence only.

Beaver dam presence was also recorded during this inventory. Beaver dams were simply counted along the survey and given a sum total at the end of each stream. Only intact full spanning dams were counted. This variable may then be sorted in the database for presence, absence and trend within each basin.

There was also commentary recorded within each of the surveyed reaches that included information on temperature, tributary junctions, culvert function, the abundance of other species and adjacent land use. This commentary is included in only the raw Access database under the "comments" field and not in the Excel Pivot Table Summary.

Distribution profiles

The distribution of juveniles and their observed rearing densities for each surveyed reach provide a basis for understanding how each reach is functioning in relation to the remainder of the basin or sub-basin. These profiles can help identify adult spawning locations, identify potential barriers to upstream adult and juvenile migration, identify the end point of anadromous distribution and they may also indicate how juvenile salmonid populations are responding to environmental variables such as increased temperature. You will find a review of these distribution profiles within this document for each of the streams surveyed.

Average Pool Densities and Seeding Levels

The average densities generated in this report represent the average value for a tributary or unique stream reach. They represent a snapshot in time of the current condition that can be compared to known levels of abundance that exist in fully seeded and fully functional habitats. These densities also provide a method for quantifying and comparing changes in rearing densities by reach or sub-basin over time. Average densities utilized as a metric in this analysis are calculated for pool surface areas only. Lower levels of juvenile coho abundance and higher levels of juvenile steelhead abundance exist in fast water (riffle/rapid) habitats. Replicate surveys conducted in these same reaches in subsequent years will function as an indicator of response to future restoration and enhancement strategies, potential changes in land use and changes in adult abundance.

To understand how any particular stream reach is functioning in relation to its potential, it is desirable to compare the observed densities of salmonid species to some known standard. The term full seeding is utilized to represent a density of juvenile salmonids that are rearing near the habitats capacity. The carrying capacity of habitats varies seasonally in relation to food abundance, adjacent pool / riffle ratios, flow, temperature and the species tolerance to

interspecific competition. The interaction of this multitude of values is highly complex and unquantifiable at the level of this RBA inventory. Therefore, we can only comment on seeding levels as they relate to standards observed from a combination of many other stream systems in many geographically unique locations. This renders all discussions of carrying capacity in this document subjective. Any discussion of carrying capacity in the following text is an attempt to highlight the lows and highs within a range of observed values and to use a modicum of professional judgment to help steer comparative analyses in a direction that facilitates the decision making and prioritization necessary to guide restoration.

Within the Pudding basin, cutthroat densities between the range of 0.7 and 1.2 fish / Sqm were documented as the top end of the observed range. This high range was observed only in a few small tributaries and represents just 1.3% of the total abundance of pool rearing cutthroat. The more common upper range of pool density was observed between 0.2 and 0.6 fish / Sqm which represents 28.5% of the total abundance of pool rearing cutthroat. This range was observed throughout most of the larger mainstem reaches and thus is a more representative upper end for describing the current summer capacity for aquatic habitats in Pudding River tributaries. This range is below the levels of full seeding observed in other Willamette subbasins exhibiting high quality habitat and limited interspecific competition from steelhead (0.7 fish / Sqm).

Steelhead densities were consistently low with an observed top end range between 0.08 and 0.2 fish / Sqm (below the 0.35 fish/ Sqm level observed in well seeded steelhead systems with interspecific competition from cutthroat). Resident rainbow pool densities averaged 0.18 fish / Sqm above the anadromous barrier of Abiqua falls. Because the habitats ability to rear older age class salmonids is heavily influenced by fish size, available pool surface area and food availability, we assume that in zones of cohabitation by O.mykiss and cutthroat that the combined densities of these similar sized species would not exceed the 0.7 -1.0 fish /Sqm observed in the highest quality habitats of the system. Observations from thousands of miles of RBA inventories in both Willamette basin and coast range streams suggest that densities above 0.7 fish / Sqm for older age class steelhead or cutthroat without competition from the other are rare.

For the 0+ age class, there were 223 pools in 2014 (35% of all pools) within the inventory that contained young of the year fry (combined steelhead / cutthroat). 9 of these pools (1.4% of all pools) exhibited densities between 1 and 2 fish / Sqm. Only 2 pools exhibited densities between 2 and 2.5 fish / Sqm. The highest densities observed in thousands of miles of RBA Inventory in Willamette basin and coast range streams for the 0+ age class generally hover around 3 fish / Sqm. The similarities observed in the Pudding basin to many other watersheds suggests that a value near 3 fish / Sqm is probably a good indicator that the reach is a productive spawning location for O.mykiss or cutthroat.

For coho, an extensive body of data exists that suggests that extremely high quality habitats can maintain average summer rearing densities in the range of 3.5 fish / Sqm. The Nickelson / Lawson Coho Production Model that averaged summer rearing densities across the full geographical range of the coastal coho ESU utilizes 1.7 fish/ Sqm meter of pool surface area as a value that represents habitats seeded to their summer carrying capacity. The pool densities observed in the Pudding system ranged between 0.002 and 10.3 fish / Sqm in 2014. The lowest value documented in the lower mainstem of Butte Cr and the highest value observed in Side Channel B of Little Abiqua Cr.

Spawning Location

The approximate location of coho or steelhead spawning events can often be observed by noting the presence of a distinct spike in rearing density of the 0+ age class that trails off rapidly just upstream. The physical location of a spawning destination has a range of variance plus or minus 4 pools due to the 20 percent sample methodology. Because the quality or quantity of spawning gravel can be a seasonal habitat limitation for salmonids (especially coho and steelhead), it is informative to describe not only the range of distribution of the 0+ age class but the peak zones of abundance which are indicating the presence of functional spawning beds. This information assists in guiding restoration prescriptions designed to accumulate spawning gravel to the zone where success is most likely to be achieved.

Adult and Juvenile Barriers

Adult migration barriers for anadromous salmonid species are verified by determining that no juvenile production is occurring above a given obstruction (culvert, falls, debris jam, beaver dam, etc.). There are many barriers, both natural and manmade, that impact the migration of salmonids. Some are definitive barriers that are obvious obstructions (such as bedrock falls). Many barriers however, only impede adult salmonid migrations during low flow regimes. Summer juvenile inventories allow us to definitively quantify whether passage was obtained at any point during the previous season of adult migration.

Juvenile salmonids typically migrate upstream for a variety of reasons (temperature, winter hydraulic refuge, food resources). Hydraulic refuge and food resources are typically fall, winter and spring migrations that would not be detectable during summer population inventories. Temperature however, is probably the most significant driver of upstream juvenile salmonid migrations during summer flow regimes. Potential juvenile barriers were subjectively determined based on the perception of the observer. The trend in juvenile density can be a method of detecting either partial or full barriers to upstream migration. Each of the surveyed reaches contains a comments section in the Access database to note the presence of culverts, jams and other physical factors that may influence the ability of salmonid populations to make full use of aquatic corridors.

Temperature Dependent Migrations

Potential temperature dependent migrations can be observed in the database by looking for densities that decrease significantly as the lineal distance increases from the mouth of the stream or tributary. This is more likely to be observed in low abundance years where tributary habitats that are seeded to capacity are the exception. During years of high abundance there is a more significant potential for density dependent upstream migrations that would be indistinguishable from the distribution pattern mentioned above. The recognition of this migration pattern allows us, during years of low escapement, to identify important sources of high water quality within the basin that may be traditionally overlooked because of some other morphological condition that suggests to us that there is no significant potential for rearing salmonids (i.e. lack of spawning gravel). These reaches typically exhibit declining densities with increased distance from the mouth and no indication of a spawning peak (a point near the upper distribution of the population with significantly higher rearing densities of the 0+ age class). These tributaries may be functioning as important summer refugia for salmonid juveniles

threatened by increasing temperatures in the mainstems. Several significant temperature dependent juvenile migrations were observed in the Pudding system in 2014. These migrations will be discussed within the document in each stream where the behavior is occurring.

Precautions

The specific location of spawning sites does not infer that the highest quality spawning gravels were targeted by adult salmonids or that there is any relationship between the location of a redd and the quality of the summer rearing habitat that exists adjacent to these locations.

The average densities that can be generated as an end product for each stream reach are the result of a 20 percent sample. Consequently, they probably vary significantly around the true average density. There are many sources of potential variation, start point, number of units sampled within the reach, surveyor variability, etc. The range of variability for at least one of these variables (start point), was documented in the final review of the 1998 Rapid Bio-Assessment conducted by Bio-Surveys for the Midcoast Watershed Council. To facilitate the proper utilization of the data included in this inventory, the 1998 results are included below. The true average density of a stream reach was retrieved by querying the database from an ODFW survey on East Fk. Lobster Cr in the Alsea Basin, where every pool was sampled (indicated as 100% sample frequency in table 1). Comparisons could then be made between the true average density and a randomly selected 20 percent sub sample (every 5th pool). Only mainstem pools were utilized within the range of coho distribution to match the protocol for the Rapid Bio-Assessment.

(Table 1): ODFW Lobster Creek Survey

SAMPLE FREQUENCY	AVG. COHO DENSITY	AVG. SH DENSITY	AVG. CUT DENSITY	AVG. 0+ DENSITY
100 %	1.07	.03	.04	.13
50 %	1.10	.04	.03	.14
20 % Start Pool 1	0.87	.04	.03	.13
20 % Start Pool 3	1.01	.03	.03	.13
20 % Start Pool 5	1.13	.05	.04	.12

General Observations

Pudding River System

During the summer of 2014, juvenile coho were the most abundant salmonid species rearing in pool habitats throughout the inventoried reaches of the four Pudding River sub-basins when all mainstem, side channel, and tributary habitats are combined. The total estimated pool abundance of juvenile coho was 20,053 (Table 2). Their distribution was widespread across all of the major sub-basins inventoried. Utilizing the season to season survival rates developed for coho by the Nickelson / Lawson Coho model, a back calculated estimate of 182 adult coho utilized the inventoried reaches to spawn (assuming a 1:1 male / female ratio). This was an estimated 1% of the total adult escapement of coho (18,636 adults) over Willamette falls and an unknown percentage of the total escapement to the Pudding basin (not all Pudding subbasins were inventoried). These estimates are presented as a minimum metric of adult abundance, they

are not meant to be a definitive accounting of escapement. The estimates also assume that the 4,111 jacks observed at Willamette falls were predominantly males. As a relative metric of productivity for coho, the highest densities of summer parr in the most functional 0.5 mile stream segments of Abiqua Cr (side channels included) was rearing 1982 fish/mile (avg. pool surface area 513 Sqm) and Butte Cr 921 fish/mile (avg. pool surface area 467 Sqm). The top coho producers were Davis Cr at 2543 fish/mile (avg. pool surface area 19.7 Sqm), and East Fork Drift Cr at 2450 fish/mile (avg. pool surface area 30.5 Sqm).

Steelhead abundance was low with an expanded estimate of 870 1+ age class and older individuals (table 2) observed in pool habitats for all of the inventoried subbasins combined (Table 2). Steelhead distribution was sporadic throughout most stream reaches. Steelhead were not observed at all in the Drift Cr sub-basin. Only 30 (expanded from a 20% sample, 6 observed) were estimated rearing in Silver Cr. This suggests that both Drift Cr and Silver Cr currently have no viable population of wild winter steelhead. 65% of all steelhead / rainbow were observed rearing in Butte Cr and 32% of all steelhead / rainbow were rearing in Abiqua Cr. Because both Butte Cr and Abiqua Cr also exhibited naturalized O.mykiss populations above their barriers to anadromy, all estimates of steelhead abundance in these systems should be considered completely suspect. Some unknown percentage of the observations classified as steelhead are the result of the headwater seeding of lower mainstem habitats from this residualized population of O.mykiss. Because the survey did not extend above Silver Cr falls, we were unable to verify the presence or absence of O.mykiss above the end of anadromy. However, it is likely that whatever historical stocking program that introduced O.mykiss into the headwaters of Abiqua and Butte Cr also included releases into Silver Cr. This suggests that the few observed steelhead / rainbow in the Silver Cr mainstem (30) were likely the progeny of this headwater residualized population of O.mykiss. As a relative metric of productivity for steelhead, the highest density of 1+ steelhead in the most functional ½ mile segment of Butte Cr was rearing 491 fish /mile (avg. pool surface area 283 Sqm) and for Abiqua Cr 242 fish / mile (avg. pool surface area 506 Sqm). Within the scope of this document all reference to steelhead, in text or tabular form, should be considered O.mykiss, life history and origin unknown.

Cutthroat abundance was low in most of the inventoried Pudding subbasins with an expanded estimate of 5266 documented (Table 2). It is important to recognize that unlike coho parr, steelhead and cutthroat are capable of rearing in fast water habitat types (rapids, riffles and cascades). Because these fast water habitat types were not sampled during this inventory, the observed numbers of steelhead and cutthroat do not represent any type of population estimate. These numbers can be used however as an effective tool for inter annual variation and trend analysis. In general, cutthroat numbers and densities increased above anadromous barriers due to a reduction in inter specific competition for food and rearing surface area. The highest densities of Cutthroat were observed rearing in headwater reaches in densities between the range of 0.8 – 1.0 fish / Sqm. (Likely near the full productive capacity of the habitat).

Chinook juveniles were observed in extremely low densities in Abiqua and Silver Cr. An expanded basin wide estimate of 42 fish (table 2) was documented in 2014. The observed numbers do not represent any type of population estimate because only a small percent of 0+ age chinook remain in tributary habitats of the Willamette to summer rear.

Rainbow trout were documented rearing above anadromous barriers in two sub-basins; Abiqua and Butte Cr. Their rearing densities and abundance were among the highest observed for O.mykiss within the inventory (these fish were enumerated separately from steelhead/rainbow in all of the summary tables). An expanded estimate of 2775 1+ age class and older individuals (table 2) were observed in pool habitats in the combined 10.8 miles of stream inventoried above Abiqua and Butte Cr falls. As a comparable metric of productivity above these two anadromous barriers, the most functional ½ mile segment of Abiqua Cr was rearing 822 fish / mile (avg. pool surface area 82 Sqm.) and Butte Cr 2331 fish / mile (avg. pool surface area 368 Sqm). Throughout the inventoried reaches above the anadromous barriers on Abiqua and Butte Cr the visual characteristics used for field identification of rainbow and cutthroat trout were observed merging. Widespread hybridization is occurring between the formally allopatric cutthroat and the introduced rainbow trout. The result of this hybridization is likely having detrimental effects on the previously isolated cutthroat trout populations. A review of this topic in the literature discovered that amongst west slope cutthroat trout, the risk of extinction from introgressive hybridization (namely the formation of hybrid swarms) has been recognized as a major consequence of non-native introductions in formally allopatric populations (Transactions of the American Fisheries Society 136:625,2007). Studies also indicate that in both critical swimming velocities and mirror-image stimulated aggression, where pure steelhead were the fastest swimmers and pure cutthroat were the most aggressive, the hybrid juveniles were faster than cutthroat and more aggressive than steelhead giving them a potential competitive advantage over both species (Hawkins and Quinn, 1996).

(Photo 1) Butte Cr hybrid

The high densities and abundance of rainbows above the anadromous barriers with no observable increase in abundance extending below the barriers is an unexpected observation. The following is a review of several possible scenarios that could result in this observable differentiation. The first is decreased genetic fitness in fish that navigate the falls. This could be due to the lack of competitive advantage exhibited by the introduced rainbows when challenged by anadromous fish populations below the falls where cutthroat and steelhead are historically sympatric. Second, are the differentiations in stream morphology above and below the falls, most notably stream gradient and pool surface area. In the six miles of stream habitat leading up to Abiqua falls the average pool surface area was 571 Sqm and the average gradient was 1.3%. In the inventoried reach above Abiqua falls the average pool surface area decreased to 123 Sqm and the gradient increased to 2.6%. With higher pool surface area, lower gradient, and the lack of adequate refuge in the form of wood complexity (as noted throughout mainstem reaches) the risk of avian predation increases dramatically. Sightings of merganser flocks and fecal fish remains were commonly documented in most mainstem stream reaches below the falls. Above the falls, where average pool surface areas are 78% smaller and stream gradients double, the risk of avian predation is decreased by higher water velocities giving more refuge to fish in turbulent pool heads. In addition, the reduction in open water for organized flock hunting combined with the higher gradient habitat above the falls describes more accurately the preferred habitat niche of O.mykiss when compared to the mainstem reaches below the falls. Similar morphological differences were also documented in Butte Cr. Third, there may be a temporal difference in

hybrid fry emergence from spawning events above the falls (later in the summer) that might facilitate the increased retention of the hybrid progeny near their natal spawning beds (less influenced by spring freshets).

In addition to the effects of the introduction of rainbow trout on the allopatric cutthroat populations, another concern might be the potential for out migrant hybrids to express an anadromous life history that could eventually result in cross spawning with wild winter steelhead adults. The level of this risk or extent of its effects within this watershed are unknown, though a number of studies have suggested that hybrid individuals are selected against in the marine life history stage, largely due to the observed lack of hybrid anadromous adults in nature (Campton DE, Utter FM (1985) Natural hybridization between steelhead trout (*Salmo gairdneri*) and coastal cutthroat trout (*Salmo clarki*) in two Puget Sound streams. Can J Fish Aquat Sci 42: 110–119.). Further investigation of hybrid smolt-to-adult survival is needed to determine whether or not the marine phase limits hybrid introgression.(Moore ME, Goetz FA, Van Doornik DM, Tezak EP, Quinn TP, et al. (2010): Early Marine Migration Patterns of Wild Coastal Cutthroat Trout (Oncorhynchus clarki clarki), Steelhead Trout (Oncorhynchus mykiss), and their Hybrids.

The lack of large wood complexity in all of the Pudding sub-basins and most of their tributaries is a missing fundamental building block of proper ecosystem function. The lack of wood complexity has resulted in the net transport of spawning gravels out of reaches exhibiting the optimum gradients for storing and sorting gravels to low gradient reaches where it is more likely to be burdened with silt and sediment (rendering it unusable for spawning). The lack of adequate refuge in the form of wood complexity exposes fish to increased predation further diminishing the habitats viability for rearing salmonids. A pervasive legacy of basin wide riparian conifer harvest has resulted in channel simplification (entrenchment, isolation from the historical floodplain, lack of roughness and a decrease in sinuosity).

Water quality issues within the pudding river drainage may also be limiting anadromous salmonid abundance and/or adversely affecting resident fish and aquatic food web relationships. The DEQ conducts assessments of water quality in Oregon to meet the federal Clean Water Act Sections 305(b) and 303(d) requirements and report on conditions in Oregon's surface waters. Water bodies where standards are not met are identified as water quality limited in their Integrated Annual Report and are assigned a status of either Category 4 or Category 5. Several listings were made for various reaches of the Pudding River mainstem as well as the four inventoried subbasins. The sub-basin listings will be further discussed in the Site Specific Observations. The Pudding River mainstem was sited with four Category 5 303(d) listings for: dissolved oxygen (10/15-5/15, RM 47.5-61.8); guthion (year round, RM 0-61.8); lead (year round, RM 0-35.4); and biological criteria (year round, RM 0-61.8). In addition, five Category 4A listings were made for: DDT (year round, RM 0-35.4); dieldrin (year round, RM0-35.4); dissolved oxygen (year round, RM 0-53.8 and 1/1-5/15, RM 0-47.5); iron (year round, RM 0-35.4); and temperature (year round, RM 0-61.8). These pollutants are known to affect resident fish, aquatic life, anadromous fish passage, and fish spawning. Failure to meet the minimum standards for these biological criteria suggests that insufficient water quality exists to support

aquatic species without detrimental changes in the resident biological communities (DEQ Water Quality Oregon's 2012 Integrated Report)**.**

A majority of the Pudding River sub-basins exhibit similar solar aspects and they also share a common geological foundation. The variety, order, and transition points of the geologic units intersected by the four inventoried subbasins of the Pudding River significantly influence and are critical to the discussion of how channel morphology effects fish abundance and distribution. Five of these geologic units will be referenced as brackets for discussion: (1) deep alluviums of unconsolidated sediments comprised primarily of sand, gravel and silt originating from numerous catastrophic ice age floods that inundated the Willamette valley along with lacustrine (lake) and fluvial (river) sources that comprise the lower mainstem reaches and their confluences with the Pudding River; (2) marine and /non-marine sedimentary rocks of the Scotts Mills Formation consisting of volcanic conglomerate, sandstones, mudstone, clay stone, and limestone; (3) landslide and debris flow deposits originating from a combination of steep terrain, rainfall, and earthquakes; (4) Columbia River Basalt flows commonly exposed in waterfalls and once blanketing the region; and (5) basaltic and andesitic lava flows of the western cascades (Molalla and Sardine Formations) which comprise a majority of the headwaters with exposures interspersed throughout.

The 4 inventoried sub-basins all share headwaters originating in the cascade foothills. These systems run in narrow parallel drainages with steep incised stream canyons separated by low flat divides. Lack of palmation in these drainages with predominately low summer flow and high gradient tributaries that originate on flat low elevation divides, naturally limit cold water flow contributions to mainstem stream reaches during the summer months. Inversely, these characteristics create high velocity winter flow events that aggressively scour mainstem stream channels of LWD and gravels, further diminishing salmonid spawning and rearing potential.

(Table 2)Expanded Estimates for 2014

Stream	coho	%	0+	%	Sthd	%	Cut	%	Chin	%	Rain	%
Abiqua mainstem	4164	21.8	1030	18.3	250	28.7	1385	26.3	20	47.6	1180	42.5
Side Channels A-R	2627	13.1	40				1		7	16.7		
Trib A	432	2.2	20				5					
Trib B	54											
Davis	2790	13.9	10				75	1.4				
Little Abiqua	756	3.8	170	3	25	2.9	580	11				
Side Channels A&B	162		5									
Trib A	6		30				15					
Brooks			30				50					
Abiqua Totals	**10991**		**1335**		**275**		**2111**		**27**		**1180**	
Butte mainstem	2418	12.1	3710	66.1	565	64.9	2115	40.2			1580	56.9
Side Channels A&B	104											
Trib A			30				10					
Coal			15				15					
Kirk			195	3.5			35				**15**	
Rhody			20				20					
Butte Totals	**2522**		3970		565		2195				1595	
Drift mainstem	2898	14.5	180	3.2			165	3.1				
Trib B	18											
East Fork Drift	1794	8.9	5				115	2.2				
Fox	240	1.2					10					
Drift Totals	4950		185				290					
Silver mainstem	1296	6.5	60	1.1	30	3.4	640	12.2	15	35.7		
Side channel A	294	1.5										
Trib A			35				15					
Jeff			30				15					
Silver Totals	**1590**		**125**		**30**		**670**		**15**			
Grand Total	**20053**		**5615**		**870**		**5266**		**42**		**2775**	

* Highlighted estimates represent the top 3 producers by species.

- Percent contributions are indicated for only those sub-basins that contributed greater than 1% of the total.

- 20% visual bias included for coho expansions

Site Specific Observations

Site specific observations within this document have been combined into the 4 primary subbasins represented in table 3. Following each major sub-basin heading, tributaries to that sub-basin are reviewed in alphabetical order. After each review is a summary table that lists that streams contribution to the subbasin by species.

These production estimates are based on an expansion of the 20% snorkel sample in pools only and therefore do not constitute an entire production estimate for the basin. These estimates greatly under-estimate the standing crop of 0+ (steelhead and cutthroat combined), 1 + and older steelhead, and 1+ and older cutthroat because a significant component of their summer population is rearing in riffle/rapid and glide habitats that were not inventoried. In addition, there

is also production for cutthroat that extends upstream beyond the end-point of most surveys. The information below can be utilized to establish a baseline for trend monitoring for subsequent survey years on the basin scale and by tributary. It also provides a comparison of the relative production potential between tributaries that can be utilized as a foundation for prioritizing restoration actions (some streams play a much more significant contemporary role for salmonid production than others, table 3).

(Table 3) Expanded Subbasin Estimates for 2014

Sub-basin	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%	Rain	%
Abiqua	10991	54.8	1335	23.8	275	31.6	2111	40.1	27	64.3	1180	42.5
Butte	2522	12.6	3970	70.7	565	64.9	2195	41.7			1595	57.5
Drift	4950	24.7	185	3.3			290	5.5				
Silver	1590	7.9	125	2.2	30	3.5	670	12.7	15	35.7		
Total	**20053**		**5615**		**870**		**5266**		**42**		**2775**	

- 20% visual bias included for coho expansions

Abiqua Sub-basin

The Abiqua drainage contained 28.3 miles (mainstem and tributaries combined) of inventoried stream habitat. The inventory included 19 side channels covering approximately 1.5 miles of habitat and four tributaries; Davis Cr, Little Abiqua, and Tribs A and B. The Abiqua system comprises 31% of the total miles inventoried in the Pudding basin. This system was the top producer of coho (54.8%) and chinook (64.3%) with the 2nd highest abundances of 0+ trout (23.8%), steelhead (31.6%), and cutthroat (40.1%). Expanded population estimates suggest an approximate adult escapement of 50 pairs of coho in 2013 to the Abiqua Cr sub-basin.

The Abiqua sub-basin intersects 5 geologic units along its course from headwaters to its confluence with the Pudding River: (1) deep unconsolidated alluvial sediments; (2) marine and /non-marine sedimentary rocks of the Scotts Mills Formation; (3) land slide and debris flow deposits; (4) Columbia River Basalt flows (CRB); and (5) lava flows of the western cascades (Molalla and Sardine Formations).

(Table 5) Expanded Abiqua Cr Subbasin Estimates

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%	Rain	%
Abiqua	**4164**	**37.9**	**1030**	**77.2**	**250**	**90.9**	**1385**	**65.6**	**20**	**74**	**1180**	**100**
Side Channel A	331	3	1						**7**	**25.9**		
Side Channel B	212	1.9										
Side Channel C	40											
Side Channel D	38											
Side Channel E	14											
Side Channel F	29											
Side Channel G	82		7									
Side Channel G1	589	5.4	4									
Side Channel H			2									
Side Channel I	300	2.7										
Side Channel J	1											
Side Channel K	100											
Side Channel L	13		2									
Side Channel M	47		6									
Side Channel N	65		3									
Side Channel O	265	2.4	15									
Side Channel P	30											
Side Channel Q	379	3.5										
Side Channel R	91											
Davis	**2790**	**25.4**	10				**75**	**3.6**				
Little Abiqua	**924**	**8.4**	**235**	**17.6**	**25**	**9.1**	**645**	**30.6**				
Trib A	432	3.9	20				5					
Trib B	54											
Sub-basin Total	**10991**		**1335**		**275**		**2111**		**27**		**1180**	

- Percent contributions are indicated for only those sub-basins that contributed greater than 1% of the total
- 20% visual bias included for coho expansion

Abiqua Cr Mainstem

The Abiqua mainstem inventory began at the confluence with the Pudding River and extended to approximately USGS RM 23. Anadromous fish distribution extends up to USGS RM 18.9 to Abiqua Falls (101 ft). Low salmonid abundance was documented throughout a majority of the inventory with the only stream habitats observed seeded to full capacity being those of side channels and the upper mainstem above the extent of anadromy where the progeny of an introduced rainbow trout population has displaced and hybridized with native cutthroat. A 17 mile reach from RM 3.3-20.3 was Category 5: Water quality Limited, 303(d) listed by the DEQ in 2012 for dissolved oxygen from September 1 thru June 15. This listing suggests an issue of limited water quality during critical spawning periods for coho, steelhead, and chinook and may be adversely affecting egg to fry survival.

(Photo 1) Abiqua Cr confluence with Pudding River

The first reach and geologic unit extends from the confluence up to approximately USGS RM 8 (just below the confluence with Powers Cr). This reach is comprised of deep alluviums. Floodplain interaction, channel braiding, and well sorted gravel were documented throughout this reach. These are the terraces and floodplains currently adjacent to the majority of the sub-basin's agricultural interests. Numerous noxious weeds, invasive fish and amphibians were documented throughout this reach and above. The confluence with the Pudding River (Photo 1) is broad and braided across a wide gravel floodplain. The first 3.8 stream miles was characterized by low gradient (avg. 0.3%), warm water, an entrenched active channel, and a thin riparian buffer composed of primarily deciduous species. Silt deposition on gravel tailouts was also the norm. Steelhead, cutthroat and coho showed intermittent pool presence in low densities. Coho were observed seeking thermal refugia in groundwater seeps and cold hyporheic flows accumulating in shallow alcoves at the heads of some pools.

The next 5.1 stream miles of this reach exhibited a significant increase in fish production along with an increase in stream shading (wider deciduous buffer), gradient (avg. 0.64%), and off channel habitat (side channels A-F). Of the Abiqua mainstems estimated total for each fish

species (side channels included) within the range of anadromy, this 5.1 mile reach was rearing 35.2% of the coho parr at 431fish/mile, 100% of the chinook parr, and 18.3% of the cutthroat at 18 fish/mile. Very few steelhead or 0+ trout were documented in this reach. Side Channels A and B exhibited high rearing densities with Side Channel A peaking at 2.8 fish/Sqm and Side Channel B at 3.6 fish/Sqm. Both had significantly higher abundances than the adjacent mainstem habitats. Side Channel A entered at USGS RM 4 and extended 645 ft (7 pools). Beaver activity was documented in Side Channel A. Its location, entering just above the most severely temperature limited reach and the accumulation of salmonid juveniles observed within the side channel suggest it was a final destination for obtaining thermal refugia from the mainstem. Side channels B, C, D, E, and F all enter between USGS RM 6.4 and 7. Side Channel B extended 385 ft (5 pools) isolated from the mainstem flow. Side channels C, D, E, and F were no more than one pool each. Davis Cr enters within this reach at USGS RM 6.5 and is a primary source of the nomadic coho parr attempting to utilize the lower mainstem habitats of Abiqua Cr. In a sense, there are two isolated concentrations of coho production (Figure 1), the abundance in the lower system being driven by the successful spawning occurring in Davis Cr.

The next reach, comprised of Scotts Mills Formation sedimentary rocks, extends from approximately USGS RM 8-13. This reach was characterized by a lack of sorted gravel, lack of wood complexity, channel confinement, bedrock/boulder dominated substrate, and transition to a primarily coniferous riparian zone. The average gradient was 1.1%. This reach exhibited a dramatic decline in coho production rearing less than 1% of the mainstem total at 11 fish/mile. The decline was also observed for cutthroat with just 6.4% of the mainstem total rearing in the same length of stream as the previous reach (9 fish/mile). Steelhead numbers increased but densities were very low (16% of the mainstem total) at 10 fish/mile. Powers Cr enters at USGS RM 8.2 colder than the mainstem with no coho or steelhead observed utilizing its pool habitats. Alder Cr enters at USGS RM 9 warmer than the mainstem with a10ft bedrock cascade above the first pool a permanent anadromous barrier and a surface spilling reservoir not far above. The dam and fish ladder at USGS RM 10.5 on the mainstem of Abiqua Cr did not appear to impede either adult or juvenile fish passage.

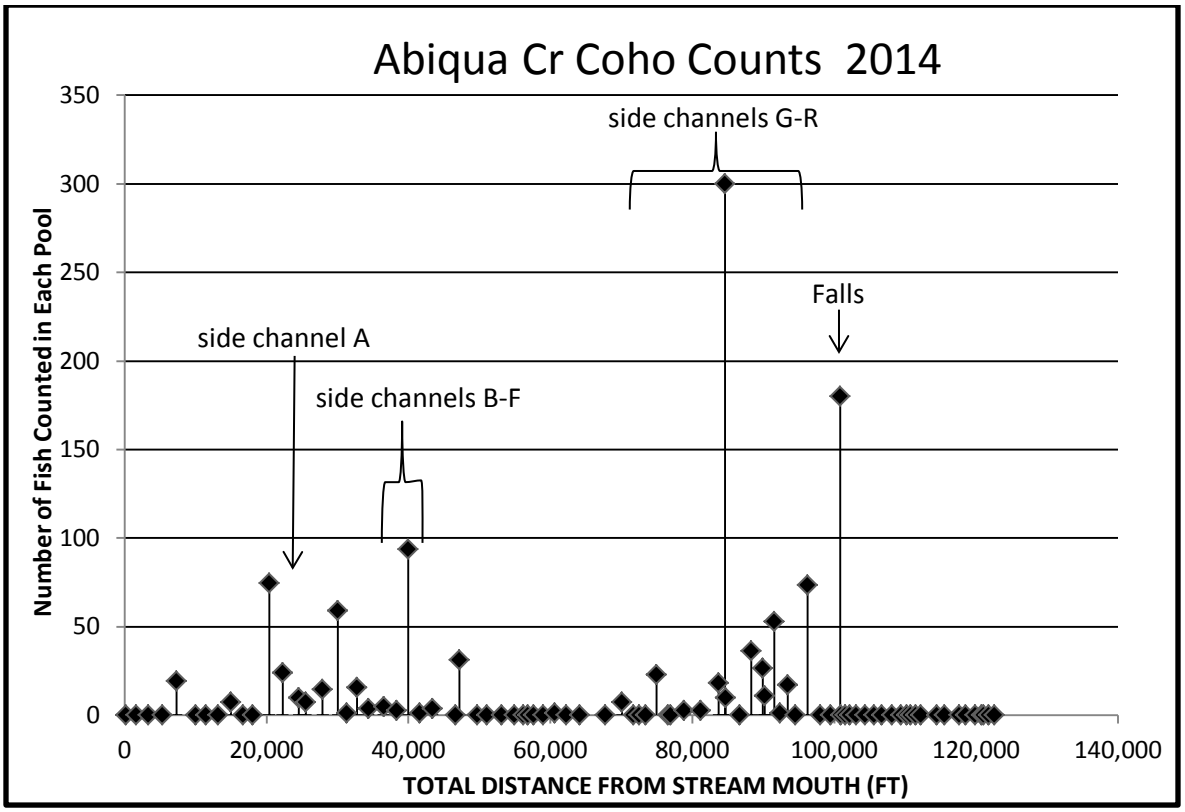
(Photo 2) Dam with fish ladder

Above USGS RM 13 the incised stream canyon and the hillslope confinement that characterized the reach of Abiqua Cr within the Scotts Mills Formation transitions to landslide/debris flow deposits. This 3rd reach begins with a transition described by a significant canyon pinch point that influences the next 0.5 miles. This pinch has allowed for the development of a broad alluvial plain with deep accumulations of mobile bedload. Above this short reach is a combination of intermixed basalt and andesite flows of the Molalla Formation to the south, landslide/debris flow deposits to the north and exposures of the Scotts Mills Formation in the lower half. The reach from USGS RM 13-18.9 exhibited an increase in floodplain width, increase in channel sinuosity, and an expansion in the abundance of off channel habitat types (side channels G-R). The average gradient was 1.4%. Salmonid production peaked within this reach. Of the Abiqua mainstems total for each salmonid species (side channels included), within the range of anadromy: 62.2% of coho parr (716 fish/mile); 78% of steelhead (33 fish/mile) 1+ and larger; 87.9% of 0+ trout parr (68 fish/mile); and 68% of cutthroat (64 fish/mile) were observed rearing within this reach. Coho densities peaked at USGS RM 15.5 at 1.5 fish/Sqm in a non-random pool. Steelhead densities peaked in the same pool at 0.2 fish/Sqm. Cutthroat densities within the range of anadromy also peaked in this pool at 0.16 fish/Sqm. A large root wad/log/debris jam was lodged at the head of this deep plunge pool against a basalt outcropping.

This pool was a supplemental sample pool (non –random) because it exhibited a high level of wood complexity (unique amongst Abiqua mainstem pool habitats). This pool may represent the potential rearing capacities of mainstem pool habitats with adequate cover and complexity.

Three tributaries enter within this 5.9 mile reach; Trib A at USGS RM13.5 with a cold water contribution and evidence of upstream temperature dependent migrations for thermal refugia (3.7 fish/Sqm in the 1st pool); Little Abiqua Cr at USGS RM 14.3 entering side channel J will be discussed further in following text and Trib B at USGS RM 15.1 which functions more as a mainstem side channel (54 coho in the first pool) as it traverses the Abiqua floodplain and before gradients increase that provide limited salmonid rearing potential.

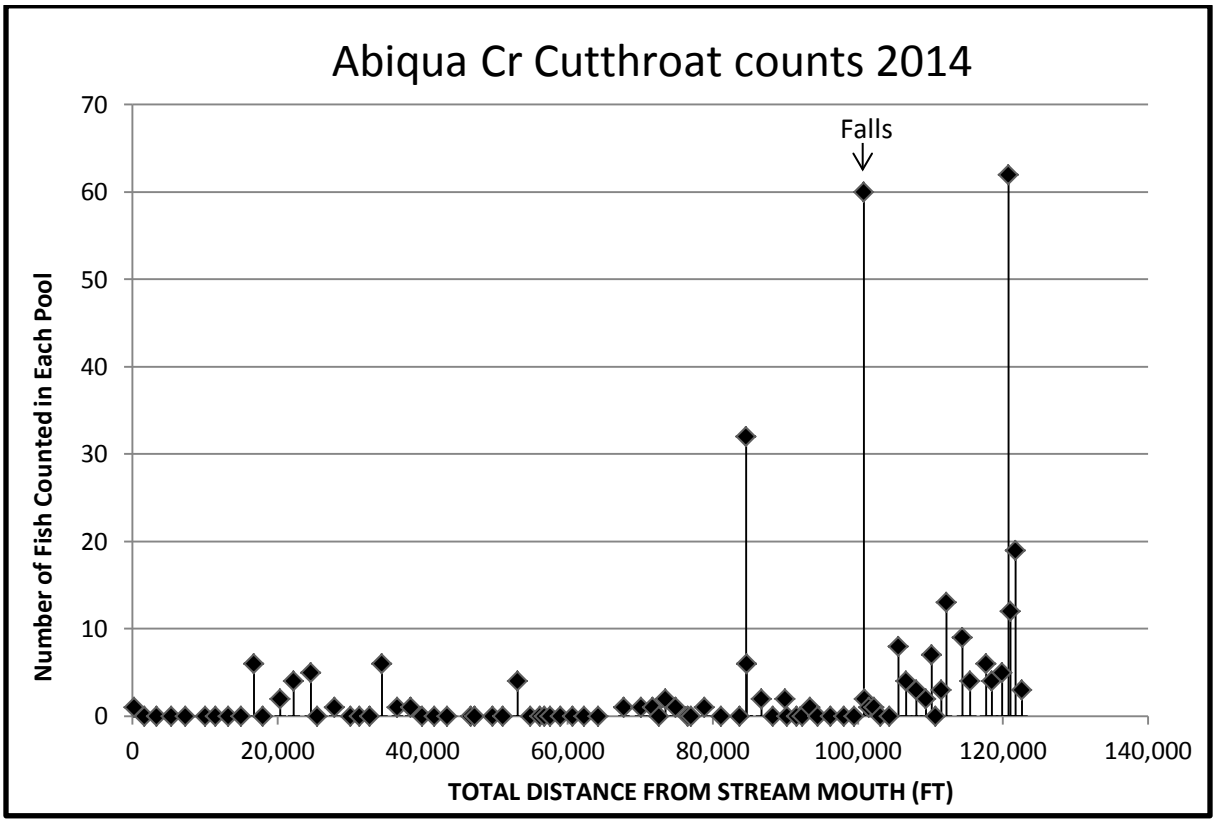
In the last 1.2 miles of habitat below Abiqua falls the canyon tightens restricting channel meander. Salmonid abundance declines in this last mile leading to the deep plunge pool below the 101 ft. columnar basalt intrusion at USGS RM 18.9. In this pool, the highest counts of steelhead, cutthroat and 0+ trout (within the range of anadromy) were documented along with the second highest pool count for coho parr. Confidence in the steelhead count in this pool is low due to the high likelihood of the intermixing of introduced resident rainbow from above the falls and the surveyor's inability to distinguish between the two. (Figure 1)



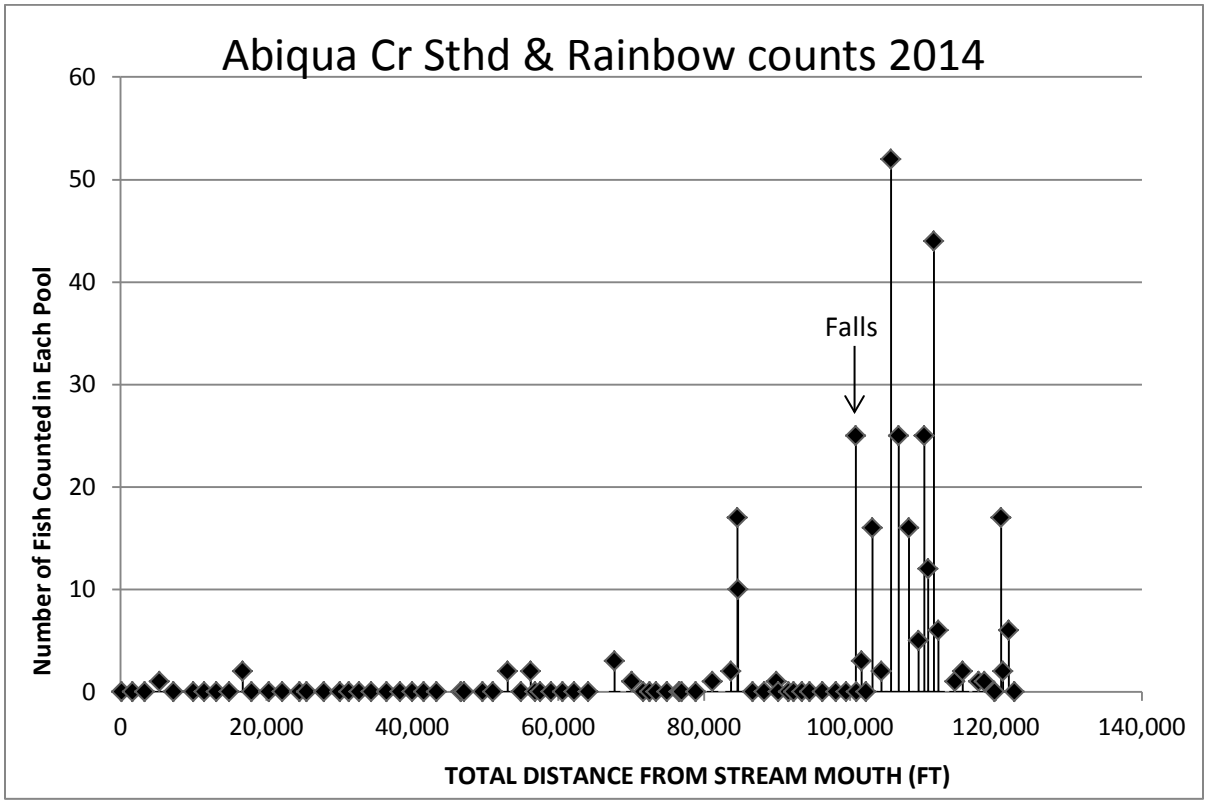
Side channel habitats were consistently rearing high densities of coho parr. Most of the side channels exhibited cold hyporheic flow with pools isolated from mainstem summer flows (evidence of an upstream winter linkage). Within this six mile reach of mainstem (USGS RM 13-

19), 0.94 miles of side channel habitat was documented rearing 46.4% of all coho parr in the reach. Very few cutthroat, steelhead, or 0+ trout were observed rearing in side channel habitats. The top three coho producers were; G1, I, and Q. Side channel G1 enters at USGS RM 13 just above the geologic unit transition from Scotts Mills Formation to landslide/debris flow deposits. G1 was the longest (0.23 miles, 16 pools) of all the inventoried side channels and exhibited both the highest spawning and rearing potential. An estimated 589 coho parr were documented in G1 with an average rearing density of 1 fish/Sqm and a peak density of 2.4 fish/Sqm. Side channel I enters at USGS RM 13.7 and extends 455 ft (8 pools). In side channel I an estimated 300 coho parr with an average density of 1.5 fish/Sqm and a peak density of 2.3 fish/Sqm was observed. Side channel I was observed disconnected from mainstem flow with cold, isolated pools during peak summer temperature and the lowest flow profiles. Side Channel Q enters at USGS RM 17.5 and extends 695 ft (6 pools). In side channel Q an estimated 379 coho parr with an average density of 3.5 fish/Sqm and a density peak of 4.3 fish/Sqm was documented. Side channel Q was also observed disconnected from mainstem flow with isolated pools fed by cold hyporehic flows.

(Figure 2)



(Figure 3)


Abiqua Cr Sthd & Rainbow counts 2014
Number of Fish Counted in Each Pool
60
50
40
30
20
10
0
Falls
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
TOTAL DISTANCE FROM STREAM MOUTH (FT)

(Photo 3) Rainbow/Cutthroat hybrids

Above Abiqua Falls, which marks the geologic unit transition to CRB's, average gradient increases to 3.3% as the channel passes through a tight basalt gorge and over two more falls (20 ft and 15 ft). This resulted in a totally scoured stream channel, bedrock/ boulder dominated substrate and limited salmonid rearing. Rainbow trout were observed in this reach (above the extent of anadromy) in low densities. These morphological characteristics extend just less than a mile to a point just above the confluence of Homestead Cr where the average gradient decreases to 2.2% and both the canyon and floodplain widen to exhibit increased channel braiding and sinuosity. Rainbow trout densities peaked in this reach at USGS RM 19.7 at 0.9 fish /Sqm. The average pool rearing density for rainbow trout above the falls was 0.18 fish/Sqm and for cutthroat 0.1 fish/Sqm. Rainbow counts remained high and dominant over cutthroat for the next 1.2 miles rearing 727 fish/mile with cutthroat at 22 fish/mile. Over the remaining 2 miles of the inventory rainbow abundance decreased to 90 fish/mile as cutthroat abundance increased to 343 fish/mile. Cutthroat densities peaked at 0.5 fish/Sqm at USGS RM 22.4 with a peak count of 62 fish / pool (Photo 4). Over the last half mile of the inventory average gradient increases to 3.1% with a bedrock/boulder dominated substrate. 0+ trout were observed at 140 fish/mile with peaks in abundance mirroring rainbow trout.

(Photo 4)

Year	Coho	Avg coho/Sqm	0+	Sthd	Cut	Chin	Rainbow
2014	4164	0.1	1030	250	1385	20	1180

Little Abiqua Cr

Little Abiqua Cr enters into side channel J at USGS RM 14.3 (Photo 5). The inventory extended 3.4 miles and included two tributaries; Trib A and Brooks Cr exhibiting limited anadromous potential and two side channels; A and B. Anadromous fish distribution extended 1.6 miles where a 5 ft sill log in a narrow bedrock pinch with no jump pool below (Photo 6) is an ephemeral terminus of fish passage for both adults and juveniles. Little Abiqua was noted as a cold water contribution with coho parr densities exhibiting patterns of upstream juvenile migration from the Abiqua mainstem. The first 4 miles of Little Abiqua are currently listed as Category 5: Water Quality Limited, 303(d) listed for dissolved oxygen from October 15- June 15 (spawning). This may be adversely affecting egg to fry survival for both coho and steelhead.

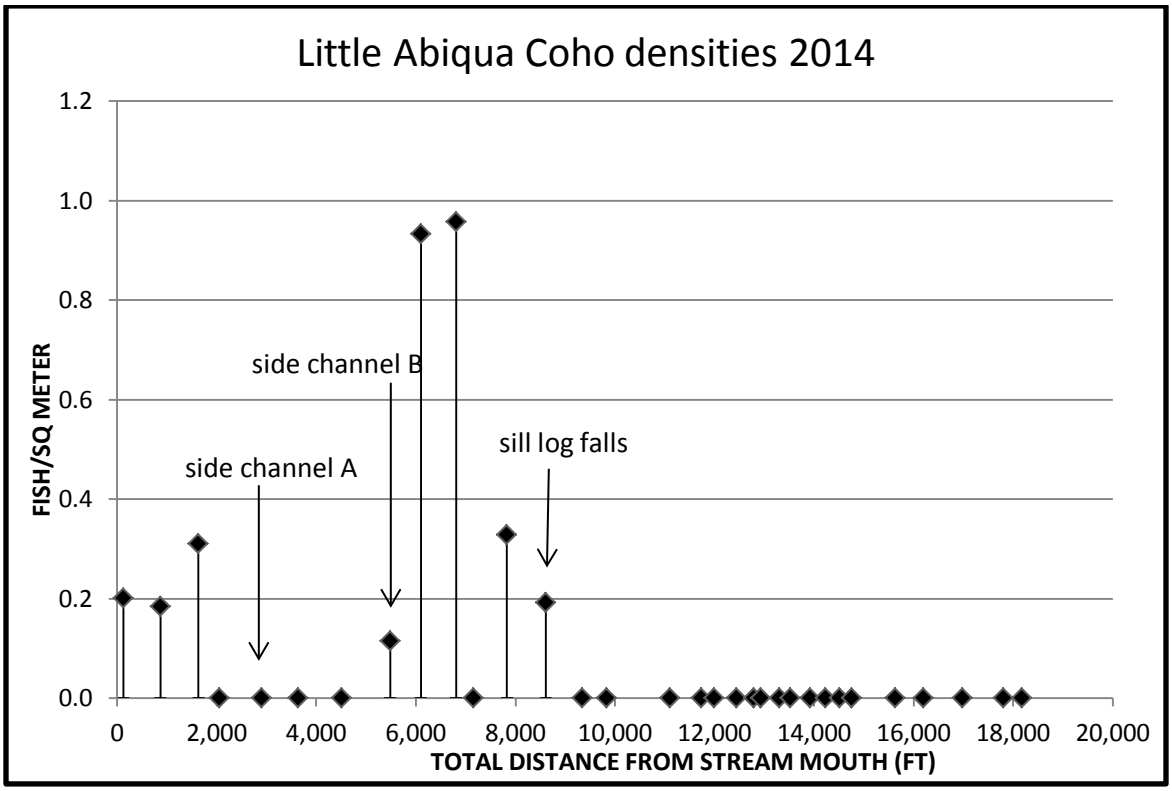
The first 1.3 miles of the inventory were characterized by low interactive floodplains, channel braiding, gravel sorting in pool tailouts, an average gradient of 3.3%, with a mixed coniferous/deciduous canopy. Wood complexity was present in a few pools, but largely absent. Above anadromous fish distribution the average gradient increases to 3.7%, canyon confinement here limits floodplain potential for the provision of winter habitat, and substrates consisted of bedrock, boulder, and cobble with unsorted gravels. No salmonids were documented in mainstem pool habitats from RM 0.3- RM 1. One dead cutthroat and one dead juvenile steelhead were observed in this reach.

(Photo 5) Confluence of Little Abiqua into side channel J

Coho densities were low throughout most of the mainstem habitats with a spawning peak at RM 1.3 of 0.96 fish/Sqm and an average density of 0.4 fish/Sqm. Side channels A and B were documented rearing 17.5% (162 coho parr) of all Little Abiqua coho parr. Side channel A entering at RM 0.55 had a peak coho density of 9.9 fish/Sqm and consisted of two cold pools of hyporheic flow with connectivity for migration at the bottom and dry at the top (isolating it from warmer mainstem flows). Coho parr were absent in the adjacent mainstem pools. Side channel B entering at RM 1 had a peak density of 10.3 fish/Sqm. This is an extraordinarily high density and the highest recorded in all four Pudding sub-basins. Side channel B consisted of three pools with connectivity at both top and bottom and no noticeable temperature differential from the

mainstem. With no temperature limitation existing in the mainstem, it is unlikely that the high side channel densities are due to fish migration in search of thermal refugia, rather the habitats in side channel B were likely the spawning destination of adult coho. Expanded population estimates suggest an estimated adult escapement of 4 pairs of coho in Little Abiqua Cr.

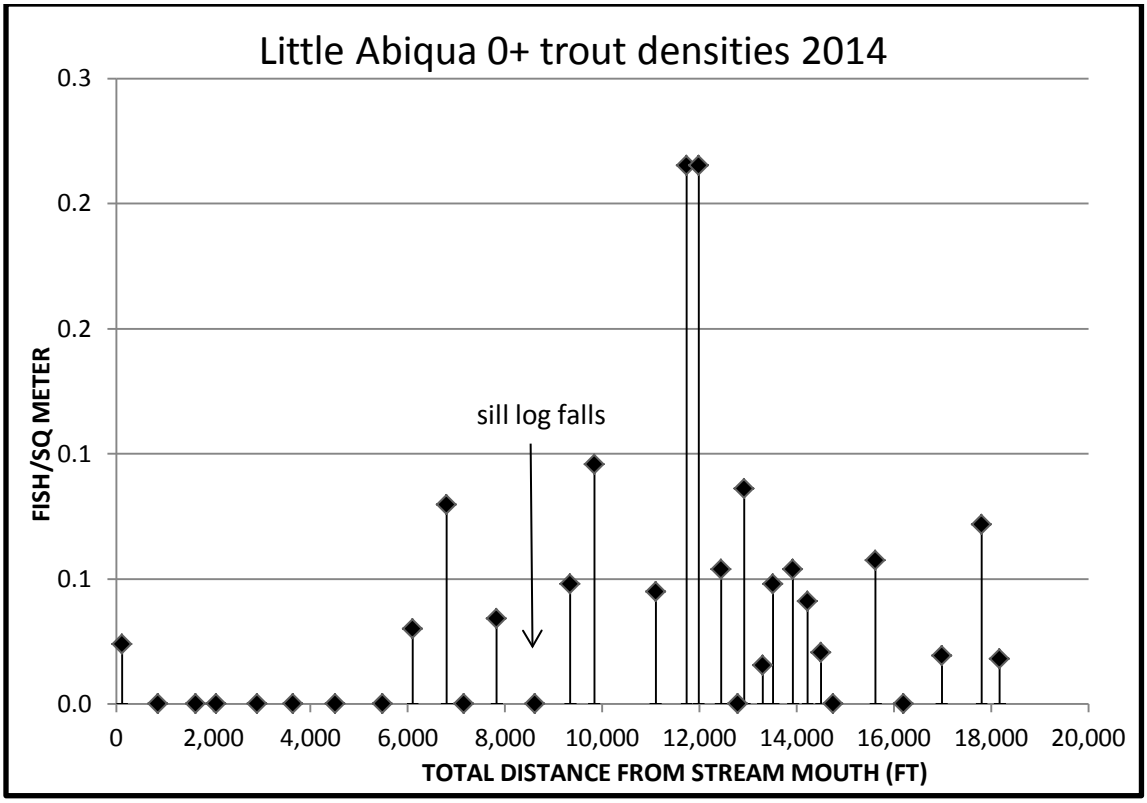
(Figure 4)



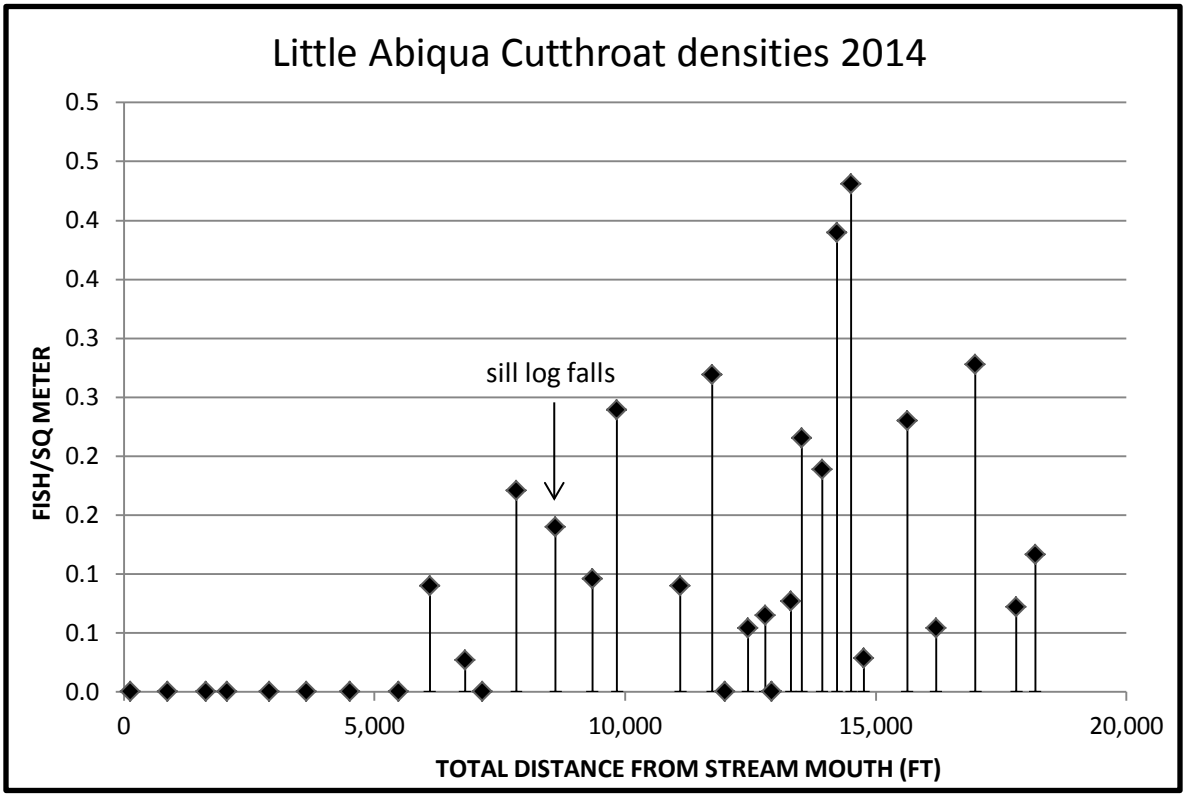
(Photo 6) Little Abiqua end of anadromy

Steelhead abundance was low and distribution intermittent with presence documented in only 2 of 13 pools to the end of anadromy. Cutthroat abundance was also low throughout the range of anadromous fish distribution (54 fish/mile) but exhibited a significant increase above the end of anadromy (290 fish/mile) with a peak density of 0.4 fish/Sqm at RM 2.75 and an average pool density of 0.15 fish/Sqm above anadromy (full seeding of fully functional habitat without intra specific competition near 0.7 fish/Sqm). White fungus was reported on cutthroat in the reach. 0+ trout abundance was low with distribution trends mirroring those of cutthroat (low in the range of anadromy and increasing above) and a density peak of 0.2 (well below normally observed full seeding at 3.0 fish/Sqm) at RM 2.3.

(Figure 5)



(Figure 6)



Year	Coho	Avg coho/Sqm	0+	Sthd	Cut	Chin	Rainbow
2014	924	0.4	235	25	645	0	0

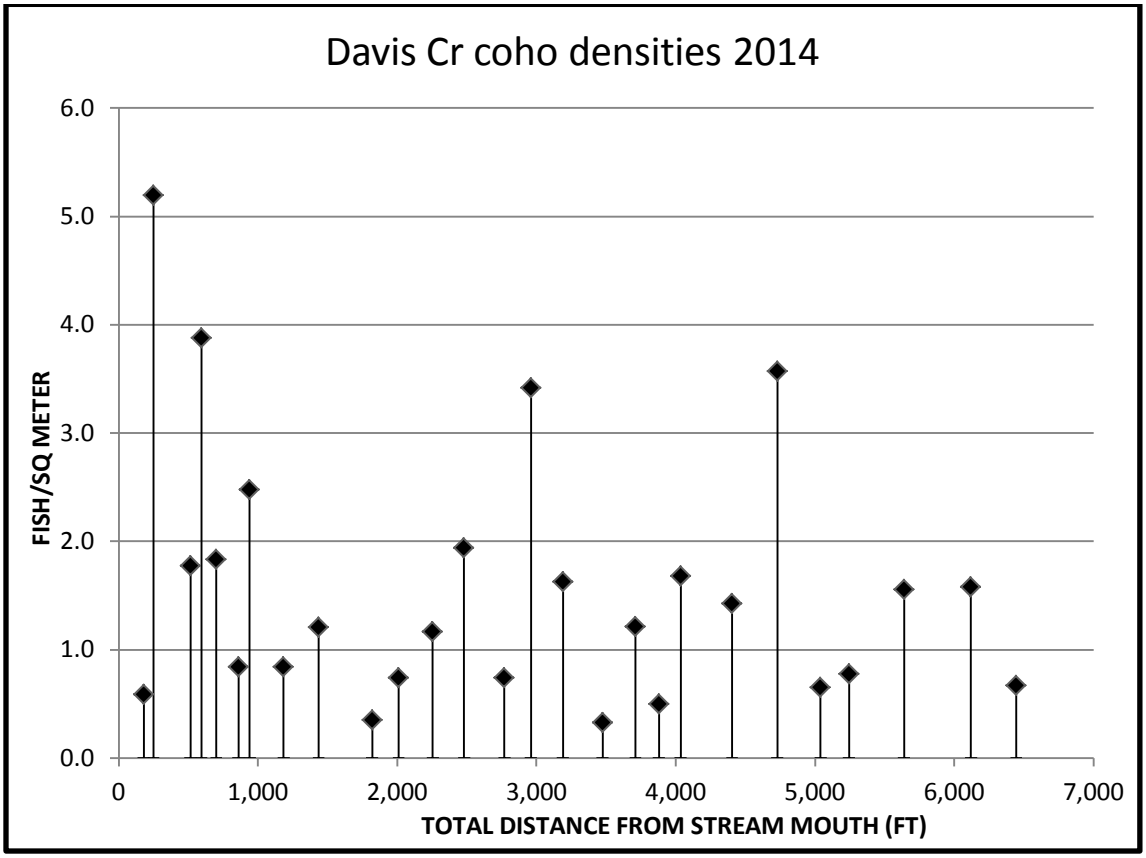
Davis Cr

Davis Cr enters mainstem Abiqua at USGS RM 6.9. The inventory extended 1.2 miles where the lack of landowner consent terminated further access. Anadromous potential extends above the end of the inventory reach. The average gradient was 1.8%. A narrow deciduous riparian buffer was documented throughout the inventory.

(Photo 7) Exposed Davis Cr channel

Davis Cr was a top producer of coho in the Abiqua sub-basin in 2014 rearing 25.4% of all coho parr at 2325 fish/mile in 5% of the total stream miles available to anadromous spawners. Davis Cr enters the mainstem as a cold water contribution. Coho appear to be utilizing Davis Cr as both cold water summer refugia from the mainstem and as a winter spawning destination. The peak coho density of 5.2 fish/Sqm and peak count of 217 was documented in a non-random pool just above the confluence. A secondary coho spawning peak of 3.6 fish/Sqm was observed at RM 0.9. The average coho density of 1.6 fish/Sqm represents a well seeded system. Expanded population estimates suggest an estimated adult escapement of 13 pairs of coho in Davis Cr. White growths (fungus) were reported on the fins of both coho and cutthroat trout.

(Figure 7)



Cutthroat and 0+ trout abundance was low. Cutthroat presence was observed in 39% of the pools with an average density of 0.1 fish/Sqm. 0+ trout parr were observed in 7% of the pools. Steelhead were not observed in Davis Cr.

Three juvenile barriers were observed in the first 0.25 miles of the inventory. The first, 600 ft above the confluence, is a culvert perched 5 in. and rusted out. Most of the summer flow was observed passing through the floor of the culvert. The second, 860 ft. above the confluence, is a 1 ft. bedrock falls. The third (Photo 8), 1185 ft. above the confluence, is a culvert perched 8 in. with some flow observed passing through the floor.

(Photo 8) 2nd culvert 8 in. perch

Year	Coho	Avg coho/Sqm	0+	Sthd	Cut	Chin	Rainbow
2014	2790	1.6	10	0	75	0	0

Butte Cr Sub-basin

The Butte Cr drainage contained 30.8 miles (mainstem and tributaries combined) of inventoried stream habitats. The inventory included two small side channels and assessed the potential of four tributaries; Coal Cr, Kirk Cr, Rhody Cr, and Trib A. This sub-basin comprised 33.7% of the total miles inventoried in the Pudding basin. The Butte Cr. sub-basin was the top producer of steelhead (64.9%), cutthroat (41.7%), and 0+ trout parr (70.7%), while only accounting for 12.6% of coho parr. This is likely due to lack of viable tributaries below the falls for spawning destinations and limited side channel habitat in the lower mainstem where the

majority of the population was observed summer rearing. Expanded population estimates suggest an estimated adult escapement of 12 pairs of coho into the Butte Cr sub-basin in 2014.

The headwaters of Butte Cr drain Rhody Lake and the 3 Butte lakes within the High Lake Recreation Area. There is approximately 34.5 river miles to its confluence with the Pudding River at USGS RM 20. Along its course it intersects 5 geologic units: deep unconsolidated alluvial deposits: Scotts Mills Formation sedimentary rocks; Columbia River Basalt flows; and basaltic and andesitic lava flows of the western cascades (Molalla and Sardine Formations).

(Table 6) Expanded Butte Cr Sub-basin estimates 2014

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%	Rain	%
Butte	2418	95.9	3710	93.5	565	100	2115	96.4			1580	99.1
Side Channel A	30	1.2										
Side Channel B	74	2.9										
Coal			15				15					
Kirk			195	4.9			35	1.6			15	
Rhody			20				20					
Trib A			30				10					
Totals	2522		3970		565		2195				1595	

Butte Cr Mainstem

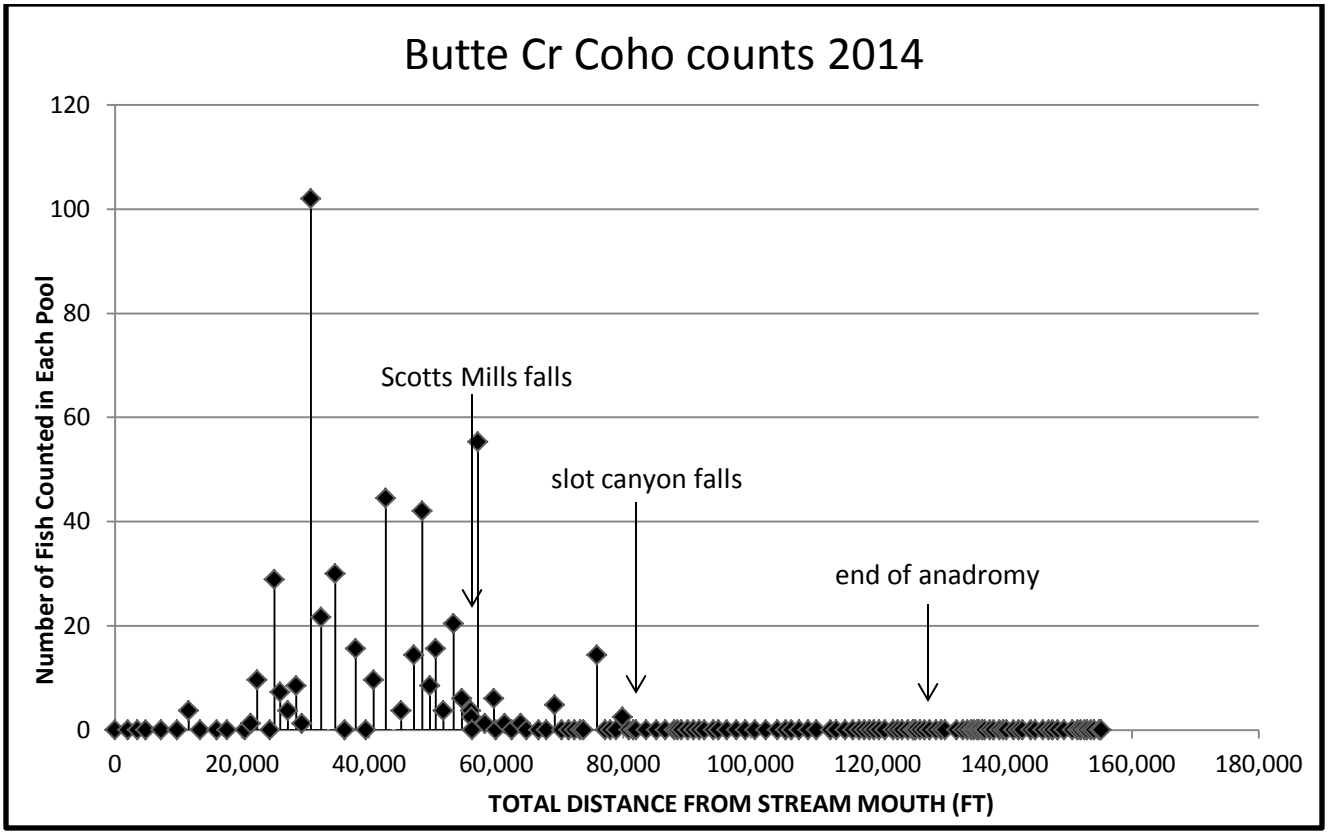
The Butte Cr mainstem inventory began at USGS RM 3.5 and extended to USGS RM 33.4 (0.4 miles above Rhody Cr). The inventory did not extend downstream to the confluence with the Pudding River due to poor visibility and the lack of salmonid presence. The lower mainstem is likely valuable overwintering habitat but high summer temperature profiles limit summer rearing potential. Anadromous fish distribution extended to Lower Butte Cr falls a 20 ft. basalt intrusion at USGS RM 26.4. Several water quality concerns for Butte Cr. were documented in DEQ's 2012 Integrated Report and 303(d) list. These included: a Category 5: Water Quality Limited, 303(d) listing for dissolved oxygen for the spawning criteria from RM 0-6.8 from January 1-June 15 and RM 11.9-16.9 from September 1-June 15; a Category 4A: Water Quality Limited listing for year round (non-spawning) temperature (core cold water habitat) from RM11.9-35.6; and a Category 5: Water Quality Limited, 303(d) listing for Bio criteria affecting aquatic life year round from RM 0-19.

The first reach of stream habitat and geologic unit extends from the confluence with Pudding River to approximately USGS RM 11.5. This reach of deep alluviums comprised 9.4 miles (28.1%) of the inventory. The first 2.6 miles (USGS RM 3.5-5.5) of stream habitat was characterized by a narrow or absent deciduous riparian buffer enabling high solar exposure in the aquatic corridor, a deeply incised active channel often stabilized with riprap, silt dominated

substrate with deposition and embedment on gravel tailouts, proliferation of noxious weeds and invasive fauna, high summer temperature profiles and an average gradient of 0.14%. An expanded estimate of 18 coho were the only salmonids observed in this 2.5 mile section. The next 6.8 miles of this unit exhibited: an increase in average gradient (0.64%); increased floodplain interaction and channel braiding; cobble/ boulder riffles with gravel sorting in pool tailouts; and more effective stream shading with an increase in riparian buffer widths. Side channels A and B enter within this reach offering a few small pools of thermal refugia. This 6.8 mile reach comprised 28.9% of the inventoried Butte Cr mainstem within the range of anadromy and was documented rearing 72.2% of all coho parr (268 fish/mile), 11.5% of all steelhead (10 fish/mile), 7.2% of all cutthroat (16 fish/mile), and very few 0+ trout. The peak pool count for coho in the sub-basin of 102 coho was observed at USGS RM 7.7 (Figure 8).

(Photo 9) Butte Cr mainstem habitat

(Figure 8)



The second unit, sedimentary rock of the Scotts Mills Formation, extends from approximately USGS RM 11.5 to the 10 ft. Basalt falls at the old mill site in Scotts Mills at USGS RM 12.9. This reach exhibited an increase in average gradient to 1.7%. The stream channel within this reach was almost exclusively scoured to bedrock (Photo 10) and confined by deep entrenchment with a narrow deciduous riparian buffer enabling extensive solar exposure. This 1.4 mile reach exhibited an increase in steelhead production rearing 43.4% of the sub-basin total at 175 fish/mile with a peak density of 0.17 fish/Sqm at USGS RM 12.8. Cutthroat production also increased with 9.2% of the sub-basin total observed within the range of anadromy at 96 fish/mile. Coho production remained steady rearing 11.2 % of the sub-basin total at 202 fish/mile. The increase in fish production within this reach is not a reflection of high quality juvenile rearing habitat or an increase in spawning potential, but rather its location below a barrier to upstream juvenile migration within a temperature limited reach lacking adequate thermal refugia.

(Photo 10) Scoured channel below Scotts Mills falls

(Photo 11) Scotts Mills falls

The falls in Scotts Mills is the first definitive barrier to upstream juvenile migration with a dysfunctional fish ladder/diversion around the falls. The diversion, (a relic of the historic mill operation and not a dedicated fish ladder) is impassable during summer flows when juveniles are seeking access to thermal refugia higher in the mainstem. The falls does not function as a definitive barrier to adult passage (coho were observed above) but the distribution of coho suggests that as few as just 2 pairs of spawning adults successfully negotiated the falls and its associated bypass channel to spawn. The observed distribution of coho parr in 2014 exhibited 82% of all coho rearing below the falls. Because coho adults are known to migrate into headwater reaches and tributaries for spawning, the observed distribution suggests that complications for adult passage may exist at the Scotts Mill dam and bypass channel.

Another probable juvenile barrier during summer flow regimes was observed as a 1.5 ft bedrock falls 225 ft. below the Scotts Mill dam. In the pool below this 1.5 ft. falls a few older age class 3+ steelhead (or resident O.mykiss) were observed. In the pool above this 1.5 ft falls, the peak pool density for Butte Cr steelhead was observed. The large plunge pool below the falls

at Scotts Mill was a deep turbid pool with a high cutthroat count that likely underestimated its actual occupancy (poor visibility due to depth and turbidity from swimmers). The higher steelhead densities in the lower quality pools below the falls may be due to fishing pressure localized at the falls.

The Scotts Mills falls marks a geologic unit transition to Columbia River Basalts. This unit extends approximately 1.8 miles and a return to Scotts Mill's formation intermixed with basalt and andesite extends to approximately USGS RM 22. Average stream gradients decreased to1.2% above the falls. Coho densities peaked just above the falls (USGS RM 13) at 0.44 fish/Sqm. A decrease in coho abundance was observed throughout the remaining 4.7 miles of coho distribution. Steelhead production remained high over the next mile of stream habitat above the falls rearing 25.7% of the sub-basin total at 145 fish/mile before a marked decrease in production was observed in the next 5 miles of the inventory to USGS RM 19. Cutthroat abundance was also low throughout this reach with intermittent pool presence from USGS RM 13.6 to USGS RM 18.5. 0+ trout abundance remained well below seeded densities throughout the extent of the inventory. This reach of stream habitat exhibiting extremely low salmonid use was characterized by a bedrock/boulder dominated substrate, channel confinement, and the absence of wood complexity (Photo 12). Surveyor's notes repeatedly mention merganser sightings and fecal remains of fish consumption throughout this reach. Avian predation is likely responsible for a significant decrease in summer fish production in this reach. Several deep pools were documented in this reach as having refugia potential. A few large cutthroat and one wild resident rainbow trout were observed in these pools.

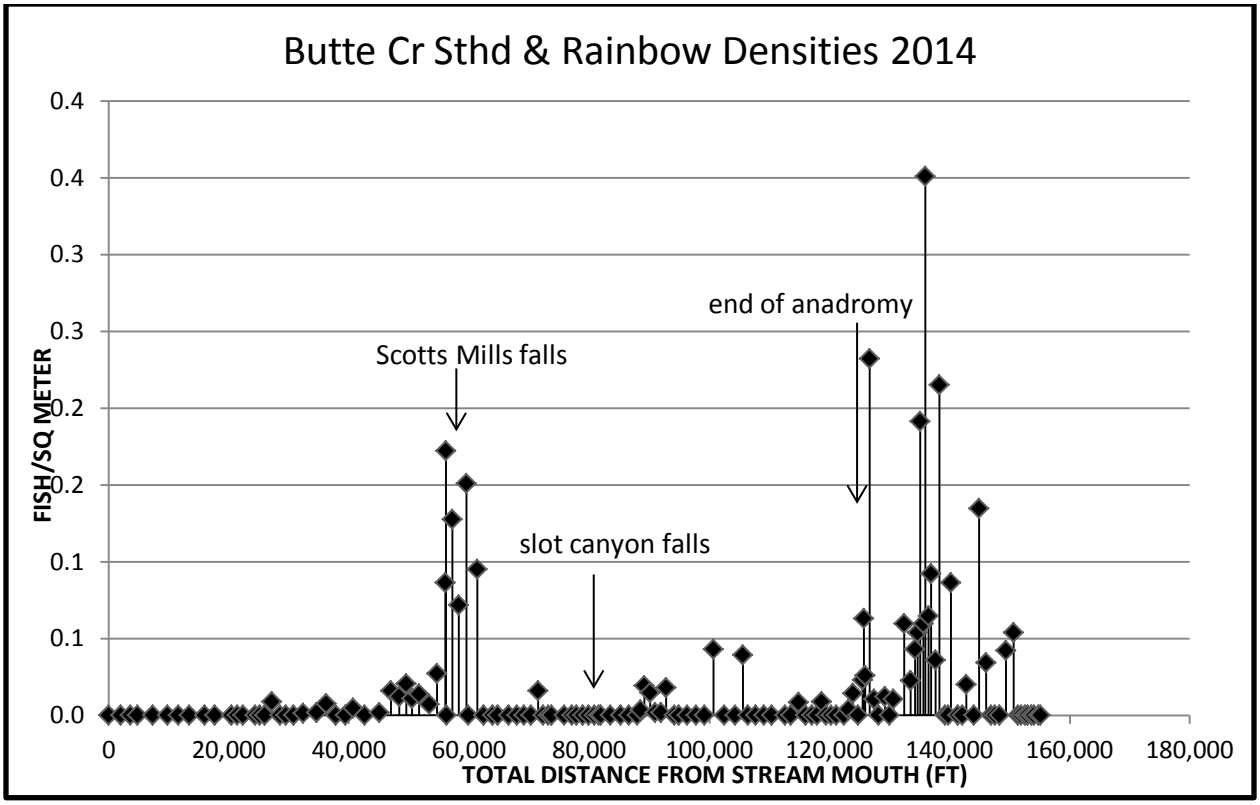
(Photo 12) Butte Cr habitat

Several falls ranging from 2-5 ft. were documented within this reach with a larger cascade/slot falls rising 20 vertical feet over 50 linear feet at USGS RM 17.7 (Photo 13). This falls marked the end of coho distribution. Coal Cr enters at USGS RM 17.2 with a steep 10 ft. bedrock falls just above the mouth that likely functions as a permanent anadromous barrier. In the upper end of this reach just above a canyon pinch point at USGS RM 20 the canyon opens up and significant increases in floodplain width, gravel bedload, channel braiding, and wood complexity were observed (Photo 14). These habitat characteristics continued for approximately 3 miles with an average gradient of 1.5%. A slight increase in steelhead abundance was observed throughout this reach and 3 large resident rainbow were also observed (indications of a residualized O.mykiss population). Cutthroat production increased significantly throughout this reach rearing 31.7% of the sub-basin total at 151 fish/mile while comprising only 12.6% of lineal stream miles within the range of anadromy. 0+ trout abundance remained low.

(Photo 13) Butte Cr Slot Falls

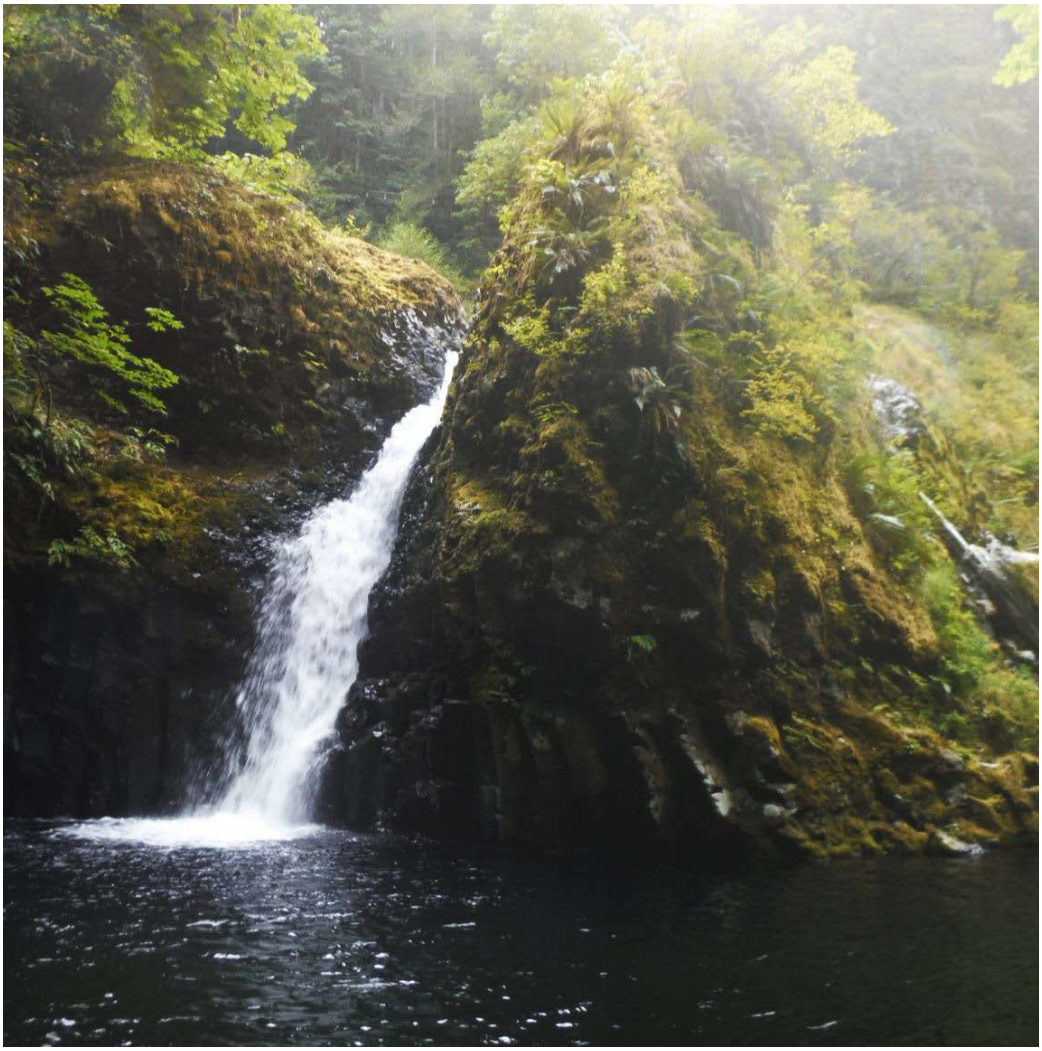
(Photo 14) Butte Cr high quality habitat

(Figure 9)



Around USGS RM 22, just above the geologic unit transition to western cascade flows, the canyon begins to tighten and by USGS RM 23 the average gradient increases to 2.5% and the stream winds through a tight gorge that continues to the falls ending anadromous distribution at USGS RM 26.4 and marking the transition to the next geologic unit of CRB's. The dominant substrate throughout this reach was boulder and cobble with isolated pockets of sorted gravel and a few larger deposits in the form of dispersed gravel bars (uncommon). Cutthroat production remained consistent, rearing 164 fish/mile and reaching a peak density for the sub-basin of 0.6 fish/Sqm at USGS RM 24.8. Steelhead presence was intermittent with low abundance throughout the remainder of stream corridor accessible to anadromous salmonids. In the deep plunge pool below the Lower Butte Cr falls the highest pool count for both steelhead (45 fish) and cutthroat (36 fish) was observed. Confidence in the steelhead count in this pool is questionable due to the likelihood of the presence of introduced rainbows from above the falls and the surveyor's inability in distinguishing between the two. 0+ trout abundance peaked in the mile below the falls rearing 575 fish/mile and accounting for 33.5% of the mainstem total (within the range of anadromy). The density peak of 0.27 fish/Sqm occurred at USGS RM 26.2. These densities are well below observations in well seeded high quality habitats in other Willamette subbasins. The higher abundance of the 0+ age class in the reach below the falls is likely also correlated with the additional recruitment from populations of both O.mykiss and cutthroat (including their hybrids) rearing above the falls (Photo 15).

(Photo 15) Lower Butte Creek falls

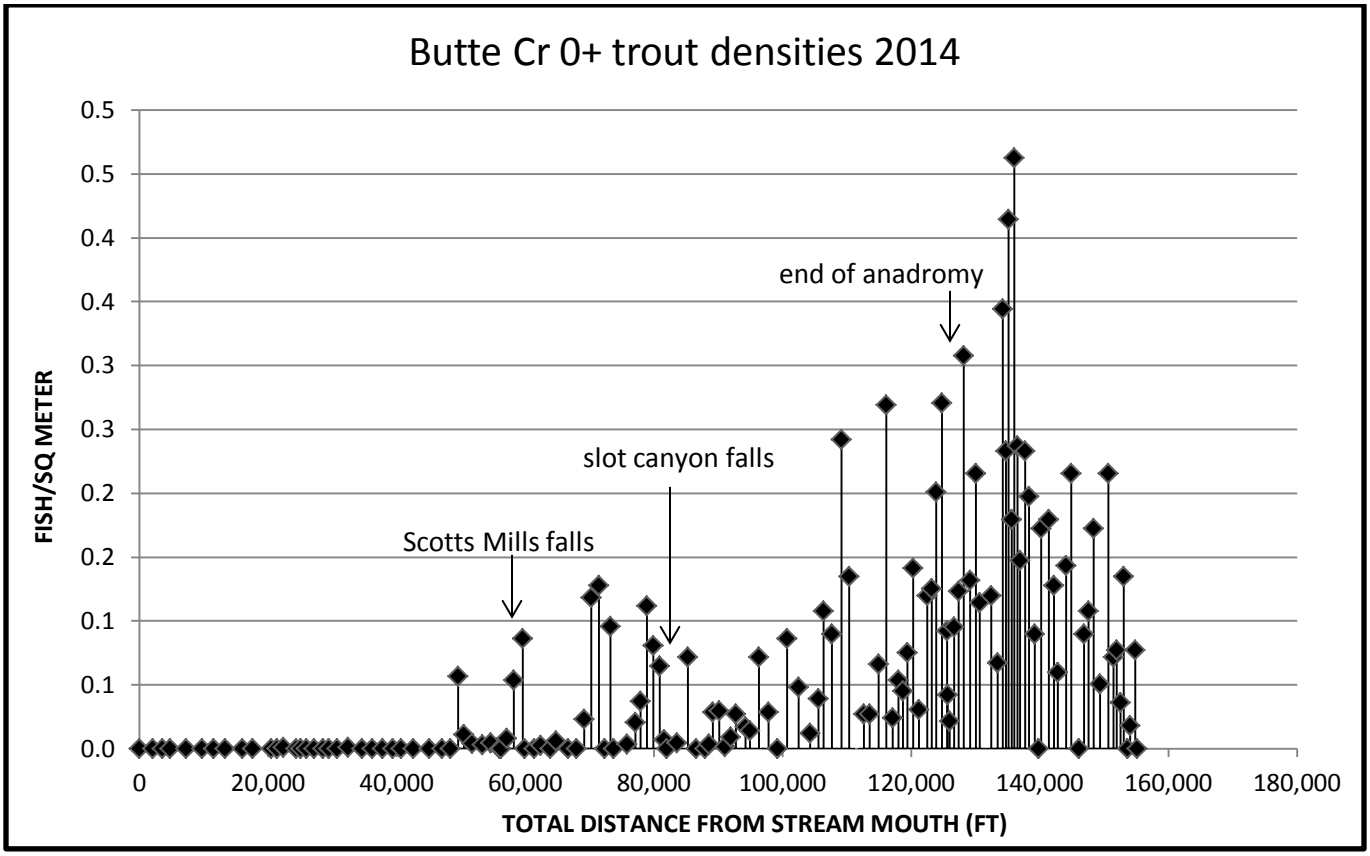


Above Lower Butte Cr falls, the middle Butte Cr falls descends 70 ft. into a deep pool over a basalt ledge and shortly above that, Upper Butte Cr falls descends 30 ft. over another basalt intrusion into a deep plunge pool. Rainbow trout were documented immediately above the end of anadromy, averaging 579 fish/mile over the next 2.6 miles of stream habitat while cutthroat production decreased to 108 fish/mile within the same reach. 0+ trout abundance increased, averaging 631 fish/mile with distribution trends mirroring those of rainbow trout. The basin wide highest pool counts for rainbow trout (220) and 0+ trout (90) were recorded in the pool below the Upper Butte Cr falls. Density spikes for rainbow trout of 0.35 fish/Sqm and 0+ trout of 0.46 fish/Sqm were documented in the same pool at USGS RM 28.2. Kirk Cr enters at USGS RM 26.8 (above the end of anadromy) contributing approximately 25% of the summer flows. 0+ trout densities in the first two pools of kirk Cr. were the highest recorded in the Butte Cr sub-basin at 1.12 and 1.2 fish/Sqm. Throughout this reach exhibiting high resident rainbow and 0+ trout production, stream habitats were characterized by an increase in average gradient to

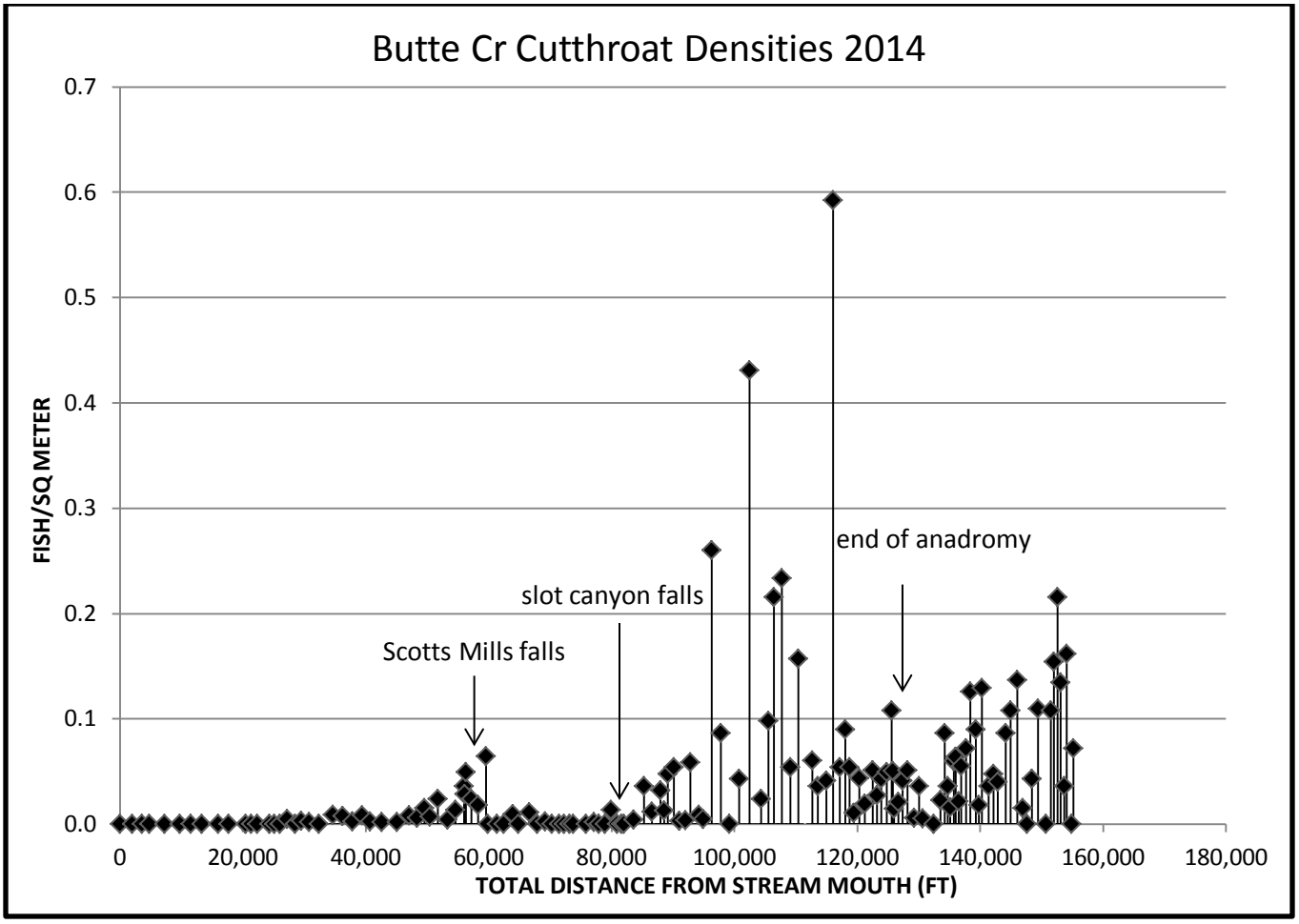
2.8%, a boulder/bedrock dominated substrate, a lack of wood complexity, and a hillslope confined channel meander.

Within the remaining 3.6 miles of inventory, the only change to habitat characteristics was an increase in the average gradient to 3.6%. Flow was reduced above the confluences of South fork Butte and Rhody Cr. Rainbow trout abundance decreased to an average of 21 fish/mile with just intermittent pool presence observed throughout the remainder of the survey. 0+ trout abundance decreased to 99 fish/mile. Cutthroat abundance remained consistent at 103 fish/mile with a steady increase in pool density as pool area decreased.

(Figure 10)



(Figure 11)



Year	Coho	Avg coho/Sqm	0+	Sthd	Cut	Chin	Rainbow
2014	2418	0.06	3710	565	2115	0	1580

Drift Cr Sub-basin

The Drift Cr drainage contained 16.7 miles of inventoried stream habitats. This included 3 tributaries; East Fork Drift, Fox Cr, and Trib B. This sub-basin comprised 18.25% of the total miles inventoried in the Pudding basin. For the sub-basins included in this review, the Drift Cr headwaters are the lowest in elevation and comprise the smallest sub-watershed. Land use within the Drift Cr watershed is predominantly agricultural with scattered stream side forest corridors. Narrow riparian buffers and deep channel incision were common throughout the inventory. Poor visibility was a consistent issue throughout the scope of the mainstem inventory. In deeper pools habitats where low pool turnover rates retained tannins and turbidity was present, the expanded estimates of abundance for both cutthroat and coho likely underestimate the actual number present. Salmonid abundance in general however was low sub-basin wide with coho by far the most abundant salmonid species. Cutthroat and 0+ trout parr were absent throughout a majority of the inventoried pool habitats. There were no steelhead parr observed rearing in the sub-basin. Expanded population estimates of coho parr suggest an approximate adult coho escapement of 22 pairs into the sub-basin. The DEQ's 2012 Integrated report and 303(d) list has assigned a Category 4: Water Quality Limited status for Drift Cr. mainstem from RM 0-9.5 for year round temperatures affecting salmon and trout rearing and migration.

Stream channel morphology within the Drift Cr drainage is controlled by three geologic units: deep alluviums of unconsolidated sediments; Columbia River Basalt flows; and sedimentary rocks of the Scotts Mills Formation.

Table 7 Drift Cr Sub-basin

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%	Rain	%
Drift	2898	58.5	180	97.3			165	56.9				
East Fork Drift	1794	36.2	5	2.7			115	39.7				
Fox	240	4.8					10	3.4				
Trib B	18											
total	**4950**		**185**				**290**					

Drift Cr Mainstem

The mainstem inventory began at its confluence with the Pudding River at USGS RM 51 and extended 15 miles upstream where reduced flows and a transition to substrates dominated by mudstone and fine erodible gravels limit spawning and colonization further upstream. Coho distribution extended 11.9 miles with no definitive barriers to adult passage observed. Expanded population estimates suggest an approximate adult coho escapement of 13 pairs.

Deep alluvial deposits comprise the first reach and extend from the confluence up 1.3 miles. The impacts of the dominant agricultural land use are evident throughout this reach. The stream habitat was characterized by an average gradient of 0.6%, a deeply incised active channel, little or no riparian cover, an infestation of noxious weeds and the prevailing siltation of all cobble and gravel tailouts. Coho parr abundance was low throughout this reach rearing 77 fish/mile and accounting for just 3.5% of the mainstems total population. Cutthroat were observed in very low abundance at 4 fish/mile.

The next reach begins with an abrupt transition to Columbia River Basalts and extends 4.8 miles from RM 1.3 – RM 6.1 (just above Victor Point Rd). The stream habitat was characterized by an increase in the average gradient (1.44%), a bedrock dominated substrate, little or no wood complexity, hillslope confinement, an increase in a forested riparian belt and some limited gravel sorting. Coho production increased within this reach and accounted for 42% of the mainstem population rearing 251 fish/mile. Cutthroat abundance increased, but remained low at 14 fish/mile.

(Photo 16) Drift Cr habitat

The next reach begins at a second abrupt geologic transition to marine and non-marine sediments located near the proposed dam site above Victor Point Rd and extends through the end

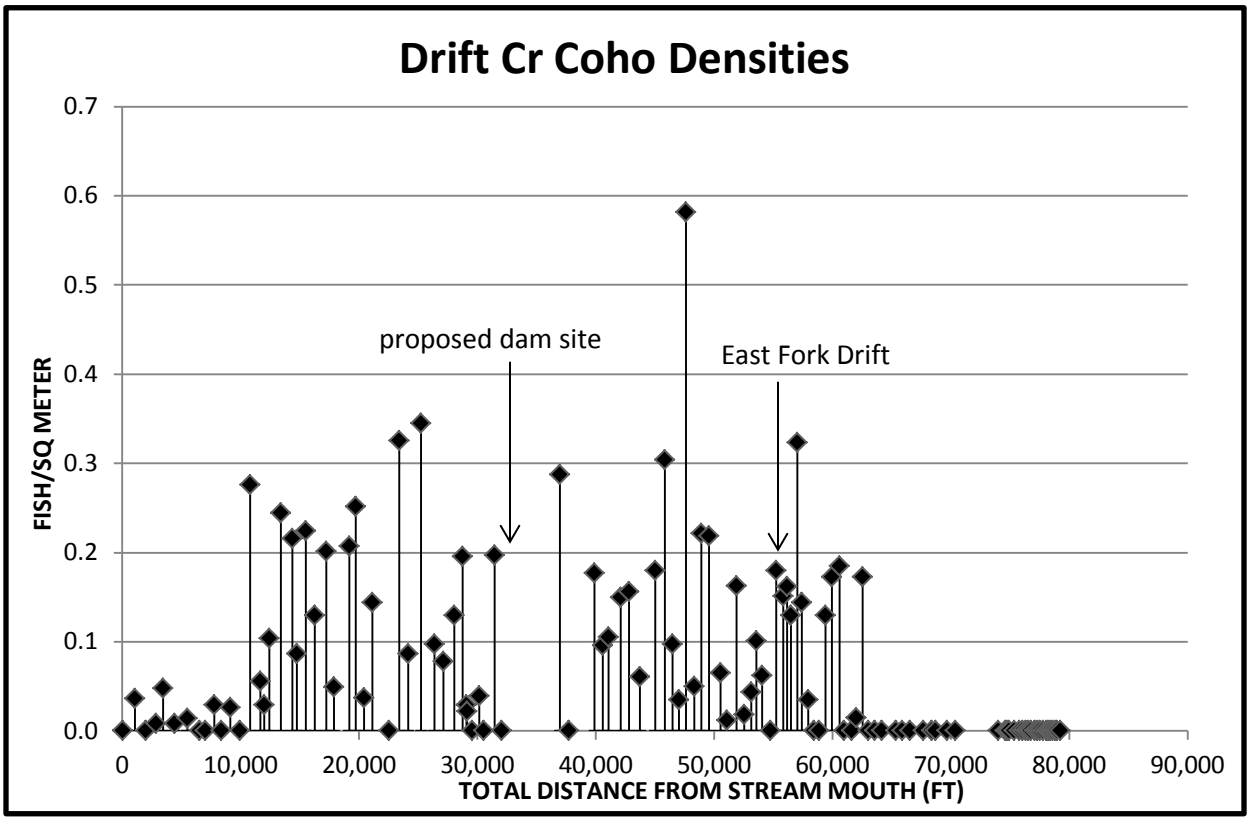
of coho distribution. The first 1.5 miles of this reach exhibited a dramatic decrease in average gradient (0.1%) that resulted in near contiguous pool habitats with no riffle habitats and an absence of any significant hydraulic controls (Photo 17). This reach exhibited deep siltation and channel entrenchment along with little or no forested riparian buffer. The impacts of unrestricted cattle use were present within the reach. Very few coho were observed summer rearing in this reach even though their distribution extended further upstream. Poor visibility for the snorkel sampling methodology prevailed in this reach suggesting that abundance estimates likely under estimate the actual occupancy.

(Photo 17) Drift Cr above proposed dam site.

1 mile below the confluence of Fox Cr the average gradient increases to 0.7%. Gravel sorting is observed in pool tailouts along with high wood complexity in pool habitats. Deep channel incision and narrow riparian buffers continue to be observed. The next 2.8 miles (RM 7.6 – 10.4) of stream habitat exhibited the highest potential for coho production in the mainstem and was observed rearing 44.5% of all mainstem coho parr at 459 fish/mile. The highest pool density for coho (0.6 fish/Sqm) was observed at RM 9 (just below the confluence of Fox Cr). Fox Cr enters as one of the few significant cold water contributions with a 12 in. perched culvert shortly above the confluence blocking temperature dependent upstream migrations of salmonid

juveniles seeking thermal refugia. Coho parr were observed above this barrier extending 0.3 miles where anadromous potential is limited by a gradient increase to 11%. A back calculation of the expanded population estimate for coho suggests 1 successful coho spawning event occurred in Fox Cr. An increase in beaver activity was observed in Drift Cr above the confluence of Fox Cr.

(Figure 12)



Coho abundance declines just below the confluence of East Fork Drift. The remaining 1.6 miles of habitat with coho distribution was documented rearing 8.3% of the mainstem total at 153 fish/mile. An increase in average gradient to 2.3% was observed in the upper end of coho distribution. A14 in. perched culvert was observed at RM 11.7. A 5 ft. bedrock falls was documented at RM 12.3, approximately 0.4 miles above the end of coho distribution. This falls is likely a consistent end point for anadromy. Inadequate riparian shading was a consistent observation within the inventory contributing to thermal loading with cumulative downstream impacts.

Above RM 12.8 the average gradient decreases to1% for the remaining 2.2 miles of the inventory. Low cutthroat abundance continued with only intermittent pool presence observed. 0+ trout abundance, largely absent up to this point, increased in the last mile of the inventory where 83.3% of the mainstem total for the 0+ age class was observed. This suggests that most

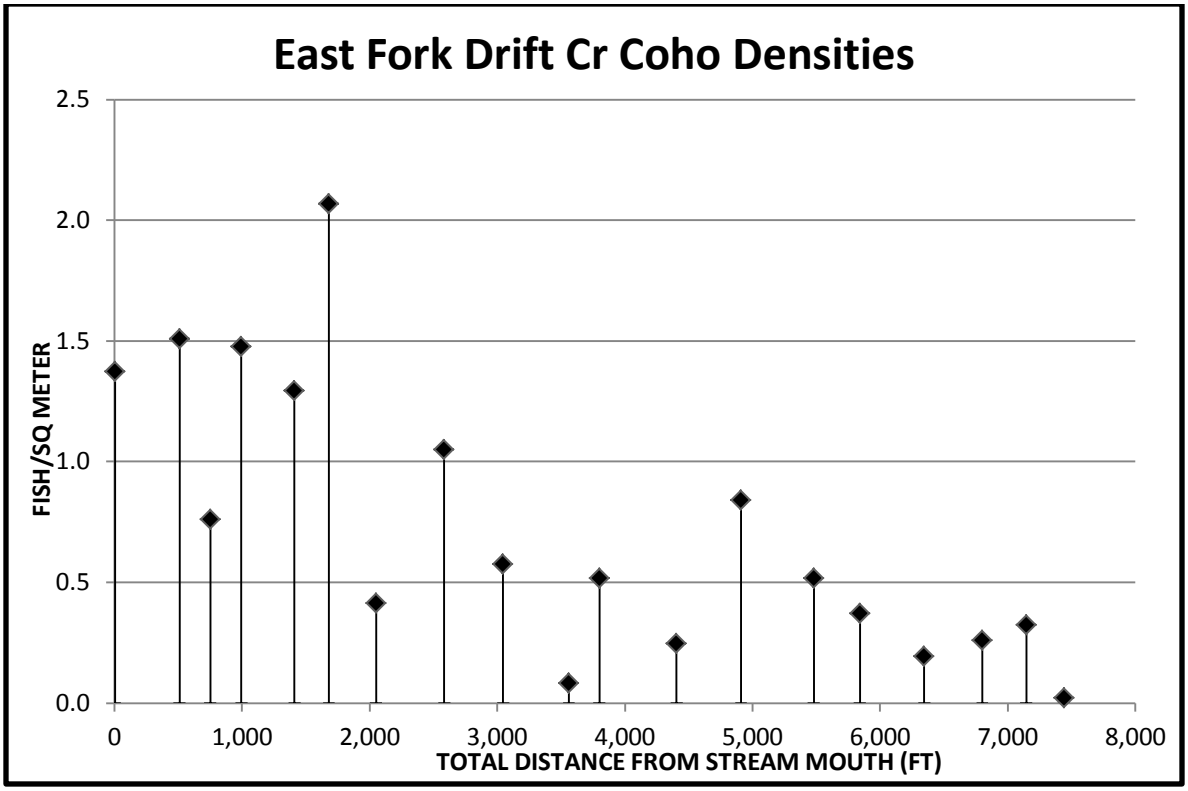
cutthroat spawning is occurring in the headwater reaches. 2 failing culverts were observed at RM 14.5 and 14.6 (currently still passable for adults and juveniles).

Year	Coho	Avg coho/Sqm	0+	Sthd	Cut	Chin	Rainbow
2014	2898	0.13	180	0	165	0	0

East Fork Drift Cr

East Fork Drift Cr enters the mainstem of Drift Cr at RM 10.5. The inventory extended 1.4 miles to Drift Cr falls, a permanent barrier to adult passage. Coho densities peaked at RM 0.3 at 2 fish/Sqm. The first 0.7 miles of stream habitat exhibited the highest anadromous potential and was documented rearing 84.6% of all coho in the EF Drift (2169 fish/mile) and 91.3% of all cutthroat (150 fish/mile). This 0.7 miles of stream corridor represented just 4.2% of the entire Drift Cr sub-basins lineal stream miles but was observed rearing 30.7% of all coho parr and 36.2% of all cutthroat in the entire Drift Cr sub-basin. This section of stream habitat was characterized by well sorted gravel tailouts, adequate riparian shading, high wood complexity, floodplain interaction for the provision of functional winter refugia, beaver activity with a total of 4 active dams and an average gradient of 2.4% (optimal for the development of functional pool/riffle ratios for summer food production). Coho distribution profiles (Figure 13) also suggest that the EF Drift is a destination for upstream juvenile migrations from the mainstem for summer cold water refugia.

(Figure 13)



In the second half of the inventory (RM 0.7 -1.4) coho and cutthroat abundances decrease with a transition in channel morphology to bedrock and cobble dominated substrates and an increase in the average gradient to 4.1%. This continues to the 60 ft. falls that ends anadromous salmonid distribution (Photo 18). A juvenile barrier documented approximately 1000 ft. below the falls indicates that coho spawning occurred in the upper end of the inventory. Expanded population estimates suggest an adult coho escapement of 8 pairs.

EF Drift should be considered the primary salmonid anchor within the Drift Cr sub-basin. This conclusion is directed at the process of prioritizing restoration and conservation actions designed to support the sub basin scale proliferation of multiple salmonid species and aquatic function.

(Photo 18) East Fork Drift Cr falls

Year	Coho	Avg coho/Sqm	0+	Sthd	Cut	Chin	Rainbow
2014	1794	0.73	5	0	115	0	0

Silver Cr Sub-basin

The Silver Cr. sub basin inventory contained 16.7 miles of almost exclusively mainstem stream habitats. It includes just 1 side channel and two short tributaries- Trib A and Jeff Cr. This sub-basin comprised 18.3% of the total stream miles inventoried in the Pudding River basin. The Silver Cr sub-basin intersects 5 geologic units along its course from the headwaters in the cascade foothills to its confluence with the Pudding River at USGS RM 49.4: (1) deep alluviums of unconsolidated sediments (2) sedimentary rocks of the Scotts Mills Formation; (3) landslide

and debris flow deposits; (4) Columbia River Basalt flows; and (5) lava flows of the western cascades (Molalla and Sardine Formation). Similar to the other inventoried sub-basins these units and their transition points were observed influencing stream channel morphology along with fish production, rearing capacities and current distribution.

Table 8 Silver Cr sub-basin

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%	Rain	%
Silver	1296	81.5	60	48	30	100	640	95.5	15	100		
Side channel A	294	18.5										
Trib A			35	28			15					
Jeff			30	24			15					
Total	**1590**		**125**		**30**		**670**		**15**			

Silver Cr Mainstem

The Silver Cr inventory began at USGS RM 0.5 and extended 16.6 miles upstream to the confluence of North and South Fork Silver Cr. Salmonid abundance was extremely low for all 4 species throughout the inventory with anadromous fish distribution ending well below any definitive anadromous barriers. Steelhead / Resident Rainbow presence was sparse and intermittent with 1+ and older parr documented in only 5 of 40 randomly sampled pools. Chinook parr were observed in 2 of 40 randomly sampled pools that exist to the end of anadromy. Coho were the most abundant salmonid species, with moderate numbers documented in low densities throughout the lower 6 miles and nearly absent above RM 6. Cutthroat abundance was low but exhibited consistent distribution above USGS RM 2.5. Water quality concerns were documented in DEQ's 2012 Integrated report and 303(d) list including: a Category 5: water quality limited, 303(d) listing for dissolved oxygen for a year round (non-spawning) criteria from RM 0.9-16.2 and a Category 4A: water quality limited listing for summer temperature affecting salmonid rearing and passage from RM 0-5.9.

The first 6.5 miles of the inventory leading up to the Silver Cr dam and reservoir is comprised of 3 geologic units: alluvial deposits extending from the confluence up to approximately USGS RM 5.7, Scotts mills formation sedimentary rock from RM 5.7-6, and CRB's from RM 6-9.2. A recent study done by the Marion Soil and Water Conservation District evaluating stream function and watershed processes affecting water quality and aquatic habitat of the lower 3.6 miles of Silver Cr described the majority of stream habitat as "functioning at risk" with the first mile up from the confluence with the Pudding as "degraded." Numerous priority concerns were outlined in the study including: stream bank incision, proliferation of noxious weeds, ineffective riparian buffers and decreased water quality resulting from poor filtering of non-point source pollution and fecal bacteria. In addition to these concerns the 2014 RBA

snorkel inventory documented various invasive fauna including: Asian clams, bullfrogs, bluegill, largemouth bass, and hatchery rainbow trout. The average gradient throughout the study reach was 0.34%. Salmonids were absent below the confluence of Brush Cr at USGS RM 1. Salmonid abundance throughout the remainder of this 3.6 mile reach was low with only intermittent pool presence documented. Coho were the most abundant salmonid with 48% of the sub-basins population rearing within this lower 3.6 miles of mainstem Silver Cr at 370 fish/mile (extremely low abundance). Coho were observed clustered in shallow alcoves that exhibited cold hyporheic ground water linkages at the heads of a few pools and in side channel habitats. This behavior suggests that critical temperature thresholds are being exceeded for juvenile salmonid survival in the majority of the mainstem during peak summer temperature profiles. Cutthroat and 0+ trout were largely absent and steelhead were not documented rearing in pool habitats within this reach. Side Channel A enters within this reach at USGS RM 1.8. It was observed as cold and clear with connectivity to the mainstem at the bottom, delinked at the inlet end with evidence of pool scour from high winter flows. The side channel was protected from solar exposure by a mature stand of cottonwood, ash and alder (Photo 19). Side Channel A extended 350 ft. with 6 pools and a coho density peak of 2.9 fish/Sqm. Salmonids were absent in the mainstem adjacent to side channel A. Mainstem coho densities peaked at USGS RM 3.1 at 0.12 fish/Sqm in a non-random pool sampled to document that coho were tightly huddled in a shallow ground water seep entering the side of the pool.

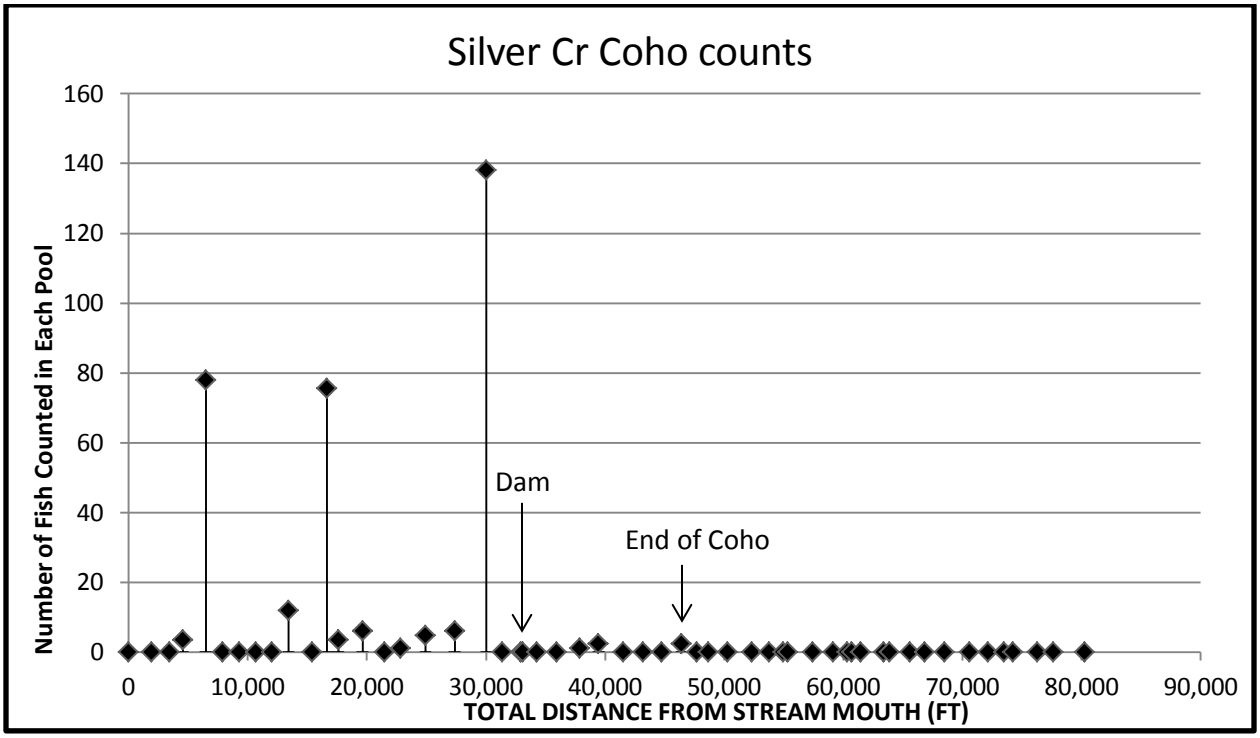
(Photo 19) Side Channel A

(Photo 20) lower Silver Cr habitat

Above the Marion SWCD study reach Silver Cr passes through the city of Silverton. Channel entrenchment, channelization in the form of stream bank fortification/armoring and the average gradient (0.8%) increased through this section. Chinook parr were documented rearing from approximately USGS RM 3.4-4 in stream habitats adjacent to the business district of downtown Silverton. Coho production remained low in this reach (USGS RM 3.4- 6) rearing 50.2% of the sub-basin total at 307 fish/mile with a high pool count of 138 coho documented just above the geologic unit transition at USGS RM 5.7. Coho were absent between a 7 ft basalt falls at the transition to CRB's just below USGS RM 6 (1/2 mile below the Silver Cr dam site) and the Silver Cr dam. The 7 ft falls at USGS RM 6 did not appear to be an adult migration barrier (Photo 21). Above the 7 ft falls the stream channel is dominated by bedrock and the average gradient increases to 2% leading up to the dam.

(Photo 21) 7 ft falls mainstem Silver Cr USGS RM 6

(Figure 14)

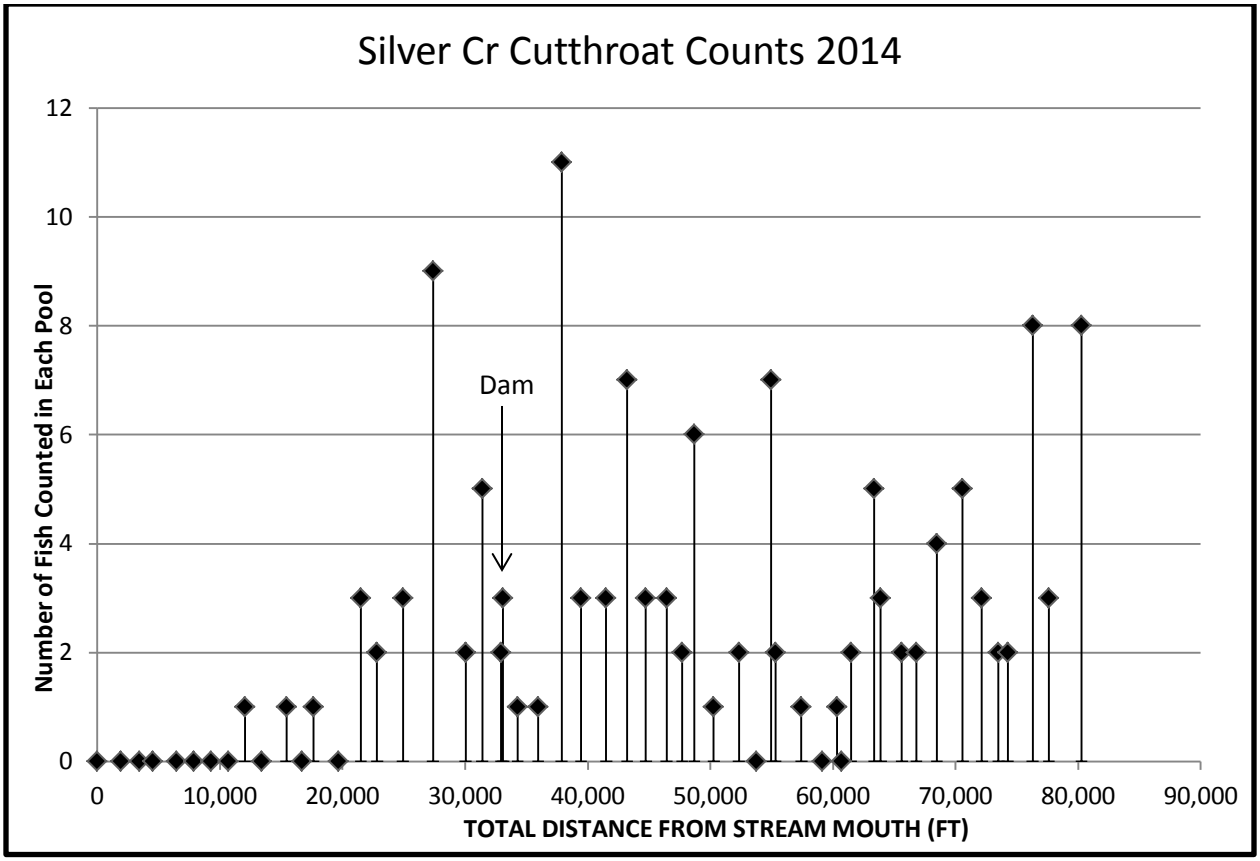


Cutthroat abundance increased above USGS RM 4 rearing 55 fish/mile in pool habitats below the dam at USGS RM 6.5. Steelhead were first observed in the pool below the falls at USGS RM 6. Hatchery rainbow trout were first observed in the pool below a 4ft dam (outfitted with a fish ladder) at USGS RM 4. Several more hatchery progeny were observed in pools below the dam but were absent in the stream habitats above the reservoir. Most of the hatchery rainbows exhibited signs of illness or injury. Silver Cr Reservoir is currently stocked with catchable rainbow that are dropping out of the reservoir and rearing in low numbers in the mainstem of Silver Cr. At USGS RM 6.5 a 65 ft. dam spans 680 ft. between confining hill slopes with a 120 ft. wide concrete spillway (Photo 22) and a 42 inch pipe at the foot of the dam for draining. The dam is outfitted with a fish ladder with a hole in the side of the dam that provides access to the ladder. The reservoir above the dam is approximately 1 mile long and 680 ft across at its widest point. This portion of Silver Cr was not included in the inventory. If the survey data is prepared for georeferencing, the missing 1 mile reservoir segment would need to be injected between pools 21 and 22.

(Photo 22) Silver Cr dam

Above the reservoir (starting at USGS RM 7.5 and pool 22 in the Access database) stream habitat was characterized by boulder/cobble/bedrock (basalt and sedimentary) dominated substrate with a few isolated gravel bars, excellent shading from a coniferous riparian, channel meander restricted by hillslope and high terraces and a prevailing lack of wood complexity. The average gradient was 0.9%. This channel morphology extends through the end of coho distribution at USGS RM 10.8 (no barrier to anadromous passage was observed) and to the end of steelhead distribution at USGS RM 12.8 (below a 10 ft. falls) and continues to a geologic transition at RM 13.2. Coho distribution extended just 2.6 miles above the head end of the reservoir and the expanded estimate of just 30 parr above the reservoir may be an indication of poor passage at the dam (unverifiable without a higher escapement of anadromous adults to the Silver Cr sub basin). Most of the emergant coho fry from what was likely just a single successful spawning event above the Silver Cr dam were probably rearing within the reservoir and not accounted for within the scope of the snorkel inventory. Steelhead / Resident Rainbow abundance was also extremely low with an expanded total of just 20 fish documented above the resevoir. Cutthroat were observed at 55 fish/mile. 0+ trout were nearly absent.

(Figure 15)


Silver Cr Cutthroat Counts 2014
Number of Fish Counted in Each Pool
0
2
4
6
8
10
12
Dam
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
TOTAL DISTANCE FROM STREAM MOUTH (FT)

(Photo 23) Silver Cr scoured channel

The next 0.6 miles of stream habitat (RM 13.2 – 13.8) exhibited an increase in floodplain interaction with high wood complexity and channel braiding and an abundance of well sorted gravels in pool tailouts. This short reach of high quality habitat exists directly below a geologic unit transition from Scotts Mills sedimentary rock to landslide and debris flow deposits which extends along the north hillslope of the creek to the confluence of Jeff Cr at USGS RM 14.3. The deep bedload accumulation observed in this section is likely depositional materials recruited from landslide/debris flow events of the Holocene. Jeff Cr climbs steeply out of the Silver Cr canyon at an average gradient of 13.5%. In the 250 ft of inventoried steam habitat in Jeff Cr 24% of the sub-basins total for 0+trout parr and 2.2% of its cutthroat were documented. Similarly, Trib A entering at USGS RM 9.1 with an average gradient of 8.5% was documented rearing 28% of all sub basin 0+ trout parr and 2.2% of all cutthroat in a 415 ft reach of stream habitat. This observed distribution does not appear to be the result of upstream temperature dependent migration from the mainstem. The mainstem reaches of Silver Cr above the Reservoir did not appear to be suffering from a summer temperature limitation. This observation highlights the absence of the 0+ trout age class in the Silver Cr mainstem. Less than 1% of the total sub-basin stream miles were rearing 52% of all 0+ trout observed.

Stream habitat in the remaining 2.5 miles of the inventory was characterized by a transition to CRB's with steep canyon walls and basalt pools and runs dominating the channel morphology. The average gradient increased to 1.2%. Cutthroat abundance in pool habitats remained depressed at 69 fish/mile. Food producing riffle habitats were scoured bedrock shelves with little or no habitat diversity for macro invertebrates (Photo 24). 0+ trout abundance remained extremely low with intermittent pool presence only.

(Photo 24) confluence of North and South Fork Silver

Year	Coho	Avg coho/Sqm	0+	Sthd	Cut	Chin	Rainbow
2014	1296	0.02	60	30	640	15	0

Recommendations

- The Dam and associated bypass channel at the Scotts Mill's dam appears to clearly influence the upstream migration of anadromous adults and provides no benefit for the temperature dependent upstream migration of juveniles seeking thermal refugia in headwater reaches. Consider the removal of the concrete stem wall at the top of the natural bedrock intrusion and a retrofit of the current bypass channel that would be capable of passing upstream temperature dependent migrant juveniles seeking upstream thermal refugia.

- LWD treatment logs and/or boulder weirs in stream reaches that displayed high fish production in an effort to: dissipate stream energy and provide cover and complexity; Increase types and sizes of pools; provide overhead cover and refuge from avian predation; Capture and store deep accumulations of bedload, sequester summer flows into contiguous accumulations of bedload to protect limited summer flows from air and solar exposure.

- Replace or remove impassable culverts and irrigation dams, the issues listed below are the highest priority because they block upstream temperature dependent summer migrations of juvenile coho and steelhead that are critical for survival in temperature limited systems. Any of these targets directly addresses the primary habitat limitation for salmonids (access to thermal refugia). This is not a complete list of culvert issues within the inventoried sub-basins. All of the passage issues are discussed in context within the body of this document.
  1) Davis Cr. - 515 ft. above mainstem confluence - culvert undercut and perched 5 in.
  2) Davis Cr. - 1185 ft. above mainstem confluence - culvert undercut and perched 8in.
  3) Fox Cr. - 350 ft. above mainstem confluence -culvert perched 12 in.

- Increase riparian buffer widths and functionality along all stream reaches that pass through cropland/pastureland that currently exhibit missing or narrow riparian corridors. Prioritize those stream reaches that currently exhibit high fish production potential and utilize a top down approach to extend current function gradually downstream. Focus on current cold water contributors of summer flow identified in this document for the highest priority riparian restoration actions (i.e., Davis Cr highest priority in Abiqua sub basin when compared to any other mainstem Abiqua riparian corridor).

- Develop delinked side channel habitats in reaches exhibiting deep accumulations of transient bedload (available in site specific descriptions of channel morphology). This provides the critical thermal refugia that is required in temperature limited mainstems corridors to achieve survival during pinch period summer temperature profiles. The refugia is expressed by deep pool scour in gravel terraces that is accessible from the bottom during summer flows and delinked from surface flows at the top. This provides

access to hyporheic flows unexposed to the influence of air and solar. This requires blocking side channel inlets with large wood complexes that only pass the high winter flows required to maintain pool scour. The prescription also includes the development of vertical scour vectors within the side channel capable of exposing the hyporheic strata during winter flows for summer use (specific design elements required).

- Increase wood complexity below known summer juvenile barriers to improve over summer survival rates during the period when temperature dependent migrations are required to access a thermal refugia. These abnormally high concentrations of juveniles are disproportionately high frequency targets of avian predators due to their forced concentration below known barriers.

Distribution and Rearing Density Graphics

An Excel Workbook has been developed from the raw Access data that allows the user to preview the distribution, density and abundance graphics by stream and by species that were utilized to conduct this analysis. This pivot table work book allows managers and users to access information for all of the streams surveyed in 2014.

In addition, it is important to note that an extensive amount of supplemental raw data (primarily in the form of surveyor notes and comments) is also available in the Access database.