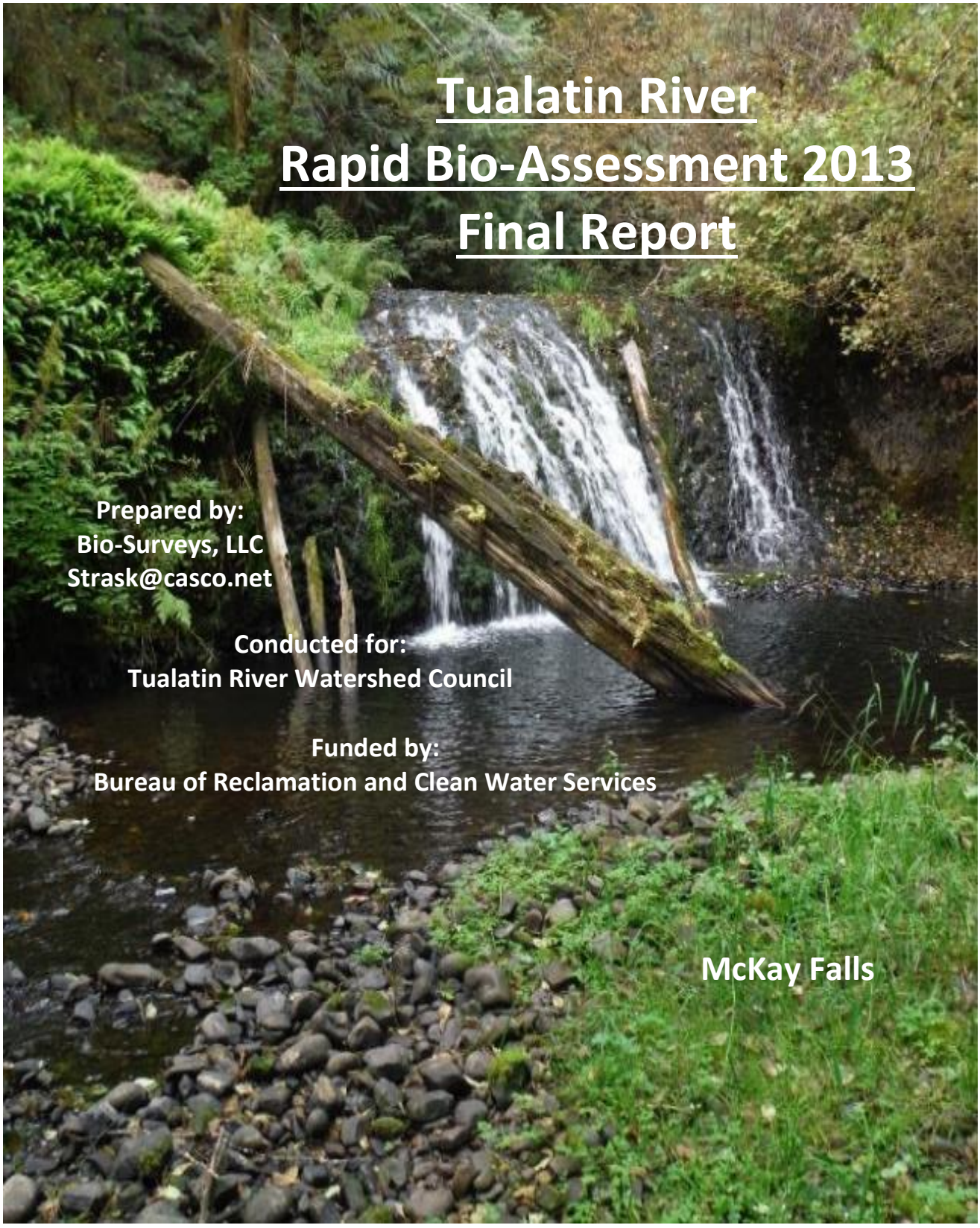
Tualatin River
Rapid Bio-Assessment 2013
Final Report



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McKay Falls

Introduction

The 2013 Rapid Bio-Assessment inventory of the upper Tualatin basin covered 138.2 miles of stream habitat. The effort encompassed much of the mainstem and tributary habitats exhibiting the potential for providing functional summer habitat for anadromous salmonids in the upper Tualatin River mainstem, Scoggins Cr, Gales Cr, and Dairy Cr (East Fork, West Fork, and McKay).

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 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 distribution and therefore describe the full extent of distribution for steelhead and coho in 2013. 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 guide 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, most side channels were sampled at a 100% rate (every pool). Sampling rates for side channels are indicated within the comment field of the Access database that accompanies this report.

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 Tualatin basin during the summer of 2013 were the result of an adult escapement of 12,941 wild coho (6,571 adults/6,370 jacks) and 7,337 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 current range of anadromous fish distribution repeatedly fell substantially short of the range of stream miles exhibiting high-quality anadromous potential (This was likely the result of inadequate adult escapement to seed the available habitat).

2) When steelhead were present they were observed in low densities. Steelhead were not observed in the subbasins of McKay Cr or West Fork Dairy Cr.

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

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

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/sq m 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. This more refined analysis 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 in the Tualatin mainstem and the Gales Cr mainstem. This was necessary because the inventories began at points above their actual river mouth. Fish distribution graphics that accompany this document 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 23 and September 18 of 2013. 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 by-product of this effort.

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 % sample. This method suggests that the data existing in the database could tend to 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.

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 (i.e., Tualatin and Gales Cr mainstem) 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:

<u>Visibility</u>
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% 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 Tualatin basin cutthroat densities between the range of 0.8 and 1.0 fish/sq m meter were documented as the top end of the observed range (this is a robust and healthy level when compared to other west side Willamette watersheds). Steelhead densities were consistently low with peaks at the 0.29 fish/sq m level (well below the 0.7 fish/sq m level observed in well seeded steelhead systems). 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 steelhead and cutthroat that the combined densities of these similar sized species would not exceed the 0.8 -1.0 fish/sq m observed in the highest quality habitats of the system. Observations in many

thousands of miles of both Willamette and coastal streams suggest that densities above 0.7 fish/sq m for older age class steelhead or cutthroat without competition from the other are rare.

For the 0+ age class, there were 1015 pools in 2013 within the inventory that contained young of the year fry (combined steelhead / cutthroat). 13 of these pools exhibited densities between 2 – 3 fish/sq m. Only 3 pools exhibited densities between 3 – 3.59 fish/sq m. The highest densities observed in thousands of miles of Willamette basin and coastal stream inventories for the 0+ age class always hover around 3 fish/sq m. The similarities observed in the Tualatin basin to many other watersheds suggests that a value near 3 fish/sq m is probably a good indicator that the reach is somewhere near its capacity for the 0+ age class and that spawning locations existed nearby.

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/sq m. 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/sq m meter of pool surface area as a value that represents habitats seeded to their summer carrying capacity. The average pool densities observed in the Tualatin system by unique stream segment ranged between 0.001 and 7.0 fish/sq m in 2013. The lowest value documented in the mainstem of Gales Cr and the highest value observed in Side Channel B of East Fork Dairy 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 % 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 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 stream 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 Tualatin basin in 2013. 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% 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% 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

Tualatin Basin

During the summer of 2013 juvenile coho were the most abundant anadromous fish species rearing in pool habitats throughout the inventoried reaches of the Tualatin basin when all mainstem and tributary habitats are combined. The total estimated pool abundance of juvenile coho was 90,090 (Table 2). Their distribution was wide spread across all of the major subbasins inventoried. Utilizing the season to season survival rates developed for coho by the Nickelson/Lawson Coho model, a back calculated estimate of 811 (+/- 90) adult coho utilized the inventoried reaches of the Tualatin basin to spawn. This was an estimated 12.3% of the total adult escapement of coho (6,571 not including jacks) over Willamette falls and an unknown percentage of the total escapement to the Tualatin basin. 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 6,370 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 ½ mile segment of EF Dairy Cr was rearing 8,109 fish/mile and for Gales Cr 1,494 fish/mile

Steelhead abundance was low with an expanded estimate of only 2,747 1+ age class and older individuals observed in pool habitats for all of the inventoried subbasins combined (Table 2). In addition, steelhead were not broadly distributed and were not observed at all in either West Fk Dairy Cr or McKay Cr. 71% of all steelhead observed were rearing in the mainstem habitats of East Fk Dairy Cr. As a relative metric of productivity for steelhead, the highest densities of the 1+ and older age classes in the most functional ½ mile segment of EF Dairy Cr was rearing 630 fish/mile and for Gales Cr 166 fish/mile.

Cutthroat were abundant in most of the inventoried Tualatin subbasins with an expanded estimate of 12,020 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 a very effective tool for inter annual variation and trend analysis. In general, cutthroat numbers and densities increased above the distribution of steelhead and coho due to the lack of inter specific competition for food and rearing surface area. The highest densities of Cutthroat

were observed rearing in headwater reaches without steelhead or coho in densities between the range of 0.8 – 1.0 fish/sq m. (Likely near the full productive capacity of the habitat).

It's important to note that poor visibility was a consistent issue in the lower mainstem of all of the primary subbasins. The presence of tannins limited visibility in deep mainstem pools where slow moving water facilitates the development of a thermocline. The presence of this deep thermocline suggests that estimates of abundance for cutthroat and coho in these reaches likely underestimates the actual number present. The raw data stored in the Access database that accompanies this final report document will indicate the zones where compromised visibility may influence observed abundance (visibility ranking of 2 or 3).

(Table 2) Expanded Estimates for 2013

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Tualatin	2,531	2.8	1,085	2.6	130	4.7	220	1.8
Side Channels	188		34		2		15	
Roaring	1,175	1.3	1,760	4.3			405	3.4
Scoggins	44		30					
East Fork Dairy	**35,175**	**39**	**8,180**	**20**	**1,950**	**71**	**2,635**	**21.9**
Side Channels	593		39				6	
Big Canyon	163		65				30	
Campbell	388		1,280	3.1			280	2.3
Denny	419		1,205	2.9	5		285	2.4
Murtaugh	150		125		10		180	1.5
Panther			130				20	
Plentywater	6		135				40	
Rock	219		1,095	2.7			265	2.2
Roundy	6		195				35	
Trib A	6		40					
Gales	2,275	2.5	**8,205**	**20**	**430**	**15.7**	**1,585**	**13.2**
Bateman	175		250				115	
Beaver	**12,700**	**14.1**	425	1			360	3
Clear	**5,705**	**6.3**	3,025	7.4	**140**	**5.1**	605	5
Coffee			325				45	
Finger	156		45				30	
Iler	2,662	3	**3,770**	**9.2**	25		735	6.1
Low Divide			110					
NF Gales	1,013	1.1	935	2.3	50	1.8	220	1.8
Prickett			70				55	
Roderick			40				5	
SF Gales	656		1,040	2.5			210	1.7
Trib A			25		5			
White	1,463	1.6	75				90	
McKay	4,669	5.2	1,390	3.4			**975**	**8.1**
Side Channels	193		7				4	
Brunswick	94		30				35	
EF McKay	3,838	4.3	1,005	2.5			940	7.8
Neil	44		40				30	
Jackson			10					
Trib B	19		10					
WF Dairy	2,544	2.8	1,205	2.9			375	3.1
Burgholzer	888		470	1.1			115	
Cedar Canyon			335				180	1.5
Cummings	175		430	1			50	
Garrigus	2,794	3.1	240				150	1.2
Kuder	94		15				25	
Mendenhall	2,931	3.3	995	2.4			395	3.3
Trib A	388		295				60	
Whitcher	2,038	2.3	525	1.3			125	1
Williams	1,519	1.7	260				90	
Inventory Total	**90,090**		**41,000**		**2,747**		**12,020**	

* 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 five 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 production role).

(Table 3) Expanded Subbasin Estimates for 2013

Subbasin	Coho	%	0+	%	Sthd	%	Cut	%
Tualatin	3,938	4.4	2,909	7.1	132	4.8	640	5.3
EF Dairy	37,124	41.2	12,489	30.5	1,965	71.5	3,776	31.4
Gales	26,805	29.8	18,340	44.7	650	23.7	4,055	33.7
McKay	8,855	9.8	2,492	6.1			1,984	16.5
WF Dairy	13,369	14.8	4,770	11.6			1,565	13
Total	**90,090**		**41,000**		**2,747**		**12,020**	

- 20% visual bias included for coho expansions

Tualatin Mainstem

The mainstem Tualatin inventory started at USGS RM 62.25 (at the bridge crossing of Highway 47) in Gaston. The survey extended approximately 12 miles to Haines falls, a permanent anadromous barrier. The inventory included 3 side channels and 2 tributaries: Roaring Cr and Scoggins Cr.

(Table 4) Upper Tualatin Expanded Estimates

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Tualatin	2,531	64.3	1,085	37.3	130	98.5	220	34.4
Side Channel A	26		32	1.1	2	1.5	8	
Side Channel B	109	2.8	2				4	
Side Channel C	53	1.3					3	
Roaring	1,175	29.8	1,760	60.5			405	63.3
Scoggins	44	1.1	30	1				
Total	3,938		2,909		132		640	

- Side channel estimates not expanded (100% sample)
- Percent contributions are indicated for only those sub-basins that contributed greater than 1% of the total.
- 20% visual bias included for coho expansions

Very low fish numbers were observed in the 12 miles inventoried below Haines Falls. Thiseach of the upper Tualatin mainstem spanned a dramatic gradient shift. Near the town of Cherry Grove, a basalt dominated mountain reach descends from Haines Falls with an elevation drop of about 60ft/mile (1.1%) and encounters the deep alluvial deposits of the Patton Valley and a radical transition in gradient to 0.2% (11.7ft/mile). Over the next several miles the river continues to decrease in gradient as it transitions into a meandering reach with an elevation drop of 1.3ft/mile (0.02%). The most productive coho and steelhead habitat began just below the basalt/aluvial transition and extended through most of the Patton Valley.

The primary coho spawning peak was observed at USGS RM 66.4 (1/2 mile above the MT. Richmond Rd bridge). Field notes indicate that this productive zone exhibited increased wood complexity, sorted gravel in pool tailouts, and increased channel sinuosity. Thin riparian buffers and deep channel entrenchment was also noted in this section.

To provide drinking water, irrigation water, and water quality benefits (lower temperatures, decrease phytoplankton growth, increase dissolved oxygen), the natural summer flow of the Tualatin River mainstem is augmented during the summer months from two reservoir sources. Stored winter rains were discharged from Henry Hagg Lake (Scoggins Cr) beginning July 7 and extending through October 22 in 2012. Augmentation from this facility averaged 41.8 cfs for the July / August period and 51.4 cfs for the September / October period. A constant release from Barney Reservoir (Trask River basin) of 14 cfs was initiated on August 31 and terminated on October 29 in 2012. This augmentation program increases summer flow profiles as much as 33% above the Tualatin's natural summer flow (Tualatin Watershed Atlas, 2001). This has the effect of increasing summer river levels and summer velocities while decreasing summer water temperatures.

Based on the clues provided by the unusual upstream migration into warmer water observed in Roaring Cr (see Roaring Cr discussion) and the extremely low abundance of salmonid juveniles in the 12 stream miles between Gaston and Haines Falls on the mainstem Tualatin, we believe conditions exist that may be negatively influencing juvenile salmonid abundance within the surveyed reach. It is also likely that the augmentation program is having a significant positive impact for salmonids somewhere lower in the system where mixing and slower pool turnover rates moderate the high volumes of cold reservoir inputs (none of these lower reaches were included in the 2013 RBA inventory).

At this juncture it's important to review the channel morphology of the upper Tualatin mainstem. Figure 1 from the Fisheries Instream Flow Analysis for the Upper Trask and Tualatin Rivers

conducted by CH2M HILL 1993, displays the gradient profile of the upper mainstem Tualatin. The 2013 RBA survey extended from RM 61 to RM 73 on this graphic. Essentially there is a 9 mile stream segment for the entire 78 mile Tualatin mainstem that contains all of the spawning habitat for steelhead and coho. Stream gradients below approximately RM 64 flatten to levels less than optimum for the deposition and sorting of gravel resources appropriate for large anadromous spawners and the deposition of mobile silts and sediments near this transition also compromise incubation success rates. The gradient in Reach F, with a drop of 10 ft/mile is only 0.2% with even lower gradients below the confluence of Scoggins Cr transitioning the system to a meandering valley stream channel form.

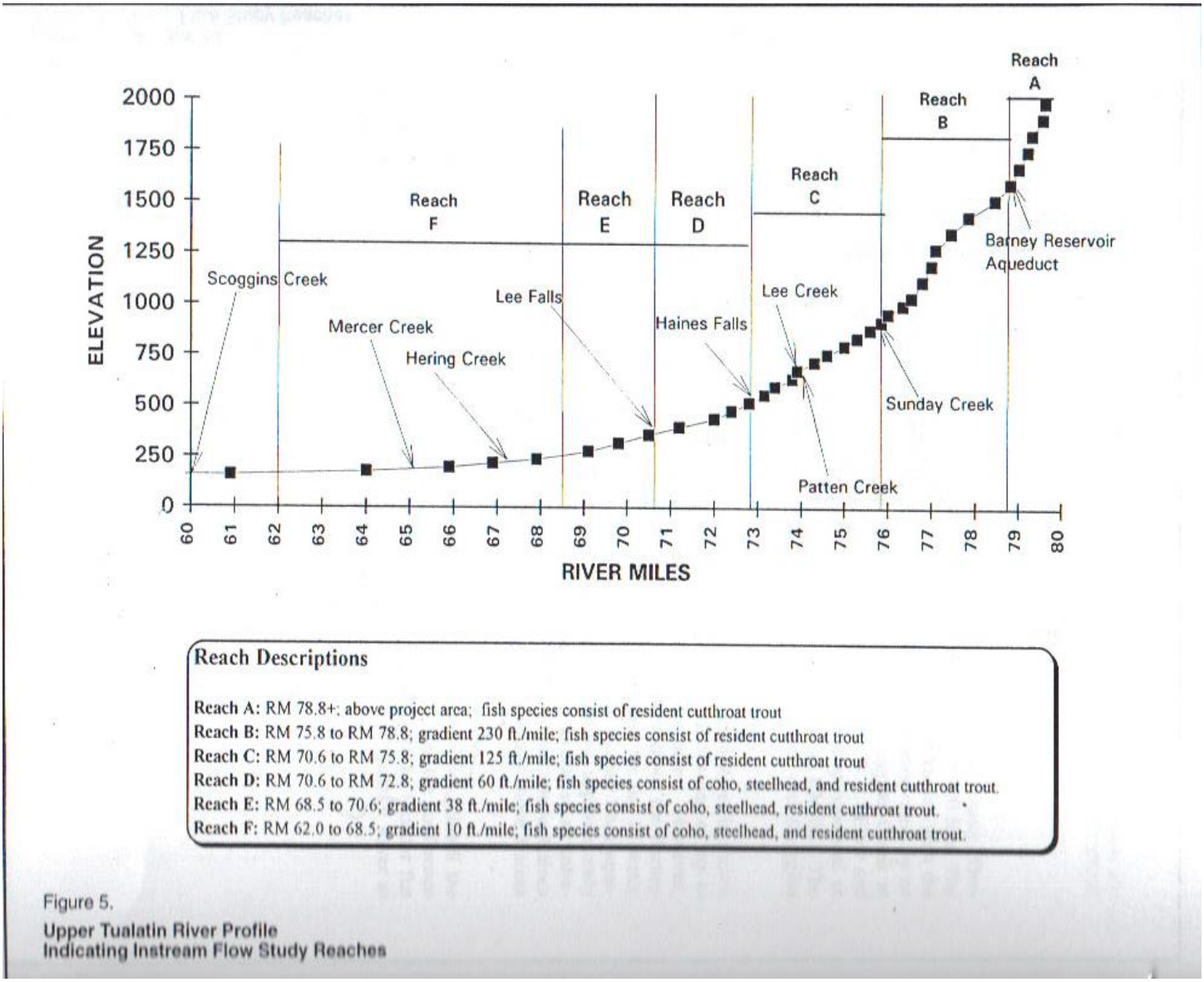


Figure 5.
Upper Tualatin River Profile
Indicating Instream Flow Study Reaches

Figure 1

The Fisheries Instream Flow Analysis for the Upper Trask and Tualatin Rivers, (CH_2M HILL, 1993, pg.40) described reductions in habitat abundance for sub yearling steelhead and coho parr of 19.21% and 27.94% as a possibility with flow augmentation in the reach (between Cherry Grove and Gaston on the mainstem Tualatin). In addition, this report suggested that the negative impacts resulting from increases in summer flows might be mitigated by temperature reductions associated with augmentation (no temperature modeling was included in the IFIM analysis). Temperatures recorded at RM67.83 (South Rd Bridge, Cherry Grove) from the 2012 Annual Flow Management Report suggest that summer temperature profiles have been highly variable (Tualatin River Flow Management Technical Committee Final Report, 2012, Appendix F, Pg. 4) with some years not exceeding 14 deg C.

In the upper portion of the inventoried reach (above Cherry Grove), which is characterized by higher gradients, low wood complexity and canyon confinement, these higher sustained flows have possibly resulted in, or contributed to compromising the abundance of high quality summer rearing habitat for juvenile salmonids as a result of increased velocity and sub optimum summer rearing temperatures. Optimum summer temperatures (17 -19 deg C, will ensure no more than a 20% reduction from max growth, Sullivan, 2000) are required for maximizing juvenile salmonid growth rates. Because fish are cold blooded, the seasonal warming of aquatic systems is necessary for eliciting the physiological response required for rapid growth and the storage of fats.

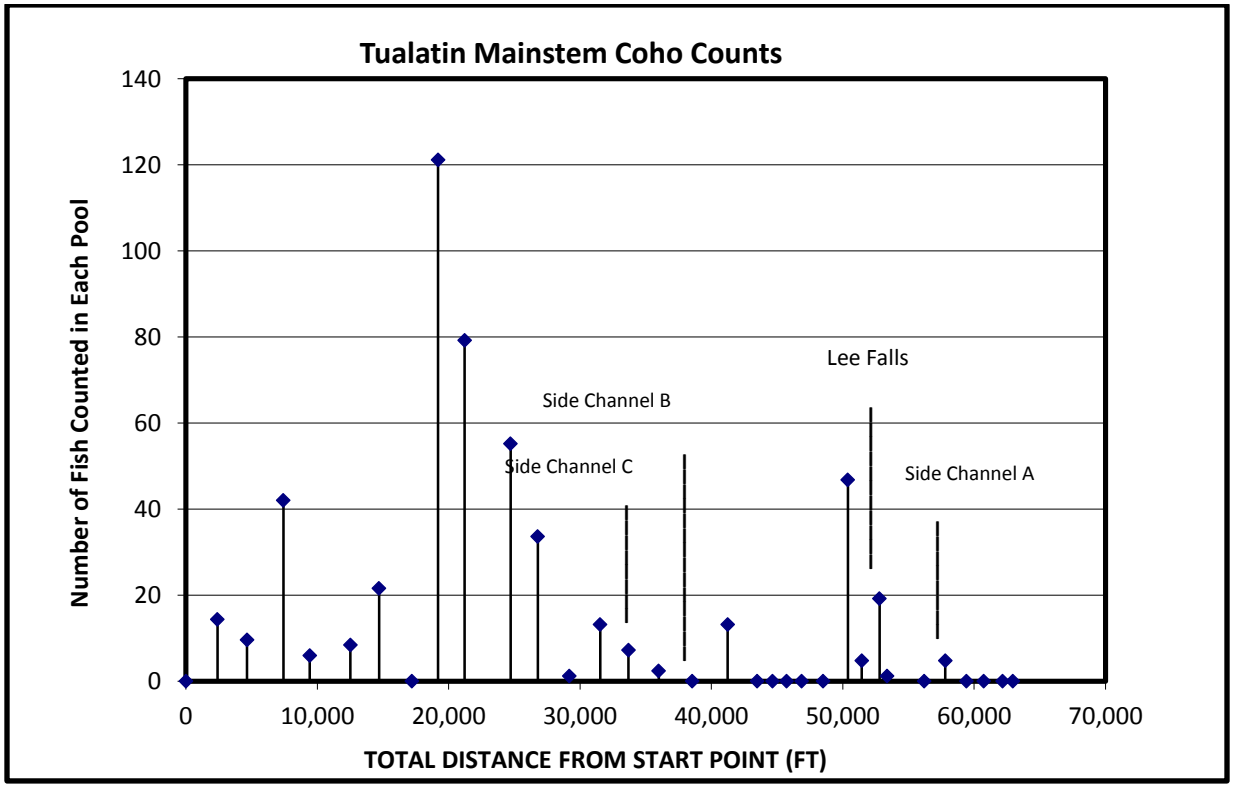
The RBA protocol is designed to be a fast moving inventory capable of covering large stream networks for the provision of a baseline fish distribution and abundance layer. We utilize the survey data to identify high priority restoration reaches and landscape scale issues that might be affecting salmonid use or access to aquatic habitats. Our recommendation is that additional replicates of the Upper Tualatin RBA Snorkel Inventory be conducted to assess whether the patterns observed in the upper 12 miles in 2013 are sustained from year to year or variable as a result of changes in adult escapement (coho, steelhead), flow or temperature. Definitive conclusions of cause and effect are not possible with the limited amount of data collected within the scope of the 2013 inventory. Our discussion is designed to highlight anomalies in the observed distribution of salmonids and to pose hypothetical relationships to broaden the discussion of the Tualatin Flow Management Technical Committee.

Potential actions for continued monitoring in the Upper Tualatin mainstem are presented in the Recommendations section of this document.

Photo 1

In the upper end of this reach, near USGS RM 67.5, Side Channel C offered a short span of off channel rearing habitat with a significantly higher abundance of coho than observed in adjacent mainstem habitats.

Figure 2



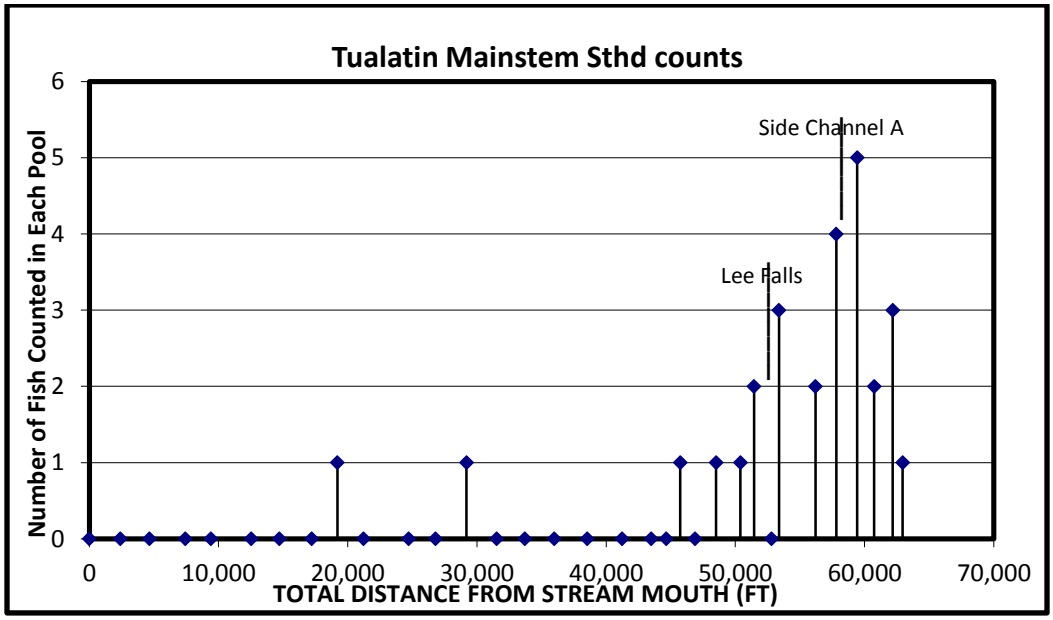
Above USGS RM 68, near the confluence of Roaring Cr, a noted gradient increase occurs. Side Channel B enters in this zone providing critical off channel habitat. This side channel (Photo 1) consisted of one lower gradient, high complexity pool that contained 109 coho (visual bias included) rearing at a density of 1.1 fish/sq m . Very few coho were observed in the adjacent mainstem pools.

Proceeding upstream to RM 69, suveyors documented a lack of wood complexity, a transition to bedrock/boulder dominated substrates, and high summer flow volumes confined within a narrowing canyon. This channel morphology persists through the end of anadromy.

Steelhead and cutthroat numbers begin to increase above Lee falls around USGS RM 71. Lee falls, a 10 ft bedrock shelf falls, contains a fish ladder that improves access to the remaining 2 miles of anadromous habitat below Haines falls, a permanent anadromous barrier.

Around USGS RM 72 surveyors noted a decrease in gradient with channel braiding over a broad floodplain. Field notes indicate that these characteristics extend approximately 2,500 ft. Steelhead, cutthroat, and 0+ densities peaked in this zone at USGS RM 72.3. Side channel A also enters at this point providing high complexity and low gradient off channel habitat.

Figure 3



Shortly above this peak in fish production the canyon tightens with a gradient increase over bedrock and boulder and at USGS RM 73.2 anadromous potential is terminated at Haines Falls, a 15 ft bedrock step (Photo 2). The City of Hillsboro withdrawal point is just above the falls.

Photo 2

Below USGS RM 64 a decrease in gradient, a lack of gravel, and very little distiction between pool and riffle units (no hydraulic controls) describe the habitat. Brush covered entrenched banks, deep silt deposits and large floating log/debris jams were also noted. These habitat characteristics continue for many miles below the survey start point as the gradient continues to decrease. While valuable for summer and winter rearing, the habitat exhibits virtually no salmomnid spawning potential. This morphological factor suggests that spawning and incubation are confined into a very short section of the upper mainstem Tualatin that includes only one supplemental spawning tributary (Roaring Cr).

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	2,531	0.05	1,085	130	220

Roaring Cr

Roaring Cr enters the Tualatin at USGS RM 68.4. Roaring Cr was noted as warmer than the mainstem Tualatin at the confluence. The Roaring Cr inventory extended 2 miles to a log jam that terminated coho distribution. Above the current distribution of coho, an increase in gradient to 3.6% and several ephemeral wood barriers limit any anadromous potential further upstream.

A concentration of juvenile coho was observed below a 2 ft bedrock falls at RM 0.4 (2.1coho/sq m, Photo 3).

Photo 3

This was the first of a series of juvenile barriers and it was sampled as an additional pool (non-random). The observed concentration was an indicator of an upstream migration pattern for the 0+ age class of coho. The comparatively warmer temperature profile of Roaring Cr (when compared to the augmented mainstem Tualatin) would normally not result in what appears to be an upstream temperature dependent migration. This behavior pattern during summer flow regimes is almost exclusively observed for the opposite scenario where the migration is triggered by a search for cooler rearing habitats. It is possible that juveniles are seeking warmer habitats to optimize growth. This hypothesis is relevant to the mainstem Tualatin discussion that observed very low abundances of summer rearing salmonids (all species) that may be related to summer temperatures below the optimum physiological range for growth as a result of flow augmentation from Barney Reservoir.

Adult coho also spawned in Roaring Cr with a spawning peak observed at RM 0.76. An average gradient of 2.8% was observed in the first mile. Expanded population estimates suggest an approximate adult coho escapement of 5 pairs.

High wood complexity and a mature riparian corridor were noted throughout most of the inventoried reach. No steelhead were observed in Roaring Cr. 0+ trout and cutthroat densities were moderate and still well below the carrying capacity of the available habitat throughout the inventory.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	1,175	0.4	1,760	0	405

Scoggins Cr

Scoggins Cr enters the mainstem Tualatin at USGS RM 60. The inventory of Scoggins Cr. extended 4.1 miles from the base of the Hagg Lake dam downstream to the Highway 47 bridge crossing. With summer flow in Scoggins Cr near bankfull height there were very few pool/riffle transitions (lack of natural hydraulic control, simulating sustained winter flows). Suspended solids in the water decreased the range of visibility throughout the survey. Poor visibility in addition to high velocities prevented the snorkel methodology from accurately enumerating fish abundance. Confidence in expanded estimates are low here. The features of very cold bankfull summer flows moving through a deeply incised channel form may reduce the abundance of optimum velocity summer habitats for all salmonids species. Mean temperatures for July August and September in 2012 were 7.8 C, 8.6 C and 10.7 C, well below the optimum range for salmonid summer rearing.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	44	0.002	30	0	0

Gales Creek Subbasin

The Gales Creek subbasin contained 49.4 miles of inventoried stream habitat that exhibited anadromous potential. This total included 13 significant tributaries. The tributaries of this palmated drainage were observed rearing 91.5% of all coho observed while contributing just 54.7% of the total stream miles within the subbasin. The opposite was true for Steelhead where only 33.8% of the subbasin totals were observed rearing in the tributaries. Each of the tributaries will be reviewed separately below.

Gales Cr enters the Tualatin River from the North West at RM 56.8 just south of Forest Grove. The drainage covers 77.9 sq m and is the 2nd largest subbasin within the Tualatin.

(Table 5) Expanded Gales Cr Subbasin Estimates

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Gales	2,275	8.5	8,205	44.7	430	66.1	1,585	39
Bateman	175		250	1.4			115	2.8
Beaver	12,700	47.4	425	2.3			360	8.9
Clear	5,705	21.3	3,025	16.5	140	21.5	605	14.9
Coffee			325	1.8			45	1.1
Finger	156		45				30	
Iler	2,662	9.9	3,770	20.6	25	3.8	735	18.1
Low Divide			110					
NF Gales	1,013	3.8	935	5.1	50	7.7	220	5.4
Prickett			70				55	1.4
Roderick			40				5	
SF Gales	656	2.4	1,040	5.7			210	5.2
Trib A			25		5			
White	1,463	5.5	75				90	2.2
Inventory total	**26,805**		**18,340**		**650**		**4,055**	

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

Gales Cr Mainstem

The Gales Cr mainstem inventory included 22.9 miles of stream habitat. The survey began at USGS RM 3.6 or the crossing of SW Ritchey Rd. The lower portion extending to the confluence with the Tualatin was not surveyed due to lack of summer rearing potential and poor visibility. The mainstem survey terminated at an 8ft bedrock falls at RM 26.5 serving as a permanent anadromous barrier.

The Gales Cr mainstem intersects an unusually broad range of geological formations along its reach of anadromous distribution. The deep alluvial deposits and fluvial terraces of the lower mainstem comprise most of the lineal stream miles, these are the floodplains currently exhibiting the majority of the subbasins agricultural interests. The upper forested reaches pass through a combination (moving upstream) of: tuffaceous siltstone/sandstone, a mafic intrusion of igneous basalt, Columbia River basalts, Yamhill formation siltstone/sandstone, and Tillamook volcanics.

Coho and steelhead distribution exhibited a strong preference for the siltstone/sandstone of the Yamhill formation. The 3 mile stream segment that interfaces with this formation was rearing 56% of

all coho and 55.8% of all steelhead documented in the mainstem. Cutthroat and 0+ trout densities both exhibited an increase in abundance within the Yamhill formation but peaked in the Tillamook volcanics observed in the headwaters.

Steelhead distribution extended to RM 24 with no adult barriers observed blocking access to the additional 2.5 miles of habitat available to anadromous migrants.

Coho distribution extended to RM 22.5 leaving some of the highest quality fish habitat in the basin underutilized with no barriers to passage observed. This is an unusual distribution pattern when both coho and steelhead are known to push high in the basin to access spawning habitats. It is likely that during higher abundance years of adult escapement over Willamette Falls, these headwater habitats would be more completely utilized for spawning and rearing.

The first 3miles of the mainstem was characterized by low gradient (0.2%), warm water, entrenched banks, deep, silty alluvial deposits, and large debris jams. No salmonids were observed in the lower 3 miles. Pike minnow, red sided shiners, dace and suckers were all abundant in the lower reaches of mainstem Gales. Notes indicated that the few sorted gravel tailouts present in the lower 3 miles were covered in algae and deeply embedded with silt and fines. Numerous irrigation pumps were observed as well as a visible decrease in flow and pool depth as the inventory progressed downstream. The cumulative effects of summer temperature limitations in the lower mainstem may be exacerbated by irrigation withdrawals. These cumulative effects limit the distribution and production potential for salmonids. Mean daily temperatures at Stringtown Rd (RM 6.98) exceeded 17.8 deg for almost all of July and August in 2012 and peaked at 23.7 deg on August 17, 2012 (Tualatin River Flow Management Technical Committee, 2012 Annual Report, Appendix F, Pg. 11). The distribution of salmonids was described by surveys conducted between July 24 and 27.

The next several miles exhibit an increase in gradient to 0.45% as well as higher flows and improved pool/riffle ratios as the channel rises out of the alluvial deposits and into a siltstone/sandstone dominated substrate. Notes indicated clean sorted gravel in tailouts and long cobble riffles in between pools. Coho, steelhead, and cutthroat are first observed in significant numbers around USGS RM 8 (temperature profiles continued to exceed DEQ standards for 15 days in July and 18 days in August at RM12.36, Tualatin River Flow Management Technical Committee, 2012 Annual Report, Appendix F, Pg 10)

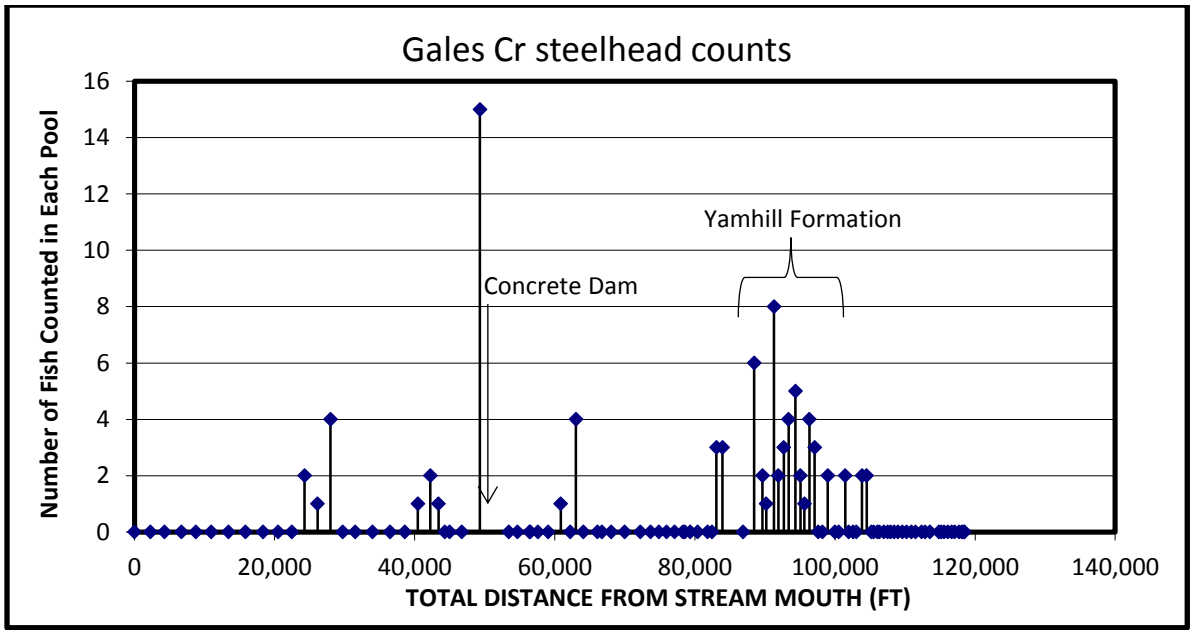
There were 4 significant tributaries offering potential cold water refugia in the temperature transition zone between RM 6 and RM 13: Pricket Cr enters at USGS RM 6.5 cooler than the mainstem with a seasonal irrigation dam just above the first pool blocking any upstream temperature dependent migration of salmonids. Roderick Cr enters at USGS RM 7.7 through a broad solar exposed wetland with temperatures higher than the mainstem of Gales Cr (no thermal refugia currently present), Clear Cr enters at USGS RM 10.66 with the first pool exhibiting coho and cutthroat densities among the highest observed in the entire Tualatin basin (behavior exhibiting a desire to seek thermal refugia). Iler Cr enters at USGS RM 11.4 cooler than the mainstem with a series of concrete steps (see Iler Cr discussion) impeding any further upstream juvenile migration 580ft above its confluence with Gales.

Upstream temperature dependent migrations within the mainstem of Gales Cr are terminated just below Parsons Rd at USGS RM 12.7 at a 3ft concrete dam (Photo 4). A density spike of steelhead and cutthroat trout were observed at the base of the falls (Figure 4). This is an indicator of both the existence of a temperature limitation in the mainstem at this milepost and unsuccessful attempts to migrate past the vertical obstruction. With a good jump pool below this is not a winter barrier for

large adult salmonids but it likely truncates access to the upper basin for late spawning fluvial Cutthroat (spawning period extends from December – May). The removal of this dam is a high priority restoration action because it exists in the zone of documented active upstream migration to escape temperature limitations in the mainstem of Gales Cr during low summer flow regimes. Above the dam the channel morphology transitions to siltstone/sandstone, exposed bedrock and deep basalt trench pools.

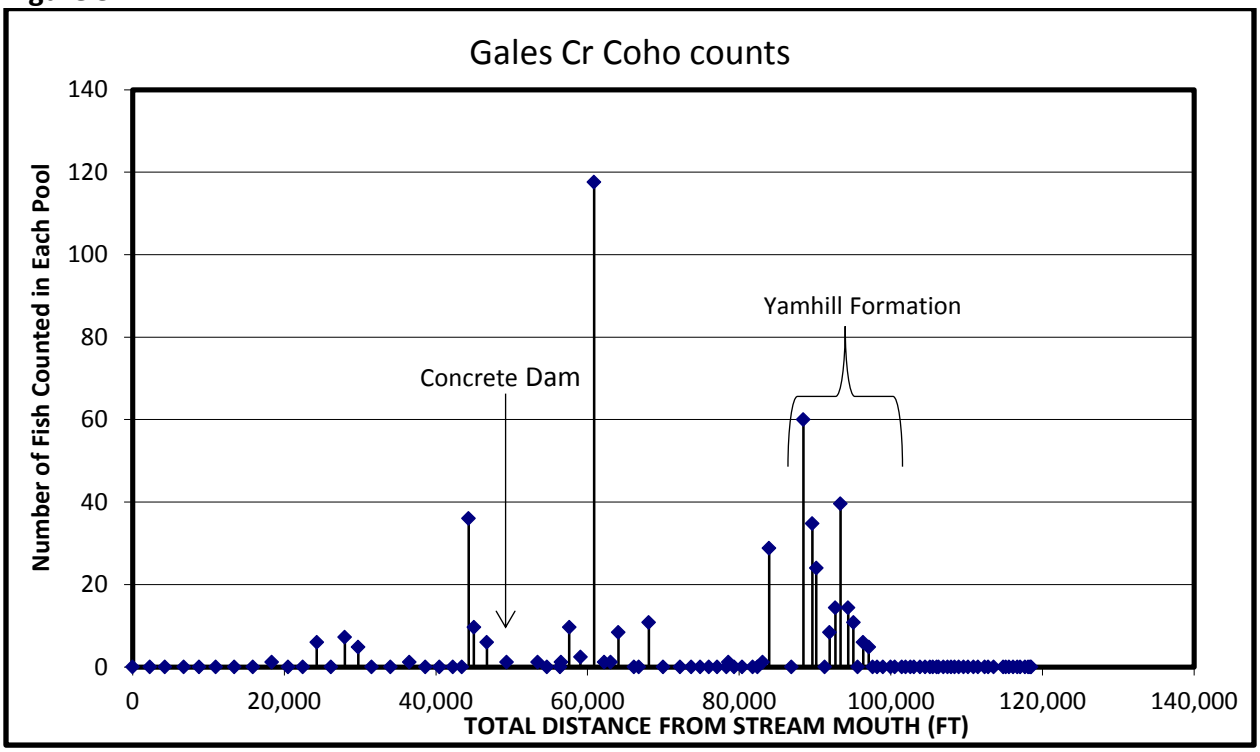
Photo 4

Figure 4



White Cr enters at USGS RM 14.4 with notes indicating a cold water contribution. A 1ft perch created by a concrete sill on the Highway 8 culvert that crosses White Cr was terminating upstream temperature dependent migrations into White Cr from the mainstem of Gales Cr. A minor coho density spike of .2 fish/sqm was observed at USGS RM 15.5 with the highest single pool count in mainstem Gales of 120 coho (Figure 5).

Figure 5



Bateman Cr enters at USGS RM 16.25 as a cold water contribution to the mainstem. Coho appear to also be utilizing Bateman Cr as a source of cold water refugia from the mainstem of Gales Cr. A series of 3-4ft bedrock falls was encountered approximately 1,100 ft above the confluence of Bateman Cr in the mainstem of Gales Cr that represent the end of upstream migrations of juvenile salmonids for thermal refugia. The spatial relationship between this natural juvenile barrier and any cold water tributaries directly downstream is important in understanding how to prioritize restoration actions. Because mainstem Gales Cr is temperature limited for salmonids during summer flow regimes, providing unimpeded access to any cold water refugia (regardless of its size) in the tributaries nearest this terminus (Bateman Cr, White Cr) directly addresses a primary limiting factor for multiple salmonid species. CWS temperature monitoring at Clapshaw Hill Rd (RM 12.36) in 2012 documented a max temp of 21.8 C on August 17 and the mean daily temperature exceeded DEQ standards 14 days in July and 18 days in August. Summer temperature limitations probably continue significantly further upstream that RM12.36, however the actual transition to a functional summer reach for salmonids is not well bracketed with temperature data.

Beaver Cr enters above the reach accessible to temperature dependent upstream migrants from the lower mainstem of Gales Cr at USGS RM 18. However, Beaver Cr enters Gales Cr with a similar

summer temperature profile as the mainstem of Gales Cr rendering it not a likely destination for upstream migrants in search of thermal refugia even if it were accessible. Salmonid distribution profiles in lower Beaver Cr support this conclusion (see Beaver Cr discussion). Beaver Cr and its tributaries were the largest producers of coho in the Gales Cr basin (over 5 times greater than the mainstem of Gales Cr).

Channels scoured to bedrock and deep basalt trench pools continue to another 4ft bedrock falls at USGS RM 19.75 (just below Coffee Cr). The low salmonid abundance observed in all of mainstem Gales Cr continues to persist to the confluence of Coffee Cr. Juvenile salmonids rearing between Bateman and Coffee Cr become isolated from thermal refugia because there are no cold water tributaries entering within the reach and multiple natural barriers deny them an escape route to the upper basin. The lack of cover in the form of wood or substrate complexity exacerbates the thermal limitations and likely reduces survival in the reach.

The next few miles encompass the most productive mainstem fish habitats as Gales Cr transitions out of the scoured bedrock of the Columbia River Basalts into the siltstone/sandstone of the Yamhill Formation. Significant increases in coho, steelhead, and cutthroat abundance were observed in this stretch. Coffee Cr and Finger Cr enter just above the juvenile barrier documented above. Both exhibited steep confluences and no evidence of upstream temperature dependent juvenile migrations. Landowners restricted access to a few thousand feet of Gales Cr above the confluence of Finger Cr. Surveyors returned to a channel braided across a wide floodplain just below the confluence of SF Gales. SF Gales enters at USGS RM 20.7 and was receiving upstream migrant juvenile coho from the mainstem of Gales Cr (thermal refugia).

Just above the confluence of the SF Gales Cr at RM 20.8 the highest mainstem coho density was observed at 0.7 fish/sq m. This density is still well below full seeding levels (1.7 fish/sq m, ODFW). In very close proximity (RM 21.3) the highest steelhead density was observed at 0 .25 fish/sq m. This is also well below full seeding capacity. Cutthroat numbers begin to climb in this reach and a noticeable increase in the abundance of older age class cutthroat was also observed. The gradient throughout this peak production reach averaged 1.5%.

At the confluence of NF Gales Cr at RM 21.65 a 0.8 mile reach treated with LWD begins in the mainstem of Gales Cr. A broad and interactive gravel floodplain with treatment logs was developing excellent channel complexity (braiding) and bedload aggradation was occurring. The structures were a good mix of high and low profiles for engaging and interacting with both summer and winter flow regimes. Treatment logs were associated with several sampled pools. At RM 22.5, just above the treatment reach, a log jam forming a significant deposition plain above was observed storing large quantities of migratory bedload. This jam was the end of coho distribution in 2012. The channel above the distribution of coho is braided through the historical alder flat (dead and still standing, Photo 5). Steelhead distribution continued above the jam but became sporadic above the treatment reach and ended at RM 24. No barriers to steelhead passage were observed near the end of their distribution.

Photo 5

The inventory extended several miles above the current end of anadromous distribution through what was the highest quality summer rearing habitat in the basin. A decrease in gradient to 1% was noted around the confluence of Low Divide Cr (within the Gales Cr campground). Extensive channel braiding, high wood complexity, and mature riparian canopy were all noted throughout the next 2 miles with a final increase in gradient to 2.2%. Trib A enters at RM 23.56 with high flow, cold water and very low numbers of steelhead parr.

In the last 1.5 stream miles, mainstem flows quickly dissipate with each tributary contribution. Pools become isolated from each other and are summer linked only hyporehicly. Cutthroat and 0+ trout densities climbed throughout this stretch with a peak cutthroat density of 1fish/sq m at RM25.8 and a peak 0+trout density of 2.9 at RM 25.4. Though these values represent fully seeded pool capacities the lack of riffle habitat has concentrated the fish populations in pool habitats boosting summer density profiles. These density values were among the top 4 highest densities recorded in the entire Tualatin basin.

Gradients continue to increase to an average of 3.7% near the end of the surveyed stream reach. There was also a decrease in pool complexity and an increase in the d50 for the dominant cobble substrates. The survey terminates at an 8ft bedrock falls above a canyon pinch at RM 26.5.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	2,275	.13	8,205	430	1,585

Bateman Cr (Tributary of Gales)

Bateman Cr joins mainstem Gales at USGS RM 16.25. The Bateman Cr survey extended .6 miles. Coho were observed in low densities for .5 miles and ended at a 3ft high sill log pour. This was most likely not an adult barrier. Two culverts were observed that definitively terminate upstream temperature dependent juvenile migrations. The first was observed at RM 0.42 and was perched 1.5 ft (Photo 6). The second exhibited a 1ft perch and was above the current end of coho distribution at RM 0.6.

Photo 6

Pool densities for coho averaged 0.32 fish/sq m with the highest density of 0.8 fish/sq m observed below the perched culvert at RM .42. An expanded estimate of 175 juvenile coho was observed within

Bateman Cr. Low coho numbers above the juvenile in Photo 4 barrier indicate that a single pair of coho spawned in Bateman Cr.

0+ trout numbers were low with an average density of 0.45 fish/sq m.

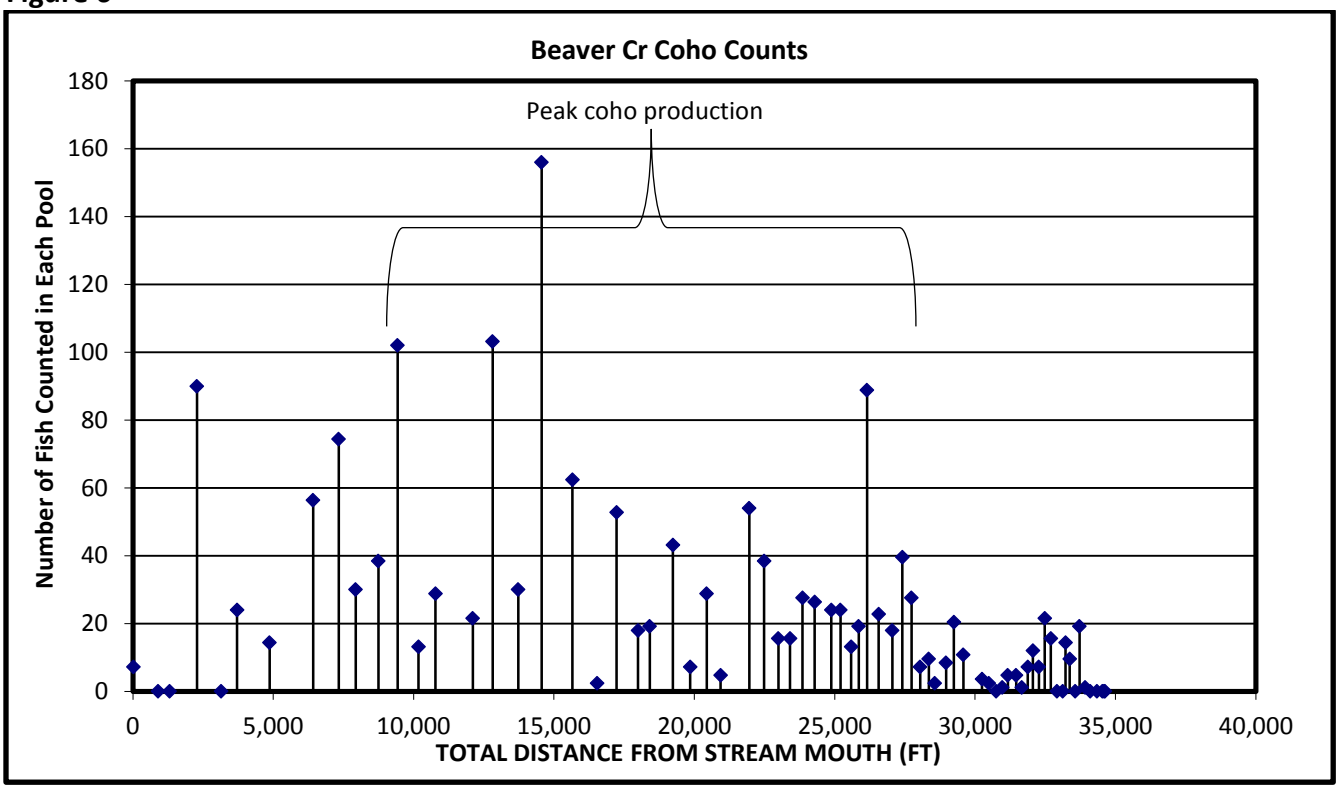
Water temperatures in Bateman Cr were lower than observed in mainstem Gales. The presence of a series of natural bedrock sills in the mainstem of Gales Cr just above the confluence of Bateman ramps up the prioritization of this culvert replacement for unimpeded access to cold water refugia for juveniles rearing in mainstem Gales Cr. Substrates were dominated by silt and cobble, no well sorted spawning gravel was observed. Fish distribution patterns indicate that Bateman Cr. is serving as cold water refugia for juveniles migrating out of mainstem Gales Cr. The lack of sorted gravels in Bateman Creek combined with heavy silt loading suggest that it's not a productive target for adult escapement. Its importance lies in its location near the top end of a known upstream temperature dependent migration route.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	175	0.32	250	0	115

Beaver Cr (Tributary of Gales)

Beaver Cr enters the mainstem of Gales Cr at USGS RM 18. Beaver Cr is the largest of the Gales Cr tributaries and exhibited an anadromous distribution that extended 6.5 stream miles. Coho distribution in 2012 terminated at a series of ephemeral sill log barriers. Anadromous potential continues above these barriers. Coho densities peaked at RM 6.2 at 1.9 fish/sq m. Though the density peak was high in the basin (associated with spawning location), the peak production spanned the middle half of the distribution with more than twice as many fish/mile observed between RM 1.8 and RM 5.2 (Figure 6).

Figure 6



The entire Beaver Cr subbasin contains at least 9.6 miles of stream habitat accessible to anadromous fish. This includes 6 tributaries labeled A – F in the Excel Pivot table workbook (contact TRWC). It should be noted that limited access prevented a full inventory of Tributary A. Tributaries A, B, and C made significant contributions to the total population estimate and will be reviewed separately below. The fish population estimates for Tribs D, E, and F are included in the mainstem Beaver Cr totals. Trib D enters at RM 5.5. Low densities of Coho were observed utilizing the first pool of Trib D below a 4ft perched culvert (inaccessible). Trib E enters at RM 5.9 and contributes approximately 40% of the flow at its confluence. Coho were only observed in the pool below a rusted out culvert perched 1.5ft above the stream channel just above the confluence (inaccessible). Trib F enters at RM 6.4. An expanded estimate of 50 coho were utilizing 0.2 miles of stream habitat in Trib F. A juvenile barrier created by a root wad ended their distribution.

Beaver Cr was the largest producer of coho in the Gales Cr subbasin. The expanded estimate of 12,700 coho parr represents 47.4% of all coho observed rearing in the Gales Cr subbasin. Back calculations from the standing crop of summer parr suggest an escapement of 57 spawning pair of adult coho to Beaver Cr and its tributaries. The low gradient (averaging 0.6%), siltstone/sandstone dominated channel morphology, high wood complexity, and mature riparian canopy provided favorable conditions for successful coho production in the Beaver Cr drainage (Photo 7).

Photo 7

0+ trout and cutthroat abundance were low throughout the inventory.

There were no steelhead parr observed rearing in the Beaver Cr system. The habitats here favored the niche exploited by coho and cutthroat. The large cobbles and higher gradients preferred by steelhead were not present.

Heavy tannins resulted in poor visibility in the lower mainstem, lowering the accuracy of the snorkel methodology. This suggests that the expanded estimates underestimate the actual population of coho parr as well as the reported adult escapement estimates.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	8,750	.38	310	0	225

Trib A (Tributary of Beaver)

Tributary A joins the mainstem of Beaver Cr at Rm 0.7. This is just above the beginning of coho distribution in the mainstem. Trib A provides low summer flows and is low gradient.

Eight beaver dams were encountered as the stream channel meanders across a wide and exposed floodplain (legacy beaver flat). Substrates were dominated by silt and Reed Canary grass overwhelms adjacent floodplain terraces here. Above the beaver swamp, the habitat is described as transitioning to well sorted gravels, a conifer dominated riparian canopy and a highly sinuous with high wood complexity.

Coho numbers were high throughout the 1.4 mile survey with an average density of 2.75 coho/sq m. The peak density of 4.3 coho/sq m was observed at RM 0.3. Trib A had the highest average density observed in the Gales Cr subbasin. A lack of landowner permission at RM 1.4 prevented the survey from describing the full extent of salmonid distribution. The trend in abundance suggests that the peak production zone may have been above the current survey endpoint. Based on a topographic review (USGS), it is unlikely that coho production persisted for more than an additional 0.5 miles.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	588	2.75	10	0	30

Trib B (Tributary of Beaver)

Tributary B enters mainstem Beaver Cr at RM 3.3. The inventory of Trib B extended 1.2 miles to the end of Coho distribution. With an expanded estimate of 1,681 coho Trib B was the largest producer of coho within the combined suite of Beaver Cr tributaries. A failed culvert perched 4in and rusted through the bottom was observed blocking upstream juvenile migration 290ft above the Beaver Cr confluence.

The channel morphology was described as low gradient and sinuous with a gravel dominated substrate and high wood complexity. Coho distribution in Trib B exhibited a defined spawning peak of 3.1 Coho/sq m at RM 0.75. This peak in density overlaps an area with extensive beaver use. Coho abundance declines as the gradient increases. The upper end of current distribution transitions to a cobble dominated stream bed and a more confined channel. No adult barriers were observed.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	1,681	1	65	0	50

Trib C (Tributary of Beaver)

Trib C joins mainstem Beaver at RM 3.5. The inventory extended 0.7 miles to the confluence of Trib C1. Trib C1 continued for 0.5miles contributing the majority of the flow to the system and containing the remainder of stream habitat with anadromous potential. In Trib C no Coho were observed above the confluence as it quickly entered a zone of legacy beaver activity with several large dams in a broad swamp. The abundance data for Trib C and C1 have been combined for consistency in the table below. Coho distribution extended 1.3 miles.

The stream habitat throughout the lower portion of the survey was described as low gradient and sinuous with an exposed channel meandering across a wide floodplain with low interactive winter terraces. Though the highest density of 3.4coho/sq m was observed at RM 0.9, 63.2% of the total Coho observed, were rearing it the lower ½ mile.

Throughout the survey 3 culverts were observed as barriers to upstream juvenile migration. The 1st culvert, just up from the confluence at the crossing of Timber Rd, is perched 4in and rusted out. All of the summer flow was observed passing through the floor of the culvert and not out the end. Adult passage through this culvert was also compromised by steel bars on the inlet end that trap debris and seasonally deny access. Coho were observed in high concentration in the pool below this culvert, indicating a blocked upstream summer migration to thermal refugia.

The 2nd culvert, located at RM 0.23, is perched 1.5ft, undercut and rusted out. The deep plunge pool below this culvert and high tannin levels frustrated an accurate count using the snorkel methodology. We were unable to verify the existence of an upstream migration pattern at this site. The 1.5ft perched pipe is however a definitive barrier to upstream juvenile migration.

The 3rd culvert was observed in Trib C1, 185ft above the confluence with Trib C. These two side by side steel culverts were completely rusted out with all flow passing underneath. The inlets were packed with debris along with a 1ft sill log. This culvert is located in the reach of the highest Coho densities.

Visibility was poor for the 1st 0.3 miles of the survey. This was attributed to a zone of extensive beaver use. It is likely that abundance estimates underestimate the actual abundance in this reach.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	1681	1.1	40	0	55

Clear Cr (Tributary of Gales)

Clear Cr joins the mainstem Gales at USGS RM 10.6. The Clear Cr inventory extended 3.3 miles to just above a steep 10 ft. bedrock cascade that terminates anadromous access (Photo 8). Clear Cr was one of the top 3 producers of salmonids within the Gales Cr subbasin.

Photo 8

The confluence of Clear Cr exists within the temperature limited reach of the Gales Cr mainstem. The spatial location of Clear Cr identifies it as an important source of thermal refugia for juvenile salmonids during the summer temperature pinch period. The protection, conservation and enhancement of water quality parameters in Clear Cr is critical for maintaining system function for salmonids. The maintenance of its current contribution of cold water and high complexity stream habitat should be ranked highly on basin scale reviews of goals and objectives.

Very high fish densities in the first pool above the confluence of Gales Cr indicate the presence of a definitive upstream migration out of mainstem Gales Cr. As Clear Cr climbs out of the influence of the Gales floodplain, a canyon pinch and a bedrock intrusion/cascade present a potential summer barrier to juvenile migration (Photo 9). Fish abundance for Clear Cr was not expanded utilizing the unusually high concentration of fish in this highly complex 1st pool because it did not represent conditions directly upstream.

Photo 9

A one mile reach of stream habitat treated with LWD extends from RM 1.3 to 2.3. The restoration occurred in 2012. An RBA fish inventory was conducted for the treatment reach on 9/10/12 prior to the projects execution. The 2013 inventory was conducted one month earlier on 8/6/13. In a comparative review of pre and post treatment effect a few elements stand out.

1) Steelhead were not observed in 2012, in 2013 there was an expanded estimate of 30 sthd within the treatment reach.
2) 0+ trout numbers increased by 143%. This is likely due to the additional presence of steelhead parr and higher egg to fry survival rates from the deep accumulations of spawning gravel observed in the reach post treatment.
3) Coho numbers increased by 323%, adult escapement over Willamette falls increased by only 94%. This may also suggest a higher egg to fry survival rate post treatment or an effective increase in the abundance of spawning gravel (unfortunately spawning gravel abundance was not documented pre project).
4) Cutthroat numbers declined by 33%. This may be more related to differences in migration timing for fluvial components of the population that change between the August and September time frame (difference in pre and post survey timing).

(Table 6) Expanded Clear Cr Comparison for Treatment Reach

Years	coho	0+	steelhead	cutthroat
2012	631	410	0	195
2013	2,669	1,000	30	130

- 20% visual bias included for coho expansion

Coho were observed at a peak density of 6.25coho/sq m and a high count of 245(visual bias included) in the first pool. This was the 2nd highest density observed in the Tualatin basin. A spawning peak was observed at RM 1.75 with a high density of 1.7coho/sq m. This spawning peak occurred within the LWD treatment reach. Expanded population estimates suggest an adult escapement of 26 pairs of coho.

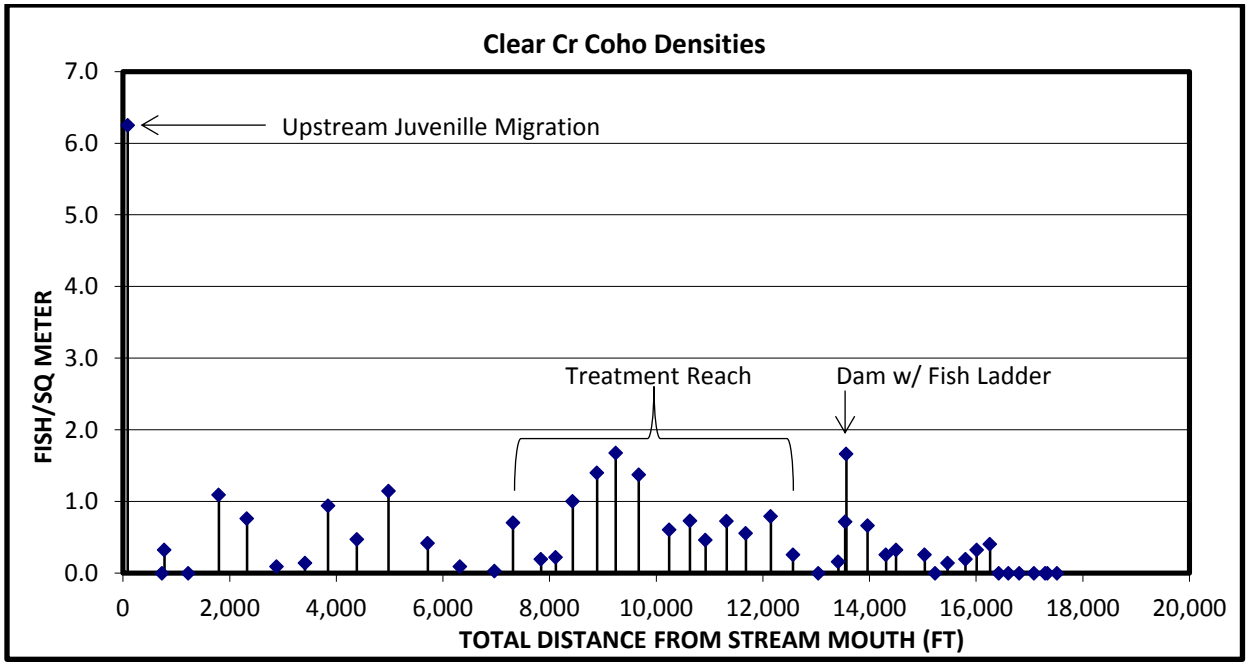
Steelhead were observed at a peak density of 0.23sthd/sq m in the first pool. Though this value is well below full seeding capacity it was among the highest values observed in the Gales subbasin (also verifying the existence of an upstream temperature dependent migration). Steelhead numbers were low and sporadic but persisted to the end of anadromous potential. Clear Cr exhibited the highest abundance of steelhead among the tributaries in the Gales subbasin.

Cutthroat were observed at a peak density of 1.0 fish/sq m and a very high count of 37 also in the first pool. Abundance was low throughout the remainder of the inventory averaging 0.13 fish/sq m.

0+ Trout abundance was moderate averaging 0.54 fish/sq m. The highest pool counts were documented just below the treatment reach (Photo 10).

Photo 10

Figure 7



Clear Cr provides a municipal water supply to the city of Forest Grove. The concrete diversion and intake dams on Clear Cr and Roaring Cr exist within the range of anadromous fish distribution. The Clear Cr structure is outfitted with a fish ladder for passing adult salmonids. The progeny of both coho and steelhead were observed rearing above the diversion dam indicating successful passage. The concrete dam on Roaring Cr is not outfitted with a passage structure and terminates both adult and juvenile passage. Above the dam the high gradient, cobble/boulder dominated stream habitat offers limited anadromous potential and a 20 ft boulder falls at RM 0.5 naturally terminates historical access.

Thomas Cr enters Clear Cr at RM 1.5. The first pool was observed with a coho density of 4.4 fish/sq m. Shortly above this pool a 10ft perched culvert blocks adult and juvenile passage. Above the culvert the gradient quickly increases over boulders and root wads. Very limited anadromous potential exist in Thomas Cr and no recommendations for the provision of passage are appropriate.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	5,705	0.75	3,025	140	605

Coffee Cr (tributary of Gales)

Coffee Cr joins mainstem Gales at USGS RM 19.75. The Coffee Cr inventory extended 1.2 miles ending in a legacy beaver swamp. Coffee Cr enters cold over bedrock steps and boulders with a 2in perched culvert set above. Both the gradient and the substrate at the confluence, though not a definitive barrier, would complicate upstream juvenile passage.

Above the confluence, the stream exhibits habitat characteristics with anadromous potential to approximately RM 1.0. No coho or steelhead were observed in Coffee Cr. 0+ trout and cutthroat densities were low throughout the inventory. No obvious reason for the observed low fish abundance were apparent.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	0		325	0	45

Finger Cr (Tributary of Gales)

Finger Cr joins the mainstem at USGS RM 20. Low flows over a low gradient pitch of cobble and small boulders describes the confluence. The survey extended 0.6 miles.

Coho densities were low with a peak of 0.65 coho/sq m at RM 0.23. The presence of coho above several natural juvenile barriers suggest that a single spawning event occurred with low egg to fry survival. The noted presence of a high silt load and the lack of sorted gravels suggests the presence of low egg to fry survival rates.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	156	0.4	45	0	30

Iler CR (Tributary of Gales)

Iler Cr enters the mainstem at USGS RM 11.33 just below the Gales Cr Hwy Bridge. The confluence is described as exhibiting a cold contribution and a medium gradient riffle over bedrock. 580 ft above the confluence, below the first bridge, a series of 1ft concrete steps are a juvenile barrier to upstream migration (Photo 11). The removal of this artificial barrier is a high priority restoration action because of the spatial relationship of Iler Cr to the temperature limited reach of mainstem Gales Cr.

Photo 11

Coho distribution extended for 2.5 miles at an average gradient of 1.5% and was terminated at a natural log jam. With the log jam classified as an ephemeral barrier, the inventory continued to the end of anadromous potential. An additional 1 mile of stream habitat was described as having: a sinuous channel, an interactive low floodplain, high wood complexity, excellent gravel sorting in pool tailouts, and a mature coniferous riparian corridor. This included two tributaries that contributed short reaches of functional habitat.

Iler Cr contributed 9.9% of all coho observed in the Gales Cr basin. At RM 1.9 Coho population estimates exhibited a defined spawning peak with a density spike of 1.7 Coho/sq m and the highest pool count of 59 (visual bias included). Expanded population estimates suggest an adult escapement of 12 pairs of adult coho.

Steelhead were observed in sporadic distribution and very low densities for 1.5miles.

0+ trout densities averaged 0.6 fish/sq m. This value is well under full seeding capacity, but among the top 3 highest averages for all of the primary tributaries of the Gales Cr subbasin. Densities peaked with 2.3 fish/sq m at RM 3. Iler Cr was also among the top 3 streams for the entire Tualatin basin with 9.2% of all 0 age trout fry observed here.

Cutthroat densities were low with an average density of 0.13 fish/sq m. Higher densities were observed in two of its tributaries, Tribs A and B. Trib A showed the most potential with gravel sorting and beaver documented in the lower reach. The highest cutthroat density was observed in a tributary to Trib A where just above its confluence and below a 2.5 ft. perched culvert, a density of 0.84 fish/sq m (including a few older age-class cutthroat) was recorded.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	2,662	0.43	3,770	25	735

North Fork Gales

NF Gales joins the mainstem at USGS RM 21.7. The confluence is within an LWD treatment reach on mainstem Gales (Photo 12). Treatment extends up the NF Gales Cr from the confluence to RM 0.6. The inventory extended to RM 1.5 where reduced stream flow and coarse substrate diminishes anadromous potential (spawning and rearing). No adult barriers to passage were observed.

Coho distribution extended to RM 1.3 and was terminated by a natural sill log with a 4 ft perch (ephemeral). The peak Coho density of 2.7 fish/sq m was observed within the treatment reach at RM 0.4. In addition, 79% of the total population estimate for Coho in the NF Gales was documented rearing within the treatment reach.

An average gradient of 2.5% was measured for the treatment reach. An average gradient of 4.2% was observed for the remainder of anadromous fish distribution.

Steelhead numbers were low and sporadic. Steelhead distribution extended to RM 0.8. White fungus was observed on the pectoral fins of several steelhead parr.

Cutthroat densities increased in the upper reach above coho distribution. A density spike of 1.0 fish/sq m was observed in the last pool surveyed, at the base of a sill log pour. This was the 3rd highest cutthroat density observed in the Tualatin basin. This pool was located in a reach where pool habitats lacked connectivity due to isolation resulting from dry intermediate channels (deep bedload accumulation, high quality hyporehic storage).

Photo 12

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	1,013	1.04	935	50	220

South Fork Gales

SF Gales joins the mainstem at USGS RM 20.7. SF Gales is a high flow, cold water tributary with a low gradient confluence. Coho distribution extended to only RM 0.3. The inventory continued to RM 1.6 where a 15 bedrock falls permanently terminates anadromous migration (Photo 13).

A span of only 10 pools that extended approximately 1,100 ft were observed rearing coho parr. Coho densities peaked at 2.4 fish/sq m in the middle of this distribution at the pool that probably contained the single spawning event that occurred in SF Gales.

There were no steelhead observed rearing here and cutthroat densities were low at 0.13 fish/sq m.

Photo 13

Above Coho distribution a gradient increase that averages 4%, an incised stream channel and the lack of sorted spawning gravel limit the capacity of the habitat for significant salmonid production. SF Gales Cr is a cold water contributor to the mainstem but the mainstem at its confluence did not appear to be functioning as temperature limited (no need for juvenile salmonids rearing in the adjacent mainstem to seek thermal refugia).

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	656	1.35	1,040	0	210

White Cr (Tributary of Gales)

White Cr enters mainstem Gales at USGS RM 14.2. The inventory extended to the end of Coho distribution at RM 0.76. No adult barriers were observed, field notes however indicate an increase in gradient (5.7%) and a lack of spawning gravel limit salmonid production potential above the current documented end of coho distribution.

A defined spawning peak of 5 fish/sq m was observed at RM 0.3. An average stream gradient of 2.7% was observed throughout the extent of coho distribution.

White Cr's cool summer temperature profile and spatial location within the temperature limited reach of mainstem Gales Cr suggests that it has the potential to function as thermal refugia during summer flow regimes. The first pool of the inventory was below a 1ft perched culvert. The high counts of Coho in this pool suggest that the culvert is blocking upstream temperature dependent migrations. From mainstem Gales Cr.

The first ½ mile of the inventory observed an exposed stream channel and a thin riparian buffer resulting from a legacy of agricultural impacts.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	1,463	1.64	75	0	90

EF Dairy Subbasin

The EF Dairy drainage contained 24.75 miles (mainstem and tributaries combined) of inventoried stream habitats. This comprises 18% of the total miles inventoried in the Tualatin basin. EF Dairy Cr contained some of the highest quality stream habitat observed in the Tualatin basin and was responsible for a large percentage of all salmonids documented rearing in the Tualatin basin.

Though 9 tributaries were included in the inventory, the mainstem was observed rearing the vast majority of salmonids. Many of the tributaries were observed with high gradient confluences which continued to increase with distance as they climbed out of the EF Dairy Cr canyon. Most of them exhibited a decrease in gradient further upstream (headwater flats) once out of the mainstem canyon, but none of the tributary reaches were rearing salmonids to full capacity.

EF Dairy Cr maintains high summer flows and low summer temperature profiles throughout the extent of the survey (both attributes that are foundational for successful salmonid production). These system attributes are responsible for the observation that the summer distribution of coho and cutthroat extends 5 miles below the range of spawning potential in the mainstem of EF Dairy Cr. This is an important comparison to the other surveyed subbasins within the scope of this Assay (Gales, WF Dairy McKay) whose mainstem reaches were consistently temperature limited and over allocated for withdrawal well up into the range of available spawning habitat.

(Table 7) Expanded East Fork Dairy Subbasin Estimates

Stream	Coho	%	0+	%	Sthd	%	Cut	%
East Fork Dairy	35,175	94.8	8,180	65.5	1,950	99.2	2635	69.8
Side Channel A	234		9					
Side Channel B	284		25				6	
Side Channel C	75		5					
Big Canyon	163		65				30	
Campbell	388	1	1,280	10.2			280	7.4
Denny	419	1.1	1,205	9.6	5		285	7.5
Murtaugh	150		125	1	10		180	4.8
Panther			130	1			20	
Plentywater	7		135	1.1			40	1.1
Rock	219		1,095	8.8			265	7
Roundy	6.25		195	1.6			35	
Trib A	6.25		40					
Inventory Total	**37,124**		**12,489**		**1,965**		**3,776**	

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

EF Dairy Mainstem

The EF Dairy inventory began at the Highway 26 crossing and extended 15.5 miles upstream at which point reduced flows and natural debris jams limited anadromous potential. All stream miles in the EF Dairy Cr discussion are referenced from the start point at the Hwy 26 crossing as RM 0. Coho distribution ended at RM 14.3. Steelhead distribution ended at RM 15. No permanent adult barriers to passage were observed. Representing 11.2% of the total stream miles inventoried in 2013 for the Tualatin basin, the EF Dairy mainstem was observed rearing 39% of all coho observed (basin scale), 20% of its 0+ trout, 71% of all steelhead, and 22% of all cutthroat.

From the start point to RM 5 the stream habitat is characterized by low gradient (0.15% average), entrenched banks, deep silt deposits, and brushy banks with debris jams. Low densities of coho and cutthroat were present throughout.

Above RM 5 (Photo 14), spawning gravel, balanced pool to rifle ratios and the potential for floodplain interaction during winter flow regimes all began to set up to form a functional anchor habitat reach. The abundance of all salmonid species increased rapidly above this point and continued to improve for several miles. Peak coho and steelhead production occurred between RM 8-10 in a zone expressing an average gradient of 1.2%. This reach overlaps a geologic unit transition from the alluvial deposits that characterize the lower mainstem to the marine sedimentary and tuffaceous layers that comprise the upper mainstem. In this high production reach, extensive gravel sorting was observed in pool tailouts and channel sinuosity was exceptional (1.3). Side Channels A, B, and C were all within this reach. A thin riparian canopy and a lack of interactive LWD was commonly noted. A white haze on the entire dermal layer (similar to the symptoms of cold water disease) and pectoral fungus were frequently observed.

Photo 14

Parr distribution trends indicate that two significant coho spawning peaks occurred in the EF Dairy Cr mainstem. The first with a density spike of 2.9 fish/sq m at RM 9.9 (0.45 miles below the confluence of Plentywater Cr) was observed just upstream of Side Chanel C with the highest pool counts in the basin occurring in the pool habitats just downstream. Following this first zone of peak spawning action the canyon tightens and a series of cobble/boulder riffles dominate the next 2 miles of stream corridor to a 3ft bedrock falls that functions to terminate upstream juvenile migrations.

A rapid decline in coho abundance was observed throughout this 2 mile segment of the mainstem. The second spawning peak occurs above the falls near RM 14 with a density of 2 coho/sq m. Channel characteristics here exhibit braiding over a wide flood plain. Shortly above this highly interactive floodplain section an increase in gradient (averaging 7.5%) over bedrock is observed with a 1 ft bedrock falls marking the end of coho distribution in 2013 (this is an insignificant barrier for adults and does not describe the permanent end of anadromy, Photo 15). Back calculating from summer parr abundance (w/ side channels included) suggest an adult coho escapement of 162 pairs for the EF Dairy Cr mainstem.

Photo 15

Steelhead exhibited a bimodal distribution similar to coho between RM 6-14, with the highest counts of both species recorded from RM 6-10. The two highest densities observed were 0.29 sthd/sq m, below the 3ft falls at RM 11.8 and 0.24 sthd/sq m, below the 1ft falls at RM 14.3 (Photo 15). Indications are that there may be upstream movements occurring in the mainstem of EF Dairy as well.

Cutthroat and 0+ trout densities exhibited similar relationships to the two barriers described at RM 11.8 and RM 14.3. 0+ trout were observed at 3.1 fish/sq m and cutthroat at 0.7 fish/sq m below the barrier at RM 11.8. The distribution profiles of cutthroat and 0+ trout resembled those of coho and steelhead with bimodal increases in abundance occurring at the exact same locations.

Figure 8

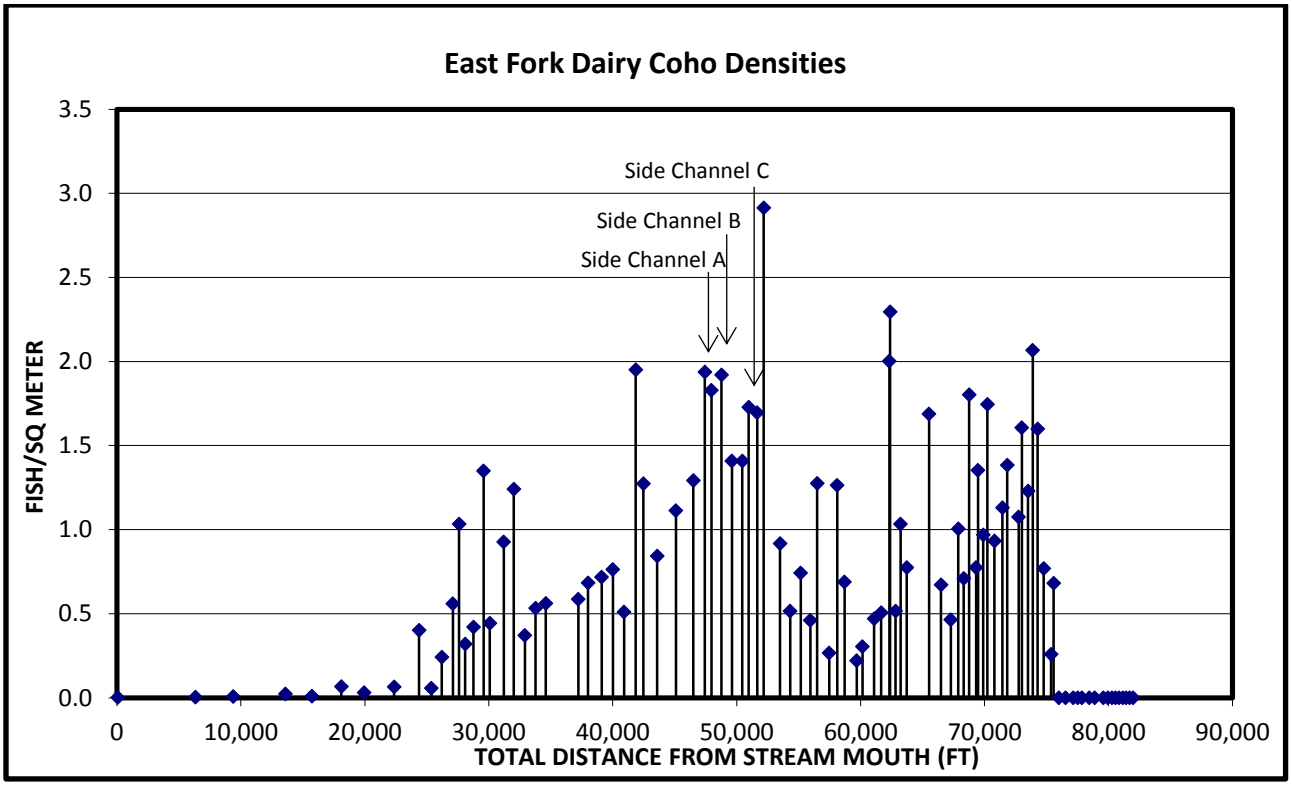
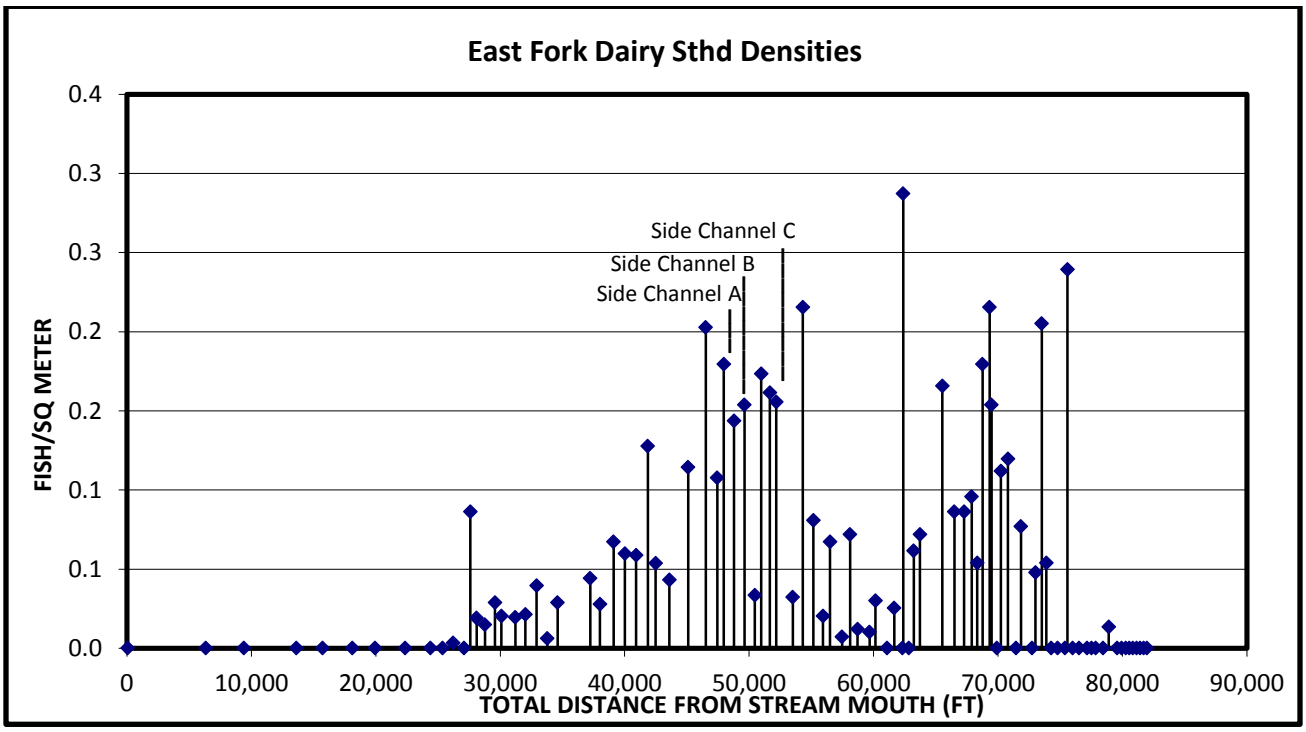


Figure 9



Above the juvenile barrier and gradient increase to 7.5% that ended coho and steelhead distribution, the gradient decreased to an average of 3.7% and high quality stream habitats for salmonid rearing continued for an additional mile. Well sorted gravel, significant channel meander and low interactive floodplain terraces were observed. High wood densities were also noted throughout this upper reach. The quality of the habitat suggests that in years of higher adult escapement (the current primary limiting factor) over Willamette Falls that this habitat would be also be utilized for spawning and rearing. Currently there is more high quality habitat in the subbasin than is being utilized by salmonids.

Even though 3 functional side channels were observed rearing high densities of coho parr, side channel habitats did not appear to be serving a critical function in the EF of Dairy Cr. Instead they appear to be adding to the capacity of an already high quality mainstem that is currently under seeded. With that said, there is no doubt that these side channel habitats provide some of the highest quality winter refugia in the mainstem. Only Side Channel A (of the 3 side channels documented) that enters at RM 9, appeared to be serving as thermal refuge. Side channel A provided connectivity to the mainstem at the bottom and was delinked from the mainstem at the top (Photo 16). This allows hyporehic subsurface flows percolating through bedload to well up in the lower end of the side channel and develop a thermocline protected from mainstem flows. The provision of these cold pockets attracts large numbers of salmonid parr in temperature limited stream corridors (Photo 17). Coho densities in side channel A were exceptional at 4.8 fish/sq m.

Photo 16

Photo 17

Side Channel B enters at RM 9.2 and was observed functioning like an extension of the mainstem with contiguous surface flows and no hyporehic expression. High wood complexity and high quality spawning gravels were noted throughout this side channel. Densities above full seeding capacity were observed in every pool of the side channel with the peak pool density of 7.3 fish/sq m being the highest documented in all of the inventoried Tualatin basin.

Side Channel C contains low summer flow (still mainstem linked), is shallow and cobble dominated. Consisting of only 3 small pools, its contribution was small but educational. Densities were again high at 6 fish/sq m and the existence of this isolated pool life history should suggest to managers that maintaining this type of habitat diversity is critical for supporting genetic resilience. Side Channel C was located at RM 9.8 and just below the peak coho densities observed in the EF Dairy Cr mainstem.

Out of the 9 tributaries inventoried in the EF Dairy subbasin, only 2 appeared to have provided spawning habitat for coho; Denny and Campbell. The rest (except Panther Cr) exhibited only upstream temperature dependent migrations of juveniles from the mainstem of EF Dairy. These migrations never extended more than 1,300 lineal ft (displayed by decreasing densities with increased lineal distance from the mouth and fish distribution ending below the first juvenile barrier). This upstream migration pattern displayed in at least 6 of the 9 tributaries of mainstem EF Dairy Cr suggest the need of summer rearing salmonid juveniles to find thermal refugia from the mainstem.

Big Canyon enters EF Dairy at RM 7.6. Coho were observed at a peak density of 2.6 fish/sq m in the first pool. Coho distribution extends for 0.3 miles. The stream within the surveyed reach displays a mature coniferous riparian canopy and high wood complexity. A lack of sorted spawning gravel and shallow silty pools was also documented (not a concern when the function of the habitat is to provide pinch period thermal refugia).

Murtaugh Cr enters EF Dairy at RM 8.5 (just below the Meacham Rd crossing). Coho were observed at a peak density of 0.82coho/sq m in pool #1. A 6ft bedrock falls with a shallow jump pool terminated both adult and juvenile migration access at RM 0.16. A few steelhead were observed with pectoral fungus in the pool below the falls.

Panther, Plentywater, Roundy, and Trib A all exhibited limited anadromous potential. Steep gradient, shallow pools, and lack of spawning gravel were noted as the primary limitations.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	35,175	0.92	8,180	1,950	2,635

Campbell Cr (Tributary of EF Dairy)

Campbell Cr joins the EF Dairy mainstem through a 2.5 ft perched, rusted out and undercut culvert at RM 13.3 (just below the gate where Powerline Rd enters). The culvert (Photo 18), a definitive juvenile barrier, was passed by adult coho in 2012.

Photo 18

A peak coho density of 2.4 fish/sq m was observed 545 ft above the culvert. Coho extended 0.5 miles to where a series of ephemeral log jams associated with a gradient increase in a canyon pinch ended anadromous distribution. Expanded population estimates suggest an adult coho escapement of 2 spawning pairs. An average gradient of 3.3% was observed throughout coho distribution.

Anadromous potential continued above the canyon pinch. Field notes describe a slight decrease in gradient to 3.2%, gravel sorting and high wood complexity extending to the confluence of a tributary at RM 0.9. This unnamed tributary of Campbell Cr also exhibited anadromous potential that extended for approximately 0.25 miles. Increased gradient and a series of ephemeral log jams barriers limits access to any additional habitat upstream. Within this tributary, at RM 0.63 another perched culvert was observed with a 3.5ft perch. A high concentration of cutthroat was observed below this pipe suggesting the presence of upstream migration behavior.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	388	0.75	1,280	0	280

Denny CR (Tributary of EF Dairy)

Denny Cr enters the EF Dairy Cr mainstem at RM 11 (just below the Dairy Cr Bridge crossing where Fern Flat Rd starts). Coho and steelhead distribution extends 0.8 miles to 2ft sill log spilling onto bedrock. A combined increase in gradient (to 5.2%) and a series of log jams terminate access to habitats further upstream.

Pool densities for coho peaked 500 ft above the confluence with EF Dairy suggesting the presence of an upstream juvenile migration out of the mainstem. The expanded population estimate for Denny Cr indicates that 1- 2 pairs of adult coho successfully spawned in the tributary.

Steelhead were observed sporadically and in low numbers. The presence of steelhead here is most likely the result of an upstream temperature dependent migration and not a spawning event (based on an analysis of distribution). An average gradient of 3% was documented through the range of anadromous distribution.

Cutthroat exhibited two separate density peaks representing differences in abundance related to the lack of inter specific competition in the upper reaches above anadromous access. The first spike of 0.6 fish/sq m at RM 0.3 is representative of upstream migration out of the mainstem. The 2nd spike of 0.6 fish/sq m at RM 1.7 probably represents nearly full seeded habitats for an isolated component of the cutthroat population.

0+ trout densities peaked in this zone at 1.6 fish/sq m (RM 1.5).

Surveyors noted a lack of sorted spawning gravel throughout the inventory with the average substrate described as cobble and small boulder. Wood complexity increased further upstream with large coniferous logs noted in the active stream channel.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	419	0.68	1,205	5	285

Rock Cr (Tributary to EF Dairy)

Rock Cr enters the mainstem at RM 11.7 (just above the Greener Rd crossing). The confluence was described as high gradient, high flow and cold. The inventory extended 2.1 miles with no permanent anadromous barrier observed. This is an especially important tributary for the greater EF Dairy subbasin because of its high volume cold water contribution during pinch period flows. We would recommend taking a closer look at potential conservation measures that would protect and or enhance riparian buffers within Rock Cr for the maintenance of mainstem EF Dairy water quality parameters.

Coho extended 0.32 miles to just the first juvenile barrier. A peak density of 2 coho/sq m was observed in the first pool. A review of habitat conditions indicate a lack of spawning gravel, bedrock/boulder dominated substrate, and high gradient (9.5% average) throughout coho distribution. It appears that all of the coho documented were the result of an upstream temperature dependent migration from the mainstem. It is unlikely that adult coho spawned in Rock Cr in 2012.

Cutthroat abundance was moderate with an average density of 0.34 fish/sq m (127 fish/mile)
No steelhead were observed.

0+ trout abundance was moderately high with an average density of 1 fish/sq m (526 fish/mile) and a peak density of 2.9fish/sq m at RM 1.9. This value is considered near full seeding in high quality stream habitats. This density was observed in the upper reach where subsurface flows had limited the abundance of riffle habitat for rearing and concentrated fish in isolated pool habitats. Cutthroat densities also peaked in this reach at 0.9 fish/sq m.

Steep gradients continued above coho distribution to an ephemeral adult barrier at RM 0.68. Above the log jam notes described a gradient decrease, channel meander, a low interactive floodplain, and gravel sorting.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	219	1.19	1,095	0	265

WF Dairy Cr Subbasin

The West Fork Dairy Subbasin contained 28.3 miles (mainstem and tributaries combined) of stream habitat with anadromous potential. Coho parr were currently utilizing only 67% of this habitat. Cutthroat trout were not observed in the first 5 miles of the mainstem inventory but were present in low densities throughout the remainder. No steelhead parr were observed in the WF Dairy subbasin.

Within this palmated drainage the 9 tributaries of WF Dairy constituted 66% of the inventoried stream miles and were observed rearing 81% of the coho parr, 74% of 0+ trout, and 76% of cutthroat trout.

The dominant channel morphologies were characterized by low gradient, wide floodplain, siltstone/sandstone substrate, and sinuous channel meander. The lower reaches of the WF Dairy mainstem and most of its tributaries displayed evidence of heavy impacts to riparian corridors and water quality as a result of the human foot print. The effects of this legacy include but are not limited to: thin or no riparian canopy, deeply entrenched banks from the clearing and channelization designed to accelerate winter runoff, bank stabilization restricting channel migration, silt deposits burying spawning gravels, infestation of invasive species and large amounts of refuse commonly deposited in the active stream channel (Photo 19).

(Table 8) Expanded West Fork Dairy Subbasin Estimates

Streams	Coho	%	0+	%	Cut	%
West Fork Dairy	2,544	19	1,205	25.3	375	24
Burgholzer	888	6.6	470	9.9	115	7.3
Cedar canyon			335	7	180	11.5
Cummings	175	1.3	430	9	50	3.2
Garrigus	2,794	20.9	240	5	150	9.6
Kuder	94		15		25	1.6
Mendenhall	2,931	21.9	995	20.9	395	25.2
Trib A	388	2.9	295	6.2	60	3.8
Whitcher	2,038	15.2	525	11	125	8
Williams	1,519	11.4	260	5.5	90	5.8
Inventory Total	**13,369**		**4,770**		**1,565**	

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

Photo 19

Visibility was poor throughout the lower reaches of the mainstem and tributaries. Heavy tannins restricted the range of visibility, thick brush covered the banks, and thermoclines forced salmonids into deeper colder water. The accuracy of the snorkel methodology in the lower mainstem was reduced by these conditions and the resultant estimates of abundance probably underestimate actual abundance.

WF Dairy Mainstem

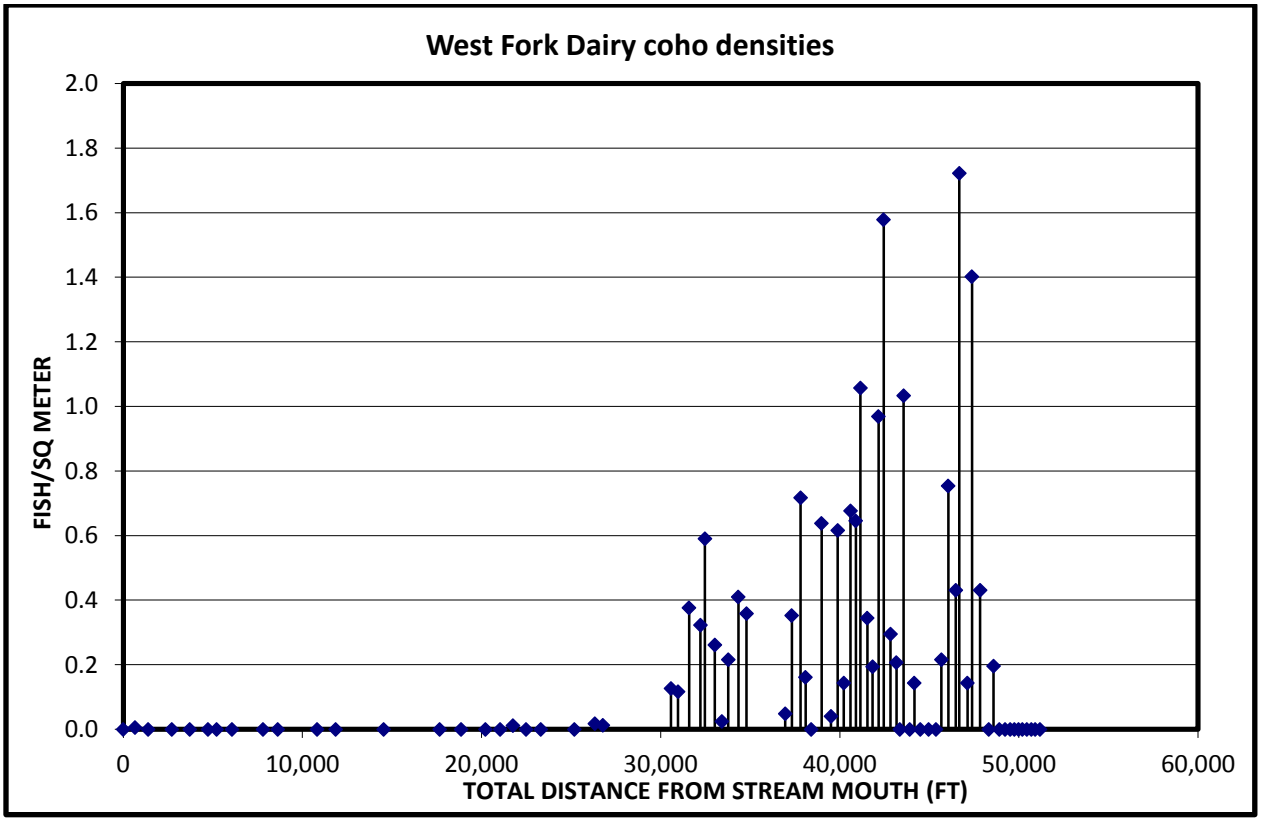
The West Fork Dairy inventory began 1000 ft above the confluence of Garigus Cr (about a 1/2 mile above the Green MT Rd crossing). Low gradient (0.3% average), Poor visibility, lack of spawning potential due to silty alluvial deposits and limited rearing potential due to high summer temperature profiles rendered inventory efforts down stream of this start point impertinent. The survey extended 9.7 miles upstream to Stub Stewart State Park where a radical increase in gradient, steep hillslope confinement and reduced flows terminate anadromous potential.

Coho were observed in the 2nd sample pool of the inventory and not again until the confluence of Mendenhall Cr, 4 miles upstream. The lower 4 miles of the inventory was characterized by low gradient, deeply entrenched banks, no riffle habitat and deep silt deposits. No other salmonids were observed in the lower 4 miles of the WF Dairy mainstem. It is unlikely that any significant abundance of summer rearing salmonids existed below the chosen start point of this inventory.

Above the confluence of Burgholzer Cr (RM 5) the habitat conditions that support salmonid production begin to improve (pool / riffle complexes). This is where a transition in the underlying geology of the alluvial deposits of the lower mainstem give way to the marine sedimentary and tuffaceous layers that form the foundation of the stream habitat that is capable of supporting all the life history needs of salmonids from incubation to summer and winter rearing habitat. This transition is accompanied by a gradient increase to 1.25%, gravel sorting, higher pool to riffle ratio and finally further upstream, a land use transition from cropland/pastureland to predominantly forest land.

A normal distribution pattern (Figure 10) for coho between RM 5 – 9 describes the primary zone in mainstem WF Dairy with any potential for salmonid production. This 4 mile reach is just 41% of the total mainstem habitat that was included within the scope of the 2012 inventory. The bracketed 4 mile reach is a definitive target for instream restoration actions designed to support and enhance the current distribution of anadromous salmonids in the subbasin (see recommendations). The epicenter of this effort and the most likely zone to experience a response from restoration actions extends from RM 6.1 (confluence of Williams Cr) to RM 9.0. This stream segment exhibited the highest rearing densities for coho (1.6 coho/sq m) in the mainstem and likely contained the bulk of the spawning events. Coho distribution ended at RM 9.3 as the gradient increased and the substrates shifted to boulder and cobble dominated. Back calculating from the abundance of coho parr produces an estimate of 12 pair of spawning coho for the mainstem of WF Dairy Cr.

Figure 10



Cutthroat were absent in the lower 5.8 miles. Abundance was low and sporadic throughout the 0+ trout were absent in the lower 4 miles. The absence of the 0 age class suggests that very low potential exists in the lower mainstem for spawning cutthroat. This also suggests that tributary habitats play an important role for native cutthroat for both spawning and rearing. O+ densities in the upper 5 miles of the mainstem averaged only 0.5 fish/sq m (216 fish/mile).

An LWD treatment reach extends from RM 9.2 – RM 9.4 overlapping the upper end of coho distribution. A hillslope confined canyon pinch at RM 9.3 (Photo 20) marked the end of coho distribution in 2013. There is no reason to suspect that this was a definitive barrier to anadromous migration. There was a flat of well sorted gravel with well engaged treatment logs functioning above the current end point of anadromous distribution. Low wood complexity was noted throughout the WF Dairy inventory leading up to the existing treatment reach.

Photo 20

Land owner access issues prevented a contiguous inventory of the upper mainstem that resulted in the inventory under estimating actual abundance in some of the habitat exhibiting the highest potential. In particular, the section of stream habitat from the confluence of Williams Cr (RM 6.1) to Cummings CR (RM 7) exhibited high potential. Field notes for this reach described high quality steam habitat with well sorted gravel, low floodplain, sinuous channel meander, and an average gradient of 1.25% but the incomplete inventory incorrectly portrays it as unproductive.

Cedar Canyon Cr enters the WF Dairy mainstem several miles below the start point of WF Dairy Cr outside the town of Banks. The inventory also includes two tributaries of Cedar Canyon Cr: Sadd Cr and Park Farms Cr. The first two miles of this system are engulfed by a massive wetland. The inventory begins above this wetland where gradients begin to increase.

No coho or steelhead were observed using Cedar Canyon, Sadd, or Park Farms. Cutthroat and 0+ trout densities were low throughout all inventoried reaches with Sadd Cr exhibiting the highest densities of both cutthroat (0.26 fish/sq m) and 0+ trout (0.36 fish/sq m). These density peaks are well below full seeding.

Cedar Canyon Cr expressed limited anadromous potential with deep silt depositions in the lower 0.7 miles and then a sudden gradient increase to 6%. Almost no spawning gravel was observed. Very poor visibility ended the survey at RM 1.23.

Sadd Cr exhibited viable anadromous habitat throughout the first mile of the inventory with stream gradients averaging 2% and abundant beaver activity (13 dams) observed in the first ½ mile. No barriers to passage were observed blocking adult passage in Sadd Cr to approximately RM 1.0. Above this point there is a series of 3 culverts with 1-4 ft perches that definitively terminate juvenile migrations and possibly terminate adult migrations. It was also noted that above RM 1.0, stream gradients increase, habitats are scoured to bedrock and very limited potential for salmonid production exists. This situation suggests that the replacement of the series of perched culverts is in general classified as low priority until a more comprehensive strategy can be formulated for restoring the degraded channel.

On Park Farms Cr, the dam below Hofer Pond was observed as a juvenile and possible adult barrier where 2x12 planks denied access above the spillway. Above the pond anadromous potential extended for about another mile. Field notes indicate a low floodplain, channel sinuosity, sorted gravel, and an average gradient of 2.7%. A white film was observed on the dermal layer on several fish. Above the dam where the channel reenters the forest some fine spawning gravels were observed.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	2,544	0.44	1,205	0	375

Burgholzer Cr (Tributary of WF Dairy)

Burgholzer Cr joins WF Dairy at RM 4.4 (at the Highway 26 crossing west of the Vernonia Highway). The Burgholzer Cr inventory extended 2.5 miles where channel confinement, gradient increase, and a lack of spawning gravel began to limit additional anadromous potential. The inventory included Paisley Cr, the only significant Tributary of Burgholzer Cr with anadromous potential.

Landowner issues restricted access to the majority (1.1 miles) of the most productive habitat (morphologically) which resulted in a very limited assay of fish distribution and abundance. A coho density spike occurred below the confluence of Paisley Cr indicating that there were likely coho emanating from habitats in Paisley Cr (RM 0.4). This reach was characterized by low gradient, entrenched banks, and silty substrate. A 15in perched culvert, rusted out and undercut, was observed at RM 0.7. This culvert is a definitive juvenile barrier but did not stop adult migrants during winter flow regimes.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	319	0.16	255	0	40

Paisley Cr (Tributary of Burgholzer)

Paisley Cr joins Burgholzer Cr at RM 0.5. The Paisley Cr inventory extended 1 mile at an average gradient of 2.3%. Field notes indicated a lack of spawning gravel with increased gradient limiting further potential upstream.

A coho density spike of 2.26 coho/sq m was observed just above the confluence with Burgholzer suggesting an upstream temperature dependent migration to thermal refugia existed. Back calculated estimates of adult abundance suggest a minimum of 2 pair of coho spawned in Paisley Cr. Above the confluence with Burgholzer coho were evenly distributed in low densities to a perched culvert (Photo 21).

Photo 21

0+ trout abundance was low with an average density of 0.3 fish/sq m. Cutthroat abundance was very low and sporadic with an average density of 0.14 fish/sq m.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	569	0.68	200	0	75

Cummings Cr (Tributary of WF Dairy)

Cummings Cr enters WF Dairy at RM 7 (just below the Highway 47 crossing). The inventory extended 0.7 miles. In this small tributary a lack of spawning gravel, low flows and shallow summer pools limits salmonid production potential. At the confluence, Cummings Cr was noted to be colder than the WF Dairy. Notes also indicated that subsurface flows through cobble and root wad perches would likely frustrate use by upstream temperature dependent migrants.

A density peak of 2.7 coho/sq m was observed at RM 0.2. Back calculating from expanded population estimates suggest that 1 spawning event occurred for adult coho.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	175	0.78	430	0	50

Garrigus Cr (Tributary of WF Dairy)

Garrigus Cr enters WF Dairy 1000ft below the mainstem start point. The inventory extended 1.8 miles to where coho distribution ended in a series of beaver ponds. Garrigus was a top coho producer when compared to other locations in WF Dairy Cr. It contained 21% of all coho documented in the WF Dairy Cr subbasin. An average gradient of 2.8% was observed throughout the most productive distribution of coho. The stream is also cold and enters a temperature limited reach of the mainstem WF Dairy Cr.

The primary coho spawning peak occurred at RM 0.7. Spawning also occurred above all of the documented beaver dams near the end of distribution. A high count of 256 coho (visual bias included) was observed in a beaver pond at RM 0.4. Beaver exhibited a strong and vibrant presence in both the upper and lower reaches of the system with 22 active dams documented. The average rearing density of 0.55 fish/sq m suggests that the habitats were far from seeded to their current capacity. 60% of the coho parr were observed rearing in beaver pools. Expanded population estimates suggest an adult escapement of 13 pairs of coho in Garrigus Cr.

Cutthroat abundance was low, averaging 83 fish/mile. O+ trout abundance was also low at 133 fish/mile.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	2,794	0.55	240	0	150

Kuder Cr (Tributary to WF Dairy)

Kuder Cr joins WF Dairy at RM 0.9. The inventory extended 0.5 miles where a 10ft falls terminates anadromous access (Photo 22). Coho were observed in low densities up to the waterfall. A review of distribution related to the location of juvenile barriers suggests one spawning event with low egg to fry survival occurred just below the waterfall.

Photo 22

There was no indication of any upstream juvenile migration into Kuder Cr which suggests that there is likely not a temperature gradient at the mouth providing cold water attraction. There were 3 perched culverts documented as juvenile barriers. The spatial relationship of Kuder Cr in the lower mainstem (no summer parr rearing in the lower 4 miles of mainstem WF Dairy) also suggests that the replacement of these culverts to improve juvenile passage may be very low priority. All of the crossings are currently passable for adults during winter flow regimes.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	94	0.22	15	0	25

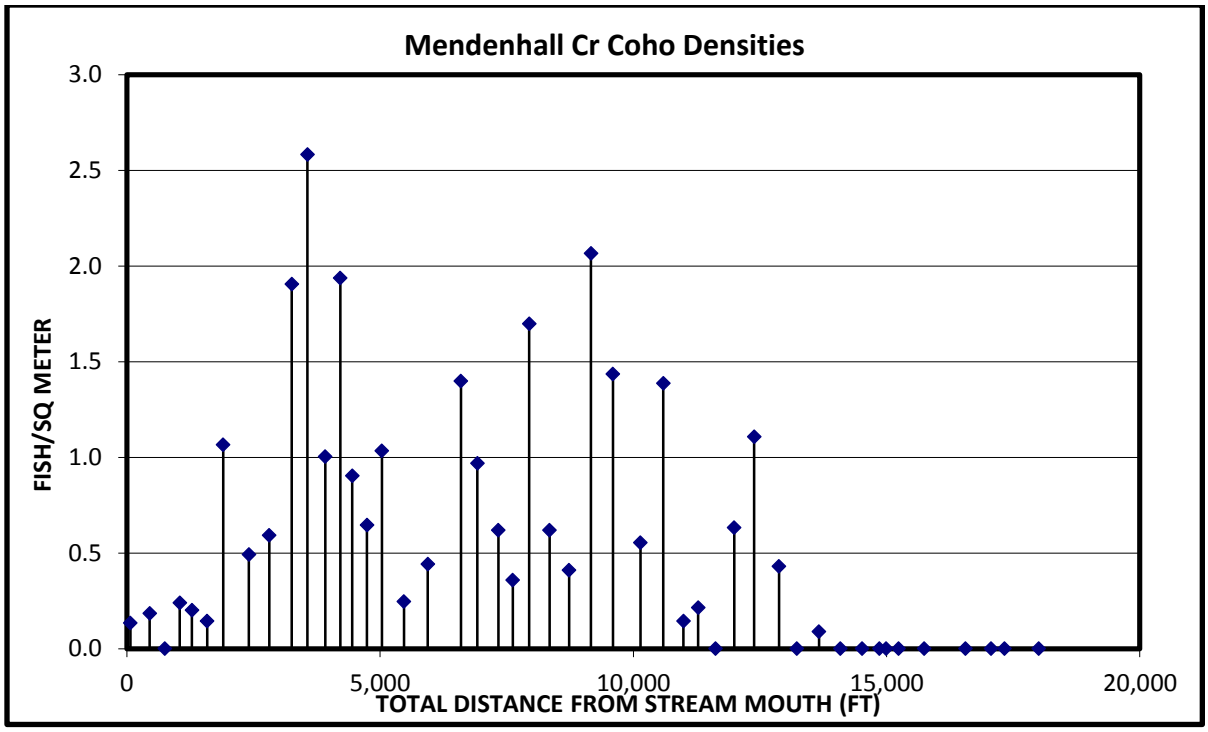
Mendenhall Cr (Tributary of WF Dairy)

Mendenhall Cr joins WF Dairy at RM 4.1. The inventory extended 3.4 miles where increased gradient over exposed bedrock mixed with a cobble / small boulder substrate limit the incubation and rearing potential of habitats upstream of this point. Coho extended 2.8 miles with no barriers to adult passage observed. There is however a failing culvert 110 ft above the mouth with a 6 inch perch that likely denies access to Mendenhall from the mainstem of WF Dairy Cr (Photo 23).

Photo 23

Mendenhall Cr was the top producer of coho in the WF Dairy subbasin rearing 22% of the total estimated population. It was also a top producer of cutthroat (25%) and 0+ trout (21%).

Figure 11



The expanded population estimate of coho parr suggests an adult escapement of 13 pairs. The distribution of summer rearing parr is strong throughout their range and the average pool rearing density was 0.8 fish/sq m. Peak spawning appears to take place over a 1 mile zone in the middle of the 2.8 mile rearing distribution. This zone begins just above the Pongratz Rd Bridge and extends to just above the Banks/ Vernonia Trail railroad trestle. The gradient increases to about 1.5% in this section from the 0.6% average leading up from the confluence. This reach also had the highest pool counts. Surveyors noted that just upstream, a short reach appeared to have been treated with LWD (about 10 logs). Deep channel incision was also observed within the reach. Several coho were observed with white growths.

The reach above the peak spawning zone has an average gradient of 2.1%. It was described as having a riparian canopy of mature conifers along with a wide floodplain and well sorted gravel, but lacking large wood complexity. These habitat characteristics continued to the end of coho distribution.

Above the current end of coho distribution, an additional 0.4 miles of stream habitat exhibiting functional characteristics for salmonids is available and underutilized. The abundance of coho adults currently limits the capacity of the habitat currently available in Mendenhall Cr.

Cutthroat densities peaked above coho distribution but abundance remained moderate and steady throughout the inventory and averaged only 0.2 fish/sq m (113fish/mile).

0+ trout abundance increased rapidly above coho distribution and continued to climb to a peak density of 0.9 fish/sq m near the end of the survey. An expanded value of 520 0+ trout (58%) was observed in the upper mile.

No steelhead were observed.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	2,931	0.8	995	0	395

Trib A (Tributary of WF Dairy)

Trib A enters WF Dairy at RM 7.8. It's a primary head water tributary of WF Dairy providing 30-40% of the summer flow and contributing cool water. The stream habitat was described as having a well forested riparian canopy, moderate wood complexity and cobble dominated substrate. Due to landowner access issues the inventory only extended 0.3 miles. With a gradient decrease from 4.6% observed throughout the inventory to 2.9% further upstream it is possible that anadromous fish production extends for up to additional mile in this tributary (unsurveyed).

A peak coho density of 2.84 was observed 0.25 miles above the confluence. This pool was below a 1ft sill log and indicative of upstream migration behavior. Expanded population estimates of summer parr suggest 2 pairs of coho spawned in the subbasin.

0+ trout distribution also suggest upstream migrations out of WF Dairy were occurring. 0+ trout abundance remained high with an average density of 1fish/sq m for the short reach surveyed.

Cutthroat abundance was moderate with an average density of 0.3 fish/sq m.

An 8in concrete sill on the top side of the culvert below the Highway 47 crossing was noted as a barrier to upstream juvenile migration. Moderately high densities of coho, cutthroat and 0+ trout were observed in the pool below the culvert.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	388	1.6	295	0	60

Whitcher Cr (Tributary of WF Dairy)

Whitcher Cr joins WF Dairy at RM 2. The confluence is described as med-flow, cool water entering over an accessible cobble riffle. The inventory extended 2.4 miles where the gradient increased to 7%, the channel becomes confined and no additional spawning gravel was observed. Channel conditions were described as exhibiting extensive solar exposure, a thin riparian buffer and deeply entrenched terraces for the first 0.7miles of stream corridor. These conditions improve further upstream.

Coho distribution extended to RM 2.3. An average gradient of 2.7% was observed throughout the zone maintaining the best rearing densities of summer parr. The expanded population estimate of

coho parr suggests an adult escapement of 9 pairs. In addition, there appears to be an upstream temperature dependent migration from mainstem WF Dairy Cr occurring.

0+ trout densities peaked at 1fish/sq m at RM 1.4, but were well below full seeding with an average density of 0.3fish/sq m (218 fish/mile).

Cutthroat numbers were low and sporadic averaging 52 fish/mile.

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	2,038	0.68	525	0	125

Williams Cr (Tributary of WF Dairy)

Williams Cr enters WF Dairy at RM 6.5. The confluence is described as low gradient and broad. The inventory extended 1.9 miles to a series of large beaver dams. Coho distribution ended in a canyon pinch at RM 1.5. The first 0.8 miles of the inventory with a gradient average of 1.7% was by far the most productive reach, containing 87% of summer rearing coho parr. No strong signal for the existence of an upstream temperature dependent migration from the mainstem was observed in the coho distribution.

A coho spawning peak of 1.8 fish/sq m was observed at RM 0.7. This spawning peak also contained the highest pool count of 67 coho. This peak overlapped a stream reach with high beaver activity. Coho abundance quickly declined above this reach but distribution continued for another 0.7 miles. Expanded population estimates suggest an adult escapement of 7 pairs of adult coho to the subbasin.

Cutthroat abundance was low and sporadic, averaging 48 fish/mile. 0+ trout densities were low averaging 0.3 fish/sq m (139 fish/mile).

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	1,519	0.5	260	0	90

McKay Creek

McKay Cr, a tributary to Dairy Cr was the smallest of the five inventoried Tualatin subbasins (McKay, EF Dairy, WF Dairy, Upper Tualatin, Gales). A total of 16.5 miles was inventoried in the

combined mainstem of McKay and its tributaries. Five tributaries and two side channels were included in the inventory. Of the five tributaries, only EF McKay exhibited significant spawning potential for large salmonids. No steelhead were observed rearing in McKay Cr.

(Table 9) McKay Subbasin Expanded Population Estimates

Stream	Coho	%	0+	%	Cutthroat	%
McKay	4,669	52.7	1,390	55.8	975	49.1
Side Channel A	173	1.9	4		4	
Side Channel B	19		10			
Brunswick Canyon	94	1	30	1.2	35	1.8
EF McKay	3,881	43.8	1,045	41.9	970	48.9
Jackson			10			
Trib B	19		10			
Total	8,855		2,492		1,984	

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

The inventory began at the West Union Rd bridge crossing in North Plains and extended to a 10 ft basalt bedrock falls at RM 10.7 (cover photo). Stream mileages in this discussion are all referenced from this start point. Anadromous potential was terminated just downstream at a steep 7-9 ft basalt cascade with no jump pool at RM 10.5. Coho distribution ended at a 5ft falls, not described as a definitive adult barrier, at RM 9.6 (Photo 24).

Photo 24

McKay Cr flows through the town of Northplains on the way to its confluence with Dairy Cr several miles downstream. Below Northplains salmonid rearing and spawning potential is severely limited due to very low gradient (0.09%), low flow, a high summer temperature profile and silty alluvial deposits. Heavy tannins also limited visibility throughout this lower gradient reach. These poor visibility conditions extended upstream to RM 6 where the channel morphology changes with an increase in gradient to 0.8%. The increased gradient resulted in gravel dominated substrates and less channel incision which facilitated a higher frequency of floodplain interaction.

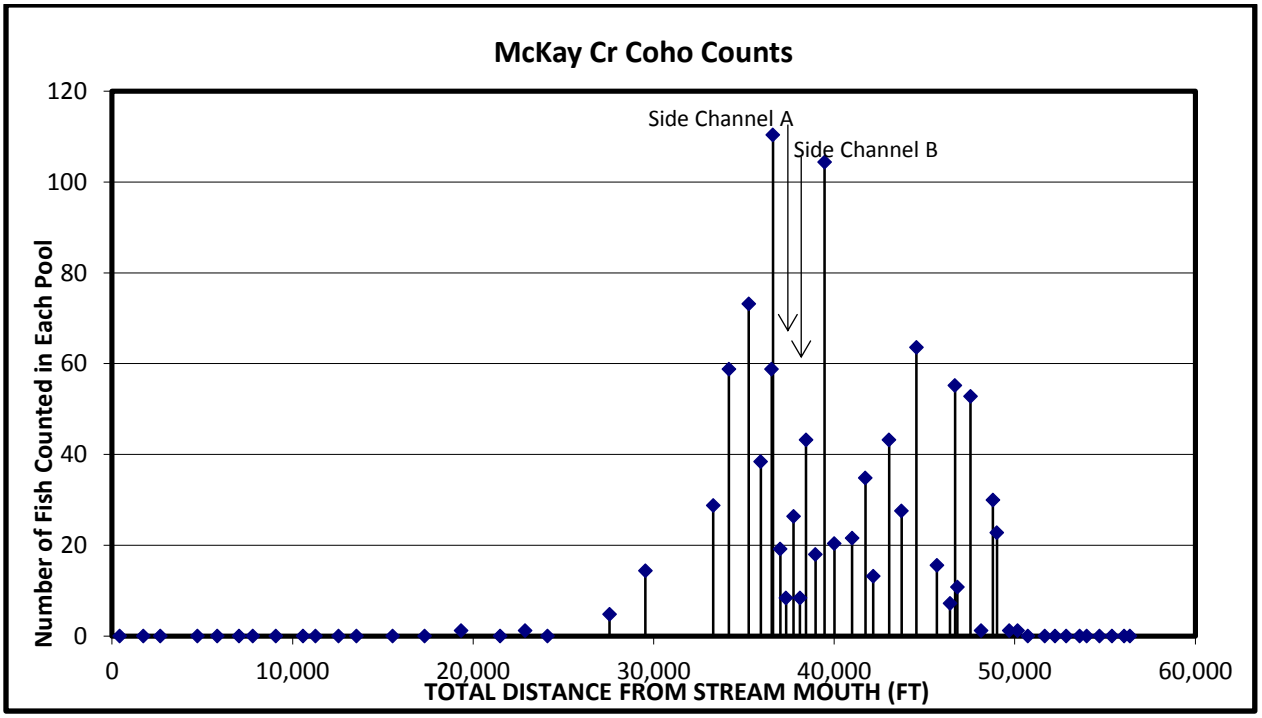
Very low densities of coho parr were observed as low as RM 3.7. Confidence in the abundance estimates within the lower 6 miles was compromised by the issues that affect visibility; heavy tannins, thermoclines providing cold water refugia in the deeper pools and high wood complexity (Photo 25).

Photo 25

Clearly no spawning potential exists below RM 5.6 as a result of deep silt deposits and low gradients. Trib B enters at RM 5.9. Coho were observed in the first pool of this cold, low flow, and silty tributary.

Coho abundance peaked from RM 6.6-7.6. The highest pool count of 115 coho was observed in a beaver pool at RM 6.9. This reach contained the braided confluences of Brunswick Canyon Cr, EF McKay Cr and side channels A and B. With the side channels included (193 coho), this one mile reach, approximately 16% of the usable stream habitat, was rearing 52% of the coho parr in mainstem McKay Cr.

Figure 12

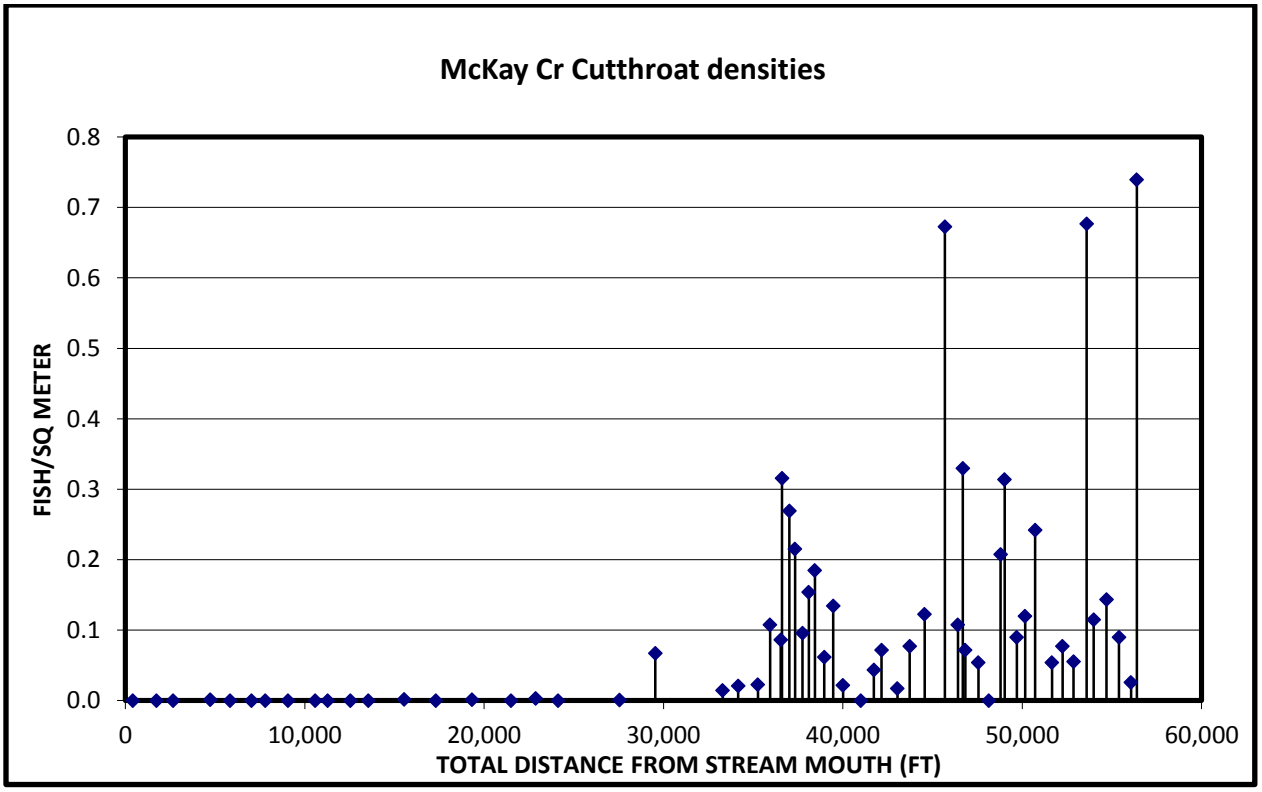


This section of high quality stream habitat displayed sinuous channel meander across a low flood plain, high wood complexity, well sorted spawning gravel, a coniferous riparian canopy and a gradient of 1.6%. Two strong, active beaver dams were also documented in this reach.

This reach overlaps a geologic unit transition from alluvial deposits of the lower mainstem to marine sedimentary and tuffaceous layers that extend through anadromous fish distribution and end at the waterfall that delineates the transition to Columbia River basalts.

A second spawning peak can also be observed near RM 8.7. The stream habitat in this reach had a moderately high gradient of 3.2% and a confined canyon with cobble/boulder dominated substrates. Coho distribution terminates at a bedrock falls at RM 9.6. Field notes indicated a long bedrock riffle/rapid and an absence of spawning gravel for the remainder of the inventory limiting additional spawning potential to the permanent anadromous barrier at RM 10.7. Expanded coho estimates for McKay Cr suggest an adult escapement of 22 spawning pairs (mainstem only).

Figure 13



Cutthroat abundance was low throughout a majority of the inventory. In their range of distribution cutthroat averaged 126 fish/mile. Cutthroat densities increased within the zone of the highest coho abundance to 0.67fish/sq m in the best pools. The dependence of cutthroat on the presence of coho (eggs and fry) is a common aquatic relationship. The highest observed pool density for cutthroat existed above the distribution of coho at 0.74 fish/sq m in the pool below the 10ft bedrock falls.

0+ trout abundance was low with an average density of 0.25 fish/sq m being well below full seeding capacity.

Brunswick Canyon Cr entered at RM 6.8. It had a strong beaver presence with sporadic coho distribution for a ½ mile. Gradient quickly increases above that point and limits any additional anadromous potential. The density pattern and population estimate suggests that one spawning event took place with low egg to fry survival.

Jackson Cr enters McKay at RM 1.5. Heavily impacted by agriculture, it has been ditched straight for several thousand feet with no riparian canopy and exhibits a deeply incised active channel. Both channel and riparian characteristics improve upstream but the tributary displays little to no anadromous salmonid incubation or rearing potential.

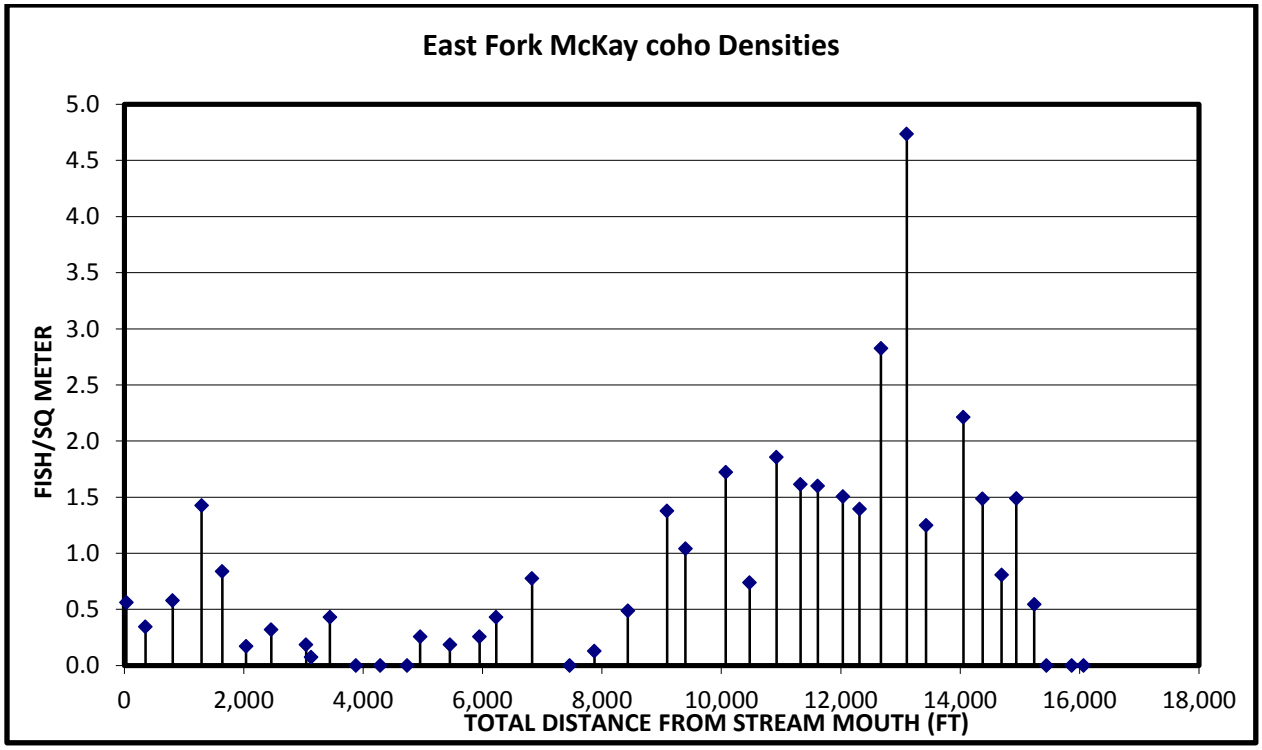
Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	4,669	0.64	1,390	0	975

EF McKay

EF McKay enters mainstem McKay at RM 6.9 within a broad interactive floodplain and a braided confluence. EF McKay is the primary tributary to McKay Cr. The inventory extended for 3 miles where a 7ft bedrock falls terminated anadromous fish distribution (Photo 26). The average gradient throughout the inventory was 2.6%.

Photo 26

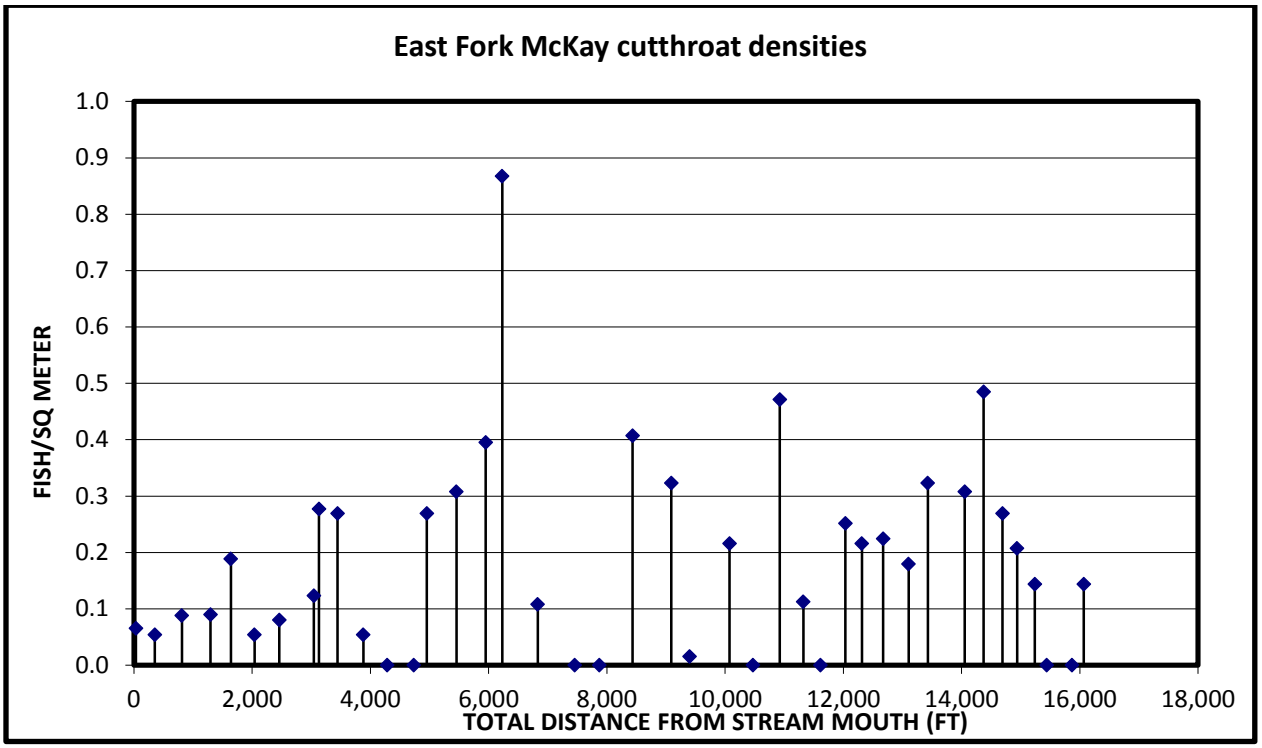
Figure 14



Coho exhibited a bimodal distribution pattern. The first peak, just above the confluence of Neil Cr, is the result of upstream migrants from the mainstem of McKay Cr. Neil Cr, a small, cold, and silty tributary exhibited a similar upstream temperature dependent juvenile migration for a ¼ mile. The dominant coho spawning peak extended from RM 1.7-2.9 with a peak pool density of 4.9 fish/sq m at RM 2.5. This 1.2 mile reach constituted 40% of the steam miles and was rearing 62% of the coho parr. Population estimates for the entire inventory suggest a total coho adult escapement of 17 pairs.

Cutthroat abundance was moderately high with an average density of 0.23fish/sq m and a peak density of 0.86 fish/sq m. This expanded to 309 cutthroat/mile.

Figure 15



Field notes reported poorly sorted gravels throughout much of inventory as well as a lack of LWD. Despite these limitations coho were observed effectively utilizing the available habitat (although the average rearing density of 1.0 fish/sq m was still well below full seeding levels).

Year	Coho	Avg coho/sqm	0+	Sthd	Cut
2013	3,838	1	1,005	0	940

Recommendations

- 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. An attempt has been made to list from higher to lower priority. 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) Balm Grove Dam on mainstem Gales just below Parsons Rd (RM 12.7) blocks all juvenile salmonids and adult cutthroat migrations to upstream thermal refugia.
    2) Iler Cr - Concrete steps at mouth (just below bridge) block access to all salmonids for thermal refugia during low summer flow regimes.
    3) White Cr - 1ft perched concrete culvert below Highway 8 blocking migration out of a temperature limited reach of mainstem Gales.
    4) Trib C of Beaver Cr – rusted out and perched 4in with the top caged in steel below Timber Rd.
    5) Trib C of Beaver Cr – rusted out and perched 1.5ft at RM 0.23.
    6) Trib C of Beaver Cr – top side of culvert packed with debris and eroding roadbed at high flows at RM 0.67.
    7) Trib C1 of Beaver Cr – rusted out with all flow draining underneath and packed with debris on top side located just above confluence with Trib C.
    8) Mendenhall Cr – 6 inch perched culvert 110 ft above mouth.
    9) Campbell Cr – 2.5 ft perched, undercut and rusted out at confluence with EF Dairy.
    10) Prickett Cr – remove or modify irrigation dam installed above 1st pool that blocks upstream temperature dependent migrations to cold water refugia.
    11) Trib B of Beaver Cr – 4” perched culvert denying access to cooler tributary habitat

- Increasing effective shading along all stream reaches that pass through cropland/ pastureland/timberland with insufficient riparian buffers, but prioritizing those streams with high fish production potential. Judicious planning will be required for riparian recovery prescriptions to be effective. A primary planning question should be “Will the location of this riparian restoration project, when viewed on the 6th field scale, have a chance of reducing the cumulative downstream impacts of elevated stream temperatures during pinch period summer flows where salmonids are summer rearing?” In most mainstem applications the answer to this question will be no. Resist the temptation to plant narrow, ineffective riparian buffers adjacent to stream gradients less than 1% for a riparian recovery plan with a chance of addressing the current limitation for salmonids in the greater Tualatin basin.
    1) Mendenhall Cr – below Pongratz Rd.
    2) Garrigus Cr – lower 0.6 miles
    3) Whitcher Cr – lower 0.7 miles
    4) White Cr – lower ½ mile

- LWD treatment logs in stream reaches that displayed high fish production to: dissipate stream energy and improve fish passage, increase types and sizes of pools, provide overhead cover for fish protection, stabilize spawning areas and build deep accumulations of bedload that can store and protect a hyporehic lens for mitigating elevated summer stream temperatures.

    1) EF Dairy Cr mainstem between RM 8-10 and between RM 13-14. Lack of substantial large wood complexity was noted throughout both of these reaches. (RM 8-10) This was the most productive fish habitat in the Tualatin basin for coho and steelhead. Notes indicate a low terrace and wide floodplain with good potential to increase off channel habitat. The three side channels within this reach would also be good targets for treatment. (RM13-14) The secondary spawning peaks of coho and steelhead were within this reach. This reach had a gradient of 3.2%. A low wide floodplain was noted closer to RM 14.
    2) EF McKay Cr from RM 0-2.5. This highly productive tributary has a moderate gradient of 2.6%. For the first 2000ft field notes describe sinuous channel meander across a low and wide floodplain with a lack of large wood complexity. Throughout the rest of the inventory field notes indicated: channel confinement, lack of large wood complexity, and unsorted gravel.
    3) Mendenhall Cr - Rm 0.68 and RM 1.7. Locations around the two coho spawning peaks. Both reported having low wide flood plain and lacking large wood complexity. At RM 1.7. The proximity to the Banks/ Vernonia Trail and easy access to the creek would be an ideal opportunity to provide education on the function and importance of stream habitat restoration.
    4) WF Dairy Cr mainstem from the confluence of Burgholzer Cr and extending 4 miles upstream.

- Develop delinked side channel habitats within zones of deep bedload accumulation for the provision of thermal refugia in the form of hyporehicly fed scour pools. This can begin with blocking the inlet end of side channels B and C on mainstem EF Dairy with large wood complexes set up on the point bar. This prescription also entails creating scour vectors within the side channel to expose the hyporehic strata during summer flow regimes (specific design elements required).

- Continued monitoring will be required in the Upper Tualatin mainstem above the confluence of Scoggins Cr to further our understanding of how the altered system functions associated with summer flow augmentation impact (both positively and negatively) the abundance and distribution of various salmonid species. The following suggestions may be helpful in formulating a monitoring strategy and thinking about potential restoration trajectories.

    1) Continue summer RBA snorkel inventories as replicates that can assist in describing the inter annual variation in spawner abundance, temperature profiles and relative abundance. The scope of this inventory effort is small and encompasses only 12 mile of mainstem and 2 miles of Roaring Cr, the primary headwater tributary accessible to anadromous salmonids.

2) Implement an adult spawning survey or redd count inventory on these 14 miles in an attempt to quantify the annual abundance of adult spawners relative to escapement over Willamette Falls. The observed low densities of salmonid juveniles in this reach in 2013 may have been directly related to poor utilization by adult spawners and not a flow or temperature relationship as hypothesized by this review.
3) Include continuous temperature monitoring for Roaring Cr (primary headwater tributary of mainstem Tualatin).
4) Consider experimental study designs associated with alterations in flow augmentation allocations. Possible scenario might reduce Barney Reservoir release and increase Scoggins release to boost summer temperature profiles and reduce flows in the mainstem Tualatin above the confluence of Scoggins Cr.
5) Consider the development of side channel habitat designed to provide hydraulic refuge during summer flow regimes from the elevated velocities in the mainstem. A differential in rearing density was observed in the single functional side channel existing in the mainstem Tualatin at RM 67.5.

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, by year 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 2013.

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.

Clean Water Services, a partner in this inventory effort, has developed a GIS layer of fish distribution for the inventoried subbasins.