2022

Tualatin Rapid Bioassessment Inventory for Salmonids

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Executive Summary

A Rapid Bio-Assessment Inventory (RBA) for salmonids was conducted by Bio-Surveys, LLC within the Tualatin River Basin during the summer of 2022. A total of 122 miles of river and stream habitat were snorkeled. This effort replicated inventories conducted partially in 2013 and in 2014 and encompassed all mainstem and tributary habitats exhibiting significant anadromous spawning and summer rearing potential in the Tualatin mainstem, Dairy Creek Subbasin, Gales Creek Subbasin, and one Chehalem Mountain subbasin (McFee Creek).

The following significant observations were made during the field work and data analysis. The highlights below provide context for further review in the final report.

- As observed in previous years, the abundance of anadromous fish fell substantially short of full seeding capacities for both adult and juvenile life stages in most mainstem and tributary habitats. Though the end of anadromous distribution remained similar from 2013 and 2014 to 2022, substantial reductions in abundance and lower basin ranges of distribution were observed for 0+ age class trout, juvenile steelhead, and cutthroat. Coho abundance increased in Gales and Mckay subbasins and decreased in Tualatin mainstem and East Fork Dairy (EF Dairy), West Fork Dairy (WF Dairy), and McFee subbasins.

- Coho were by far the most abundant salmonid species observed in the Tualatin basin in 2022. The total estimated pool abundance of juvenile coho was 103,755. Based on our total coho population estimate and utilizing the season-to-season survival rates developed for coho by the Nickelson / Lawson Coho model, an estimated 976 adult coho escaped to the Tualatin mainstem and tributaries. This accounted for approximately 4% of the total adult coho escapement over Willamette Falls for the 2021 adult brood year.
- Steelhead abundance was low with a total estimate of 1,764 age class 1+ or older. EF Dairy mainstem was documented rearing 69.6% of the 2022 steelhead estimate in the Tualatin basin.

- One adult spring Chinook was observed in the mainstem Tualatin River downstream of Little Lee falls. This was the only Chinook documented in the 2022 inventories. Low summer temperatures profiles maintained from flow supplementation from Barney Reservoir have likely contributed to the increased viability of summer habitat for resting spring Chinook.
- A 46.5% decline in beaver pool abundance was documented from replicated reaches inventoried in 2013 and 2014 to 2022. The highest reduction was observed in the WF Dairy and McKay subbasins where there was a 73.6% (WF) and 69.2% (McKay) loss of beaver dams.

- As observed in previous years, a lack of significant habitat complexity and channel roughness in the form of wood complexes was documented throughout the majority of both the mainstem and tributary habitats. In most stream reaches this has led to a reduction in bedload retention, deep channel incision, and disconnection from historic floodplains. This effect is especially evident in systems comprised of more erodible substrates like WF Dairy mainstem and tributaries; Beaver Creek (Gales); and lower EF Dairy mainstem.

- Mainstem summer temperature limitations and the lack of access to thermal refugia are severely limiting summer rearing potential throughout lower mainstem reaches of Gales Creek, EF Dairy Creek, and WF Dairy Creek. The presence of these durable elevated temperature profiles during pinch period summer flows is driving large scale temperature dependent fish migrations.

- Temperature profiles in lower mainstem EF Dairy Creek (from Hwy 26 to Denny Creek) exhibited substantial increases from 2014 to 2022. Average temps recorded during the inventory in 2014 were 15.4°C and in 2022 temps rose to 17.9°C. Temps for both years were recorded at the same locations with similar times of the year and times of the day.

- The cold-water contributions of Clear Creek and Iler Creek were documented providing critical thermal refugia to high abundances of salmonids within a severely temperature limited reach of Gales Creek mainstem during the peak summer temperature regime. In 2022, the first few pools upstream from the Gales Creek confluence in both tributaries exhibited the highest salmonid densities documented in the Tualatin basin in all inventoried years.

- Availability of high-quality spawning gravel was not functioning as a limiting factor for coho production in a majority of inventoried systems. Clear Creek, Campbell Creek, Cummings Creek, Pricket Creek, WF Trib A, and White Creek exhibited coho abundance estimates that suggested a spawning gravel limitation may have been present during the 2021 spawning season.

- 56 Anchor Sites were identified as priorities for future restoration efforts. These stream segments provide all the seasonal habitat requirements for sustaining salmonids from incubation through winter rearing.

Introduction

Purpose

The intent of this project was to quantify distribution and relative abundance of all juvenile salmonid species during pinch period summer low flow regimes that truncate their distribution as a function of elevated stream temperature. The inventory consisted of snorkel surveys that began at predetermined start points or at the mouth of each tributary. Surveys extended to the end of significant rearing potential for anadromous salmonids, describing the full extent of distribution for steelhead and coho in summer 2022. The surveys did not extend to the end of cutthroat distribution. This data adds to base-line distribution and abundance metrics that were established in 2013 and 2014 RBA assessments and provides a foundation for long term trend analysis, identifies anchor habitats, and guides future restoration and management actions.

The 2022 Rapid Bio-Assessment inventory (RBA) of the Tualatin covered 122 miles of river and stream habitat. This effort encompassed all mainstem and tributary habitats exhibiting significant anadromous potential in the Tualatin mainstem, Dairy Creek, Gales Creek, and McFee Creek.

Spawning gravel abundance estimates (only spawning gravel sites appropriate for coho were quantified), anchor sites identifications (sites providing for all life history needs of salmonids), and beaver pool inventory were included in the inventory of all mainstem and tributary stream habitats. This additional sampling was conducted to increase understanding of habitat functionality as it relates to key salmonid spawning and rearing sites and the contribution of beaver augmentation to the juvenile rearing capacity of the stream habitats.

Background

The Tualatin River Watershed encompasses 712 square miles in Northwestern Oregon, primarily in Washington County, but also flowing through parts of Clackamas, Multnomah, and Yamhill Counties. Basin elevations range from nearly 3,000 feet in the Oregon Coast Range to 60 feet above sea level at the confluence with the Willamette River in West Linn. Notable uplands include the Oregon Coast Range to the west, the Tualatin Mountains to the north and Chehalem Mountains to the south. Major cities within the basin include Forest Grove, Cornelius, Hillsboro, Beaverton, Tigard, Sherwood, and Tualatin. The largest tributary streams are Scoggins Creek, Gales Creek, Dairy Creek, Rock Creek and Fanno Creek (Figure 1).

The Tualatin River enters the Willamette River from the west at USGS RM 24.1. The Tualatin River Mainstem is about 83 miles long originating in the Oregon Coast Range west of Cherry Grove. The river drops an average of 74 feet/mile to about River Mile (RM) 55.3, primarily traversing forested upland landscape. From RM 55.3 to RM 33.3 the grade decreases dramatically to an average of 1.3 feet/mile meandering through an agricultural landscape. Between RM 33.3 to RM 3.4 the descent again decreases to a descent of less than 0.1 feet/mile

where a low-head dam diverts water to Oswego Lake before finishing its journey to the Willamette River.

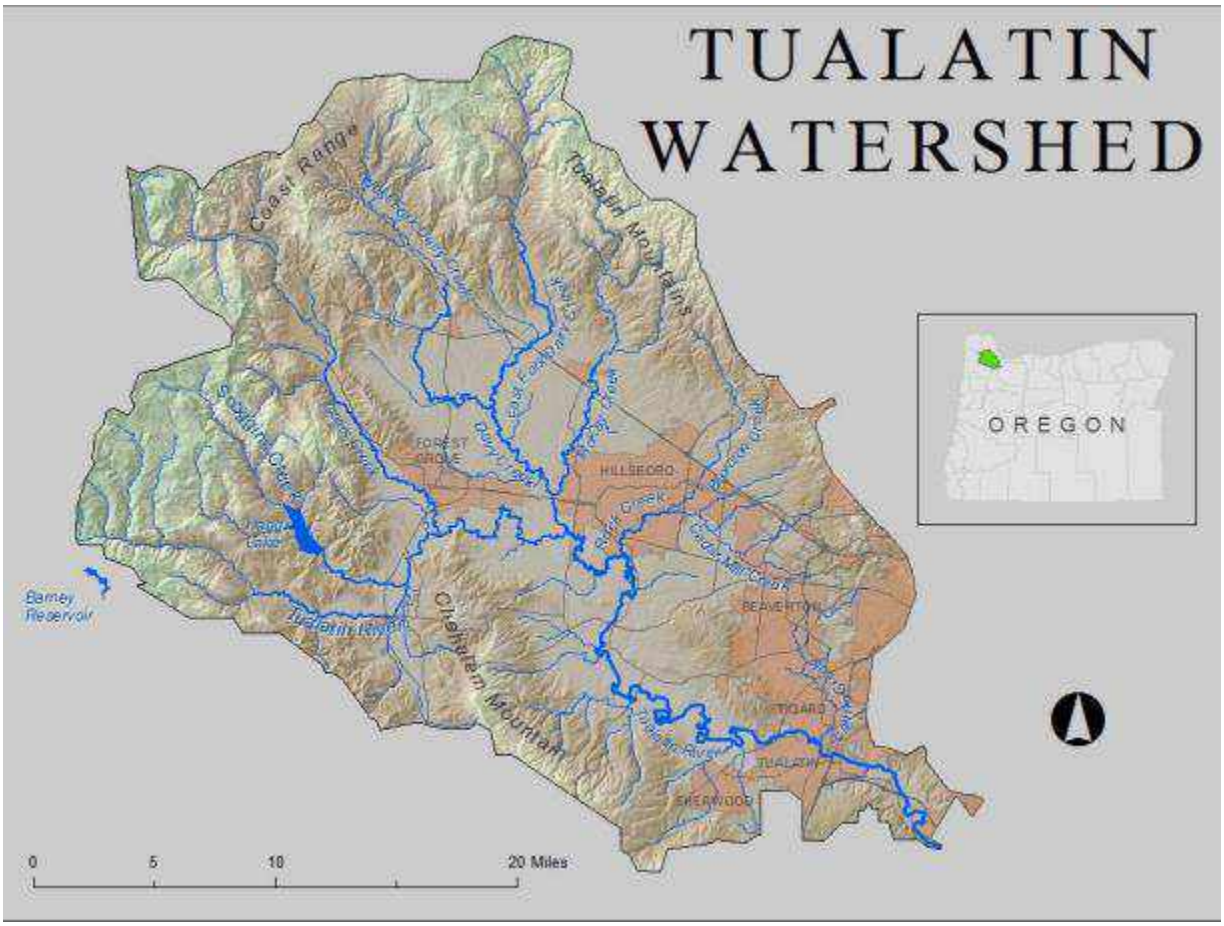


Figure 1: Tualatin watershed (Hennings, 2014)

The native Kalapuya tribes historically occupied the area. They subsisted as hunter-gatherers using a strategy of burning to promote the growth of grasslands which enabled easier hunting and seed gathering. It also kept much of the valley floor unforested. By the 1830's, diseases and colonialism had decimated the native populations and the Hudson's Bay Company was using parts of the valley to raise crops for use at Fort Vancouver. The principle economic drivers of the basin were agriculture in the lowlands and timber in the upland reaches.

The Tualatin Basin is home to Chinook salmon, coho salmon, steelhead, resident and sea-run cutthroat trout, and small populations of resident rainbow trout. Records of fish populations within the Tualatin River Basin are not thorough as the fishing industry was not a principle economic force in the region. Historic runs of salmonids over Willamette Falls are known to have been tremendous compared to current numbers.

Records suggest that, prior to the construction of the fish ladder at Willamette falls, the Tualatin River did not support a native coho run or a significant native run of winter steelhead. There is no historical documentation of coho passing Willamette falls prior to the construction of the fish

ladder. For this reason, coho are considered an introduced species in the Tualatin watershed by the Oregon Department of Fish and Wildlife (ODFW).

Westside tributaries of the Willamette valley have not been considered significant or stable contributions to the Upper Willamette River (UWR) winter steelhead population and thus not included in the four demographically independent populations (DIPs) of UWR winter steelhead. Though these westside tributaries were not included in the DIPs of UWR winter steelhead, radio-tagging studies suggest that a considerable number (63%) of winter steelhead ascending Willamette falls do not enter the DIPs that constitute this distinct population segment (DPS) (NOAA 2016). This data estimates that the Tualatin basin contributes <1% to the total UWR winter run steelhead population. For coho, these studies estimate that the Tualatin contributes 19% to the total UWR run coho population (Jepson et al. 2015).

Historically, floodplains across the Willamette valley covered far broader areas with winter flow events filling numerous side channels and associated wetlands across the valley floor. The workings of historically abundant beaver populations across this landscape further increased the habitat's capacity to retain water throughout the year, enhancing the aquatic habitats utilized by salmonids. Early loggers "improved" many reaches of these rivers and streams for log drives. This practice "eliminated sloughs and minor courses, removed trees and debris, tore out drifts...." (Boag 1992). This manipulation forced the river into a narrower channel where it has continually incised, separating it from the floodplain. River channel manipulation, in addition to the historic near extirpation of beaver from the landscape, has had a dramatic impact on fish populations and riparian habitats. The log drives eliminated the linkage to important side channels, removed logs and jams that created habitat complexity and reduced the seral complexity of riparian canopies (Boag 1992). In addition, numerous dams, ditches, and flow diversions have further modified stream habitats and blocked or complicated salmonid access to thermal refugia and spawning grounds. The legacy of these modifications has permanently reduced the spawning and rearing capacities of the basin, with salmonid life history diversity and overall abundance greatly reduced.

Current Conditions

The proximity of the Tualatin River to the largest city in Oregon has helped the Tualatin watershed to be more developed by humans than most other watersheds in Oregon. Land use in the Tualatin watershed is currently about 20% urban, 30% agriculture, and 50% forestry (Tualatin Watershed Council).

Water quality issues within the Tualatin Basin may limit anadromous salmonid abundance and adversely affect resident fish and aquatic food web relationships. These water quality issues, as well as physical habitat degradation, have caused drastic decreases in salmonid abundance relative to historic numbers.

The Federal Environmental Protection Agency (EPA) regulates and sets water quality standards for waters of the United States. Section 303(d) of the Clean Water Act authorizes the EPA to assist states, territories and authorized tribes in listing impaired waters and developing Total Maximum Daily Loads (TMDLs) for these waterbodies. A TMDL establishes the maximum

amount of a pollutant allowed in a waterbody and serves as the starting point or planning tool for restoring water quality.

The Oregon Department of Environmental Quality (DEQ) assesses water quality in Oregon to meet the federal Clean Water Act Sections 305(b) and 303(d) requirements and reports conditions of Oregon's surface waters. Oregon's most recent list of Impaired Waters (Submitted 2012) was approved by the EPA December 2016. Waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Water bodies exceeding EPA standards (including water quality issues which impair aquatic life—such as temperature) may be placed on the EPA's 303(d) "List of Impaired Waters and Total Maximum Daily Loads". In this section, we review Impaired Waters within the surveyed watershed that are assigned a 303(d) a status of either Category 4 or Category 5.

Category 2 – Attaining some criteria/uses

Category 3 – Insufficient data

Category 4 – Water quality is limited (4A TMDL approved)

Category 5 – Water is quality is limited, 303(d) list, TMDL needed.

All anadromous fish within the Tualatin watershed must travel upstream through the Lower Columbia, Lower Willamette, and Lower Tualatin Rivers. Conditions in the following tables are current water quality impairments within the Tualatin River Basin based on data collected by the DEQ that are known to affect resident fish, aquatic life, anadromous fish passage, salmonid spawning, and juvenile salmonid rearing and migration (Oregon DEQ 2012 Integrated Report). Waters of the state must be sufficient to support aquatic species without detrimental changes in the resident biological communities (Oregon DEQ 2012 Integrated Report). The EPA's Biological Criteria for water quality states that "waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities".

The primary pollutant of mainstem salmonid habitat within the Tualatin watershed is temperatures exceeding salmonid thresholds. Scoured river bottoms with a high percentage of bedrock exposure (which provides a heat sink and exposes any hyporheic linkage to the impacts of the sun) coupled with low summer water levels drive many salmonids out of large mainstem river environments. Increased temperature is known to decrease the amount of dissolved oxygen in water. Temperature pollution elevates stress levels in rearing salmonids and can be fatal if thermal refugia is not available. Many salmonids take refuge in deep pools, around cold-water seeps, and migrate up colder tributaries to escape lethal temperature limitations during summer low-flows. These raised stress levels also increase the impacts of the various other pollutants within the river on salmonids.

303(d) Listings

Section 303(d) of the Clean Water Act requires identifying waters that do not meet water quality standards and where a TMDL pollutant load limit needs to be developed. Table 1 outlines the category 4A and 5 listed pollutants which exceed EPA standards and impact aquatic life within

the Tualatin River Basin. The Tualatin River Mainstem has five level 5 pollutants and five level 4A pollutants. Gales Creek has three level 5 pollutants and one level 4A pollutant. In Dairy Creek and its tributaries (WF Dairy, EF Dairy, and McKay Creek), all reaches had temperature and dissolved oxygen levels not meeting EPA standards. Uniquely, Gales Creek contains high levels of Chromium VI, while the Upper Tualatin has high levels of copper, chlorophyll-a, and fecal coliform above acceptable levels classifying them as impaired.

Table 1: Tualatin River (RM 0-35) Category 4 and 5 303(d) Listings in the 2022 Oregon Integrated Water Quality Report

Water Body	River Miles	Pollutant	Season	Beneficial Uses/Criteria	Status
Tualatin	0 - 60.1	Dissolved Oxygen	Year Round; Spawn	Fish And Aquatic Life	4A; 5
Tualatin	0-McFee	*Biocriteria	Year Round	Fish And Aquatic Life	5
Tualatin	0-McFee	Harmful Algal Blooms	Not Listed	Toxic Substances - Aquatic Life	5
Tualatin	0 - 60.1	Iron (total)	Not Listed	Fish And Aquatic Life	5
Tualatin	0-Dairy	Methylmercury	Not Listed	Fish And Aquatic Life	4A
Tualatin	0-Dairy	Temperature	Year Round	Fish and aquatic Life	4A
Tualatin	McFee-Dairy	Fecal Coliform	Not Listed	Fish and aquatic Life	4A
Tualatin	Dairy - Wapato	Copper	Not Listed	Toxic Substances - Aquatic Life	5
Tualatin	Wapato - Sunday	chlorophyll-a	Not Listed	Fish And Aquatic Life	4A
McFee	0-Heaton	Dissolved Oxygen	Year Round; Spawn	Fish And Aquatic Life; Spawn	Cat 4A; 5
McFee	0-Heaton	Iron (total)	Year Round	Toxic Substances - Aquatic Life	Cat 5

McFee	0-Heaton	Temperature	Year Round	Fish And Aquatic Life	Cat 4A
McFee	0-Heaton	Fecal Coliform	Year Round	Fish And Aquatic Life	Cat 4A
Dairy	0-7.1	Temperature	Year Round	Salmonid fish rearing and anadromous fish passage; Spawn	Cat 4A
Dairy	Dairy, McKay, EF, WF	Dissolved Oxygen	Year Round; Spawn	Fish And Aquatic Life	4A, 5
Dairy	0-hwy 6, McKay	Iron (total)	Not Listed	Toxic Substances – Aquatic Life	5
Dairy	Dairy, McKay, EF, WF	Temperature	Year Round	Salmonid fish rearing and anadromous fish passage; Spawn	4A
East Fork Dairy	Denny - Campbell	Biocriteria	Year Round	Fish And Aquatic Life	5
Gales	0 – 16.25	Dissolved Oxygen	Spawn	Fish And Aquatic Life	5
Gales	0 – 16.25	Iron (total)	Not Listed	Toxic Substances – Aquatic Life	5
Gales	0 – 16.25	Chromium VI	Not Listed	Toxic Substances – Aquatic Life	5
Gales	0 – 16.25	Temperature	Year Round; Spawn	Fish And Aquatic Life	4A

* Biocriteria – This water body cannot support aquatic species without detrimental changes in the resident biological communities

Methods

Survey Protocol

Snorkel survey crews conducted RBA surveys between July 1, 2022 and September 15, 2022. Landowner contacts were made for all private, industrial, and public ownerships that existed on both sides of every stream reach surveyed.

Stream surveys were initiated by selecting the first pool encountered at the beginning of a mainstem reach or tributary.

By not randomly selecting the first sample pool, the method was able to identify upstream temperature dependent migrations that may not extend 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.).

Snorkelers visually searched 100% of each selected pool, counting all salmonids observed.

The survey continued sampling at a 20% frequency (every fifth pool) until at least four units without anadromous fish 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 (complex pools, and tributary junctions) were selected as supplemental sample units to ensure that the best habitat was not excluded with the random 20 percent 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). Additionally, in 2022 a 100% sample of all beaver dam pools was added to the protocol.

Detailed Methods

Typically, the snorkeler entered each sample 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. (Steelhead 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.

Sample pools had to be at least as long as the average wetted 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 are that they compromise the consistency of measuring, summarizing and

reporting lineal stream distances. Additionally, off-channel habitat types are primarily utilized by salmonids as winter refugia.

Surveys were concluded when 2 consecutive pools of zero anadromous fish were snorkeled or a definitive anadromous barrier was encountered. In sub-basins with low rearing densities or when steelhead were present, surveys were concluded when anadromous fish were not detected for more than four sampled units. These situations were left to the surveyor's discretion, whether to continue or terminate the survey. There is a possibility that minor, isolated populations of juvenile steelhead could be overlooked in headwater reaches of small 2nd order tributaries.

Distances reported in the Access database (See Tualatin_RBA_2022_accdb) are measured 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) because actual sinuosity within the floodplain is greater than that projected in GIS base map layers. If attempting to overlay this database on existing stream layer information, justify linear distances with known tributary junctions (these can be found in the comments column of the Access database). Comparisons of linear 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 typically measured at intervals throughout the survey to calibrate the surveyor's ability to judge distance but were generally estimated. Pool widths vary significantly within a single unit and a visual estimate of the average width was considered adequate to obtain an accurate pool area.

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

Cover Estimate Ratings

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 (>3ft) was not considered a significant cover component.

The following criteria were used:

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

The frequency of higher cover/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.

Visibility Estimate Ratings

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

1 Excellent

2 Moderate

3 Poor

This variable provides a measure of confidence to the collected data. Survey segments with a visibility ranking of 1 can assume normal probabilities of detection. 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. A 100% sample of all beaver dammed pools was included in the 2022 inventories. Only intact full spanning dams were counted. This variable may then be sorted in the Access database for presence, absence, and trend within each basin.

Commentary on stream conditions was recorded within surveyed reaches that includes information on temperature, tributary junctions, culvert function, the abundance of other species, and adjacent land use. Commentary is included in the raw Access database under the "comments" field.

Distribution Profiles

The distribution of juveniles and their observed rearing densities for each surveyed reach provide a basis for understanding how each reach functions in relation to the remainder of the basin or sub-basin. Distribution profiles can help identify adult spawning locations, identify potential barriers to upstream adult and juvenile migration, identify the endpoint 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. Replicate surveys conducted in these same reaches in subsequent years will function as an indicator of response to future restoration and enhancement strategies, as well as potential changes in land use and changes in adult abundance.

To understand how a particular stream reach functions in relation to its salmonid rearing potential, it is valuable 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 habitat's 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 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 discussions of carrying capacity in this document subjective. Any discussion of carrying capacity in the 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.

Extensive bodies of data suggest that, for coho, extremely high-quality habitats can maintain average summer rearing densities in the range of 3.5 fish/m². The Nickelson / Lawson Coho Production Model averaged summer rearing densities across the full geographical range of the coastal coho Evolutionary Significant Unit (ESU) sets a 1.7 fish/m² meter of pool surface area as a value that represents habitats seeded to their summer carrying capacity (1998).

For cutthroat and steelhead, the habitat's ability to rear older age class salmonids is heavily influenced by fish size, available pool surface area, and food availability. We have observed that in zones of cohabitation by steelhead/rainbow and cutthroat that the combined densities of these similar sized species would not exceed 0.8 - 1.0 fish/m² 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/m² for older age class steelhead/rainbow or cutthroat without competition from the other are rare.

For 0+ trout the highest densities observed in thousands of miles of Willamette basin and coastal stream inventories always hovers around 3 fish/m². The similar habitat characteristics observed in the Tualatin basin to many other watersheds suggests that the 3 fish/m² value

would be a fair surrogate for indicating that the reach is somewhere near its capacity for the 0+ age class and that spawning locations existed nearby.

Spawning Locations

The approximate location of steelhead and coho spawning events can often be observed by noting the presence of a distinct spike in rearing density of the 0+ age class that trails off rapidly just upstream. The physical location of a spawning destination has a range of variance plus or minus 4 pools due to the 20 percent sample methodology. Because the quality or quantity of spawning gravel can be a seasonal habitat limitation for salmonids, it is informative to describe not only the range of distribution of the 0+ age class but the peak zones of abundance which indicate 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.

Spawning Gravel Abundance

Spawning gravel was quantified throughout 122 miles of combined mainstem and tributary habitats during the 2022 inventories. Spawning gravel abundance data was collected to determine if coho in the Tualatin River Basin could potentially be limited by the abundance of appropriately sized and sorted gravels for spawning and incubation and to map the distribution of functional spawning gravel. Many reviews of habitat variables in contemporary literature refer to the abundance of spawning gravel as seldom the primary habitat limitation for adult salmonids. However, quantitative measurements of this key habitat variable are rarely included in these analyses and an invalid assumption is possible.

The effort targeted only gravels appropriate for coho and did not include the larger diameter gravels used by chinook. This was a 100% sampling effort where every potential gravel accumulation exhibiting the proper hydraulic location and size was estimated. The following criteria were used:

1 Spawning gravels had to be located in a pool tailout, glide or unconsolidated riffle (pocket pool run). All other gravels were excluded from the inventory.

2 A minimum of 1 square meter of gravel had to be present to qualify for a potential spawning location.

3 Only gravels between the diameter range of a marble and a tennis ball which were appropriately sorted from other larger and smaller diameter substrate were quantified.

The criteria utilized by ODFW's OASIS program documented in their Salmon Spawning Survey Procedures Manual 2012 describes the minimum coho redd as 2 m^2 in area and any redd less than 2 m^2 as atypical. Some of this variation exists because coho are known to spawn in stream orders of various sizes. Because the intent of the spawning gravel inventory was to both spatially describe the distribution of spawning gravel and test the hypothesis that the abundance

of gravel could be a seasonal habitat limitation, we chose to utilize 1 m^2 of gravel as the minimum area and 3 m^2 as the maximum.

Quantifying spawning gravel is an uncommon metric for collection because of the broad range of variability between surveyors. Spawning gravel estimates are a rough quantitative metric with a broad variance for this reason. Measuring this range of variance in subsequent years is highly recommended as a pre-project attribute for future restoration effectiveness monitoring. The goal was not to necessarily determine exact quantities of spawning gravel but to test the hypothesis that an incubation limitation could exist.

Quantifying the abundance and distribution of spawning gravel is a first cut toward understanding how this basin scale seasonal habitat (spawning gravel for incubation) required for reproduction is functioning. Knowledge of the quantity, quality, and distribution of spawning gravel within a basin is an essential component of designing a prioritized restoration and recovery strategy.

Spawning gravel distribution is not random. Rather, it is dependent on a combination of morphological and hydraulic variables within the stream channel as well as in the watershed that facilitate the deposition of the appropriate sized gravels for spawning.

The fact that spawning gravel distribution is not random but highly dependent on a unique combination of morphological and hydraulic variables that facilitate the deposition of the appropriately sized gravels for spawning is why the expansion of redd counts collected on a specific reach basis (normally a sub sample of total stream miles) to a basin wide estimate will always overestimate adult spawner abundance. Historically, this has been commonly done in basins to estimate anadromous salmonid run sizes.

Historic Channel Complexity in the Tualatin

Channel roughness, or the presence of channel complexity in the form of large wood or boulders can influence the hydraulic dynamics of the background attributes of gradient and flow that control the deposition and sorting of migratory substrates. Complex wood jams formed by the natural recruitment of riparian old growth conifers would have historically been more prevalent in the tributary network of the Tualatin where the bankfull widths are narrower and the hydraulic pressure of high winter flows is lower. Presently, almost none of this historical complexity remains and the loss of these wood resources has resulted in an overall increase in gradient resulting in a decline in the system's ability to store and sort spawning gravels. The system's inability to replace this wood (limited wood delivery potential from either upslope debris flows or riparian canopies) currently limits the recovery of system function.

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 migrate upstream for a variety of reasons (temperature, winter hydraulic refuge, food resources). Hydraulic refuge and food resource dependent migrations typically occur in fall, winter, and spring. Evidence of these migrations is rarely detectable during summer population inventories. Temperature, however, is probably the most significant driver of upstream juvenile salmonid migrations during summer flow regimes with young fish escaping warm larger streams up into colder tributaries.

Juvenile barriers were classified based on physical barriers of greater than 6 inches and the density profiles of juvenile fish above and below potential barriers. 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 in the database are denoted by 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 more potential for density dependent upstream migrations that would be indistinguishable from the distribution pattern mentioned above. Identifying this migration pattern allows us, during years of low adult escapement, to locate important sources of high-water quality within the basin that may be traditionally overlooked (because of some other morphological condition that suggests no significant potential for rearing salmonids, i.e. lack of spawning gravel). These reaches typically exhibit declining densities with increased distance from the mouth and no indication of a spawning peak (a point near the upper distribution of the population with significantly higher rearing densities of the 0+ age class). These tributaries may be functioning as important summer refugia for salmonid juveniles threatened by increasing temperatures in the mainstems. Several significant temperature dependent juvenile migrations were observed in the Tualatin Basin in 2022. These migrations will be discussed within the document in each stream where the behavior is occurring.

Thermal Refugia

Thermal refugia is key to the survival of salmonids in temperature limited systems. Several large stream order reaches in the Tualatin River Basin are severely temperature limited during summer months with a 303d status category 4A and 5 listings for temperature and dissolved oxygen. Assessing the abundance and availability of these thermal refugia was critical to understanding the mainstem fish population.

Limiting Factors Analysis Lite (LFA)

The purpose of the LFA Lite inventory was to identify key anchor site locations. Anchor sites are stream segments that provide all of the seasonal habitat requirements for sustaining salmonids from incubation through winter rearing. 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 to maintain and enhance their current level of productivity.

The criteria required to be expressed in the anchor were as follows:

- There must be spawning gravel present for incubation
- The anchor must not be temperature limited during low summer flows
- The anchor must exhibit a terrace height of three feet or less
- A minimum 5:1 ratio of total floodplain width to bankfull width

Additionally, a numerical rating was given to each identified anchor for the surveyor's estimate of current functionality. Anchors can be highly functioning with high wood densities and high quality off channel linkage or low functioning but with the background morphology to be a candidate for restoration. The following categories were utilized:

1 High Functioning

2 Moderately Functioning

3 Low Functioning

The function rating was estimated by assessing levels of wood complexity, available spawning gravels, channel sinuosity, and floodplain connectivity.

Beaver Pool Inventory

Pool habitats augmented by beaver dams have the potential to greatly increase the pool surface area and juvenile rearing capacity of a stream reach. In addition to improving summer rearing, beaver occupation increases the abundance of over wintering habitats (channel complexity, low velocity micro habitats, floodplain connectivity, etc.). Boosting the headwater retention of winter parr to the smolt stage enhances a life history strategy (headwater rearing) that has been in rapid decline as system function has deteriorated from the lack of natural wood recruitment that historically maintained floodplain connectivity.

In 2022, a 100% sample of all beaver dam pools was added to our 20% sample of other pool habitat types. Only beaver pools exhibiting full spanning dams which were impounding surface flows were included in the inventory (Table 8). This additional sampling was conducted to measure the contribution of beaver augmented pool habitat to the total juvenile population and rearing capacity of the existing stream habitat. A stratified sampling protocol was developed to compare salmonid rearing in beaver dam pools with all other types of pool habitats.

During our 2013 and 2014 inventories surveyors recorded numbers of full spanning beaver dams along with descriptive notes of beaver activity. This data can be used as a year-to-year comparison of beaver abundance throughout the inventoried reaches.

Precautions

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.

Average densities that can be generated as a product for each stream reach are the result of a 20 percent pool sample. Consequently, the calculated density values are likely to vary 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 in Table 2 below. The true average density of a stream reach was retrieved by querying the database from an ODFW survey on East Fork Lobster Cr in the Alsea Basin, where every pool was sampled (indicated as 100% sample frequency in Table 2). Comparisons could then be made between the true average density and a randomly selected 20 percent sub sample (every 5th pool). Only mainstem pools were utilized within the range of coho distribution to match the protocol for the RBA.

Table 2: ODFW, Bio-Surveys Salmonid Survey Densities on East Fork Lobster Creek – Alsea Basin (1998)

Sample Frequency	AVG. Coho Density	AVG. Steelhead Density	AVG. Cutthroat Density	AVG. 0+ Trout Density
100% (ODFW)	1.07	0.03	0.04	0.13
50%	1.10	0.04	0.03	0.14
20% Start Pool 1	0.87	0.04	0.03	0.13
20% Start Pool 3	1.01	0.03	0.03	0.13
20% Start Pool 5	1.13	0.05	0.04	0.12

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. 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. Juvenile distribution within side channel habitats is not evenly distributed, so all side channels were sampled at a 100% rate (every pool).

An additional 20% was added to the expansions used to generate coho population estimates to account for the visual bias identified in the development of the RBA protocol. **This calibrated total number was utilized in the tables, text, and analysis within this document but not represented in the graphics.**

The abundance estimates for steelhead and cutthroat in this document should only be utilized for interannual trend analysis and do not represent an estimate of total abundance. With a life history pattern independent of ocean conditions, cutthroat are powerful indicators of changes in system function and system health. Some cutthroat spend their entire lives within the confines of a watershed. There are also fluvial and sea run cutthroat that migrate long distances to spawn. In general, these fish enter and exit tributary habitats to spawn from fall through spring; fully emigrating out by early summer. Given the timing of this migration pattern, we would not expect this population to influence summer population estimates in tributary habitats.

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 densities by the total number of sampled pools with fish present. 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.

Average rearing density for a surveyed reach (fish/m^2 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. 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.

It is important to clarify that two different metrics for location are utilized in this assessment for describing specific fish distributions. This was necessary because all the larger mainstem inventories began upstream of their start points due to reduced visibility and/or lack of summer salmonid rearing. For management actions and for all the graphics used in this analysis, we have transposed this measurement into USGS RM locations. The fish distribution graphics that are provided in the Access database and the Excel Pivot table that archive all the recorded data have been described in linear feet above the survey start point. The use of USGS RM estimates was not required to georeference any of the tributary inventories because all the tributary surveys began at RM 0.0.

Results

During the summer of 2022, juvenile coho were the most abundant anadromous fish species rearing in pool habitats throughout the inventoried reaches of the Tualatin River Basin. The total estimated pool abundance of juvenile coho was 103,755 within the scope of the inventory. Coho distribution was spread across all subbasins except the Chehalem Mountain tributaries (McFee Creek). Based on our total coho population estimate and utilizing the season-to-season survival rates developed for coho by the Nickelson / Lawson Coho model, an estimated 976 adult coho (combined male and female) escaped to the Tualatin mainstem and its tributaries for the 2021 adult brood year. Of the total corresponding adult coho escapement over Willamette Falls for the three primary inventoried years, the RBA coho population estimate accounted for approximately 6.3% in 2012 (12,941 coho), 2.5% in 2013 (22,738 coho), and 4% in 2021 (24,257 coho). It's important to note that in their entirety, none of the inventoried years were a complete replicate of another year. These estimates are presented as a minimum metric of adult abundance and not meant to be a definitive accounting of escapement.

Steelhead distribution was low with a total estimate of 1,764 age class 1+ or older. 69.6% of all steelhead observed were rearing in mainstem habitats of East Fork Dairy. The remainder were seen in Gales Creek and the Upper Tualatin River Mainstem. No steelhead were observed in WF Dairy Creek, McKay Creek, or McFee Creek Subbasin.

Cutthroat were abundant in most of the inventoried reaches with a total of 9,408 observed. It is important to recognize that unlike coho parr, steelhead and cutthroat are capable of rearing in fast water habitat types such as rapids, riffles and cascades. Because these fast water habitat types were not sampled during this inventory, the observed numbers do not represent any type of population estimate. However, these pool numbers can be used as a very effective tool for interannual variation and trend analysis.

It is important to note that visibility was an issue in most of the lower mainstem reaches where heavy tannins and turbidity limit the range of visibility. In these reaches, slow moving water in deep mainstem pools allows thermoclines to develop providing thermal refugia to fish in the cooler, deeper strata. The limited visibility in these habitats has likely led to an underestimation of mainstem rearing cutthroat and coho populations.

Site specific results within this document have been organized by subbasin. Following each major subbasin heading is the primary mainstem summary with tributaries reviewed in alphabetical order. After each review is a summary table that lists the stream's estimated contribution to salmonid production by species.

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. Estimates greatly under-estimate the standing crop of 0+, steelhead, and 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 production for cutthroat that extends upstream beyond the endpoint of most surveys. The information below adds to the baseline data collected in previous years and allows for some trend analysis on both the basin scale and by tributary. It also provides a comparison

of relative production potential between tributaries and provides a foundation for prioritizing restoration actions (some streams play a much more significant production role).

Table 3: 2013 Tualatin RBA expanded fish counts for all salmonids

Subbasin	Coho	0+	Sthd	Cut
Tualatin Mainstem	3,558	2,845	130	625
East Fork Dairy	35,641	12,849	1,965	3,776
Gales	25,733	18,340	650	4,055
McKay	8,442	2,432		1,954
West Fork Dairy	12,885	4,695		1,495
Inventory Total	**86,259**	**41,161**	**2,745**	**11,905**

Table 4: 2014 Tualatin RBA expanded fish counts for all salmonids

Subbasin	Coho	0+	Sthd	Cut	Chin
East Fork Dairy	27,625	5,081	2,276	3,437	
Gales	31,280	6,001	441	4,110	10
Chehalem Tribs	1,967	100		370	
Inventory Total	**60,872**	**11,182**	**2,717**	**7,917**	**10**

Table 5: 2022 Tualatin RBA expanded fish counts for all salmonids

Subbasin	Coho	0+	Sthd	Cut
Tualatin Mainstem	2,256	795	65	465
East Fork Dairy	27,916	3915	1,254	2,805
Gales	48,634	4,560	445	3,513
McKay	15,810	603		1,647
West Fork Dairy	9,139	708		946
Chehalem Mt Tribs		55		75
Inventory Total	**103,755**	**10,636**	**1,764**	**9,451**

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

Table 6: Tualatin River and Subbasins 2022 expanded fish counts for all salmonids

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Tualatin	810		215	2.0	65	3.7	175	1.9
Roaring	1446	1.4	580	5.5			290	3.1
Gales	7692	7.4	2260	21.3	330	18.7	1365	14.5
Side Channel A	554							

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Side Channel B	67							
Bateman	36		75		5		40	
Beaver	14092	13.6	20				168	1.8
Beaver Trib B	2092	2.0	20				82	
Beaver Trib C	1758	1.7					55	
Beaver Trib E	468							
Beaver Trib F	78							
Clear	12708	12.3	703	6.6	80	4.5	468	5.0
Coffee	1056	1.0	270	2.5			169	1.8
Finger			21	0.2			9	
Iler	6641	6.4	601	5.7	30	1.7	617	6.5
Low Divide			75	0.7			30	
NF Gales	102		190	1.8			265	2.8
Prickett	240		15	0.1				
SF Gales	234		170	1.6			210	2.2
Trib A Gales	24		85	0.8			5	
White	792		55	0.5			30	
EF Dairy	23156	22.4	2746	25.8	1225	69.4	1827	19.3
Side Channel B	348		24	0.2	4		18	
Side Channel D	68			0.0				
Big Canyon	252		20	0.2			10	
Campbell	708		280	2.6			155	1.6
Denny	1566	1.5	390	3.7	25	1.4%	445	4.7
Meadowbrook	1098	1.1	5				60	
Trib A Meadowbrook	18		35				10	
Murtaugh	150		10				10	
Panther			25				15	
Plentywater	318		85				30	
Rock	198		195	1.8			210	2.2
Roundy	30		50				10	
Trib A EF	6		50				5	
WF Dairy	2,616	2.5	46				142	1.5
Burgholzer	1,148	1.1	55				115	1.2
Paisley	510		5				55	

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Cummings	24		80				55	
Garrigus	1,534	1.5	115	1.1			80	
Mendenhall	941		233	2.2			303	3.2
Buxton	20		2				4	
Sadd			17				5	
Trib A WF	1,074	1.0	40				90	1.0
Trib A1 WF	90		50				30	
Whitcher	486		40				35	
Williams	696		25				32	
McKay	8,730	8.4	390	3.7			1,085	11.5
Side Channel A	210		7				2	
Side Channel C	238		3				4	
Side Channel D	124		3				4	
Brunswick	646		5				27	
EF McKay	5,862	5.7	195	1.8			525	5.6
McFee			48				74	
Heaton			7				1	
Inventory Total	**103,755**		**10,636**		**1,764**		**9,451**	

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

Densities

2022 coho average density was moderate at 0.89 fish/m². The density range from 1.7 to 14.73 fish/m² (densities at or above modeled full seeding) accounted for 12.72% of the 865 inventoried pools with coho present. The highest densities observed were the result of temperature dependent migration (overcrowding) and high-quality summer rearing habitats.

2022 cutthroat average density was low at 0.14 fish/m² for all inventoried pools. Densities between 0.6 and 1.4 fish/m² were documented as representing the top end of the observed range. The top end range was observed only in 2.7% of pools which were either located below barriers to passage, in isolated pool habitats, or above the end of anadromy in high quality rearing habitats. A more representative upper end of the density range would rest between 0.2 and 0.6 fish/m² which accounted for 19.4% of inventoried pools with cutthroat presence. This range is below the normal observation of full seeding where interspecific competition for rearing habitat exists (aggregated densities of both steelhead and cutthroat exhibiting full seeding characteristics in the 0.8 -1.0 fish/ m² range). In general, cutthroat densities increased above the distribution of steelhead and coho due to the lack of competition for food and rearing surface area.

2022 steelhead average density was low at 0.08 fish/m² for all inventoried pools. Densities between 0.3 and 0.5 fish/m² were documented as the top end of the observed range but only observed in 10 sampled pools. The density range from 0.1 - 0.3 fish/m² was more representative of the upper end range and represented 18.3% of inventoried pools with steelhead presence. The habitat's ability to rear older age class salmonids is heavily influenced by fish size, available pool surface area and food availability; therefore, we assume that in zones of cohabitation by steelhead/rainbow and cutthroat that the combined densities of these similar sized species would not exceed the 0.8 - 1.0 fish/m² observed in the highest quality habitats of the system. Observations in many thousands of miles of both Willamette and coastal streams conducted by Bio-Surveys, LLC suggests that densities above 0.7 fish/m² for older age class steelhead or cutthroat without competition from the other are rare.

2022 0+ trout density was low at 0.24 fish/m². Densities between 1 and 2.9 fish/m² were documented as the top end of the observed range but only observed in 3.7% of the inventoried pools with 0+ trout presence. The density range from 0.4 - 1 fish/m² was more representative of the upper end range and represented 17.3% of inventoried pools with 0+ trout presence. The highest densities observed in thousands of miles of Willamette basin and coastal stream inventories for the 0+ age class always hovers around 3 fish/m². The similar habitat characteristics observed in the Tualatin basin to many other watersheds suggests that the 3 fish/m² value would be a fair surrogate for indicating that the reach is somewhere near full seeding capacity for the 0+ age class and that spawning locations existed nearby.

Spawning Gravel Abundance and Distribution

A supplemental sampling effort covering 122 miles of mainstem and tributary habitats of the Tualatin Basin was conducted to quantify the abundance of spawning gravel appropriate for spawning coho. This effort was designed to test the hypothesis that the abundance of appropriately sized gravels for spawning and incubation could potentially limit coho production. Literature reviews of habitat variables seldom refer to the abundance of spawning gravel as the primary limitation for adult salmonids. However, quantitative measurements of this key habitat variable are rarely included in these analyses and an invalid assumption is possible.

A decline in channel roughness (historically provided by large wood) and the resultant reduction in the trapping and sorting of spawning gravels impacts the capacity of the system to produce juvenile salmonids. For more information about spawning gravel, channel roughness, and their direct relation to salmonid numbers, see the Methods section above.

The results of the spawning gravel inventory for the 2022 Tualatin RBA are presented in Table 7 below and will be further discussed in the individual tributary sections.

Table 7: 2022 Tualatin Spawning Gravel Counts (m^2) and Extrapolated Adult Carrying Capacity based on Available Gravel

Stream	Spawning Gravel (m^2)*	Female Coho (high)* ($1m^2$/female)	Adult Carrying Capacity (high)**	Female Coho (low)* ($3m^2$/female)	Adult Carrying Capacity (low)**
Tualatin Mainstem	222	222	444	74	148
Roaring	10	10	20	3	6
Gales	733	733	1466	244	488
Side Channel A Gales	0	0	0	0	0
Side Channel B Gales	0	0	0	0	0
Bateman	0	0	0	0	0
Beaver	314	314	628	105	209
Beaver Trib B	29	29	58	10	20
Beaver Trib C	10	10	20	3	6
Beaver Trib E	18	18	36	6	12
Beaver Trib F	0	0	0	0	0
Clear	72	72	144	24	48
Coffee	133	133	266	44	88
Finger	0	0	0	0	0
Iler	157	157	314	52	104
Low Divide	6	6	12	2	4
NF Gales	3	3	6	1	2
Prickett	0	0	0	0	0
SF Gales	30	30	60	10	20
Trib A Gales	4	4	8	1	2
White	0	0	0	0	0
EF Dairy	158	158	316	53	106
Side Channel B EF	4	4	8	1	2
Side Channel D EF	1	1	2	0	0
Big Canyon	7	7	14	2	4
Campbell	1	1	2	0	0
Denny	18	18	36	6	12
Meadowbrook	44	44	88	15	30
Trib A Meadowbrook	0	0	0	0	0
Murtaugh	5	5	10	2	4

Stream	Spawning Gravel (m^2)*	Female Coho (high)* ($1m^2$/female)	Adult Carrying Capacity (high)**	Female Coho (low)* ($3m^2$/female)	Adult Carrying Capacity (low)**
Panther	1	1	2	0	0
Plentywater	3	3	6	1	2
Rock	0	0	0	0	0
Roundy	3	3	6	1	2
Trib A EF	5	5	10	2	4
WF Dairy	33	33	66	11	22
Burgholzer	58	58	116	19	38
Paisley	22	22	44	7	14
Cummings	0	0	0	0	0
Garrigus	38	38	76	13	25
Mendenhall	23	23	46	8	16
Buxton	3	3	6	1	2
Sadd	0	0	0	0	0
Trib A WF	0	0	0	0	0
Trib A1 WF	0	0	0	0	0
Whitcher	59	59	118	20	40
Williams	14	14	28	5	10
McKay	56	56	112	19	38
Side Channel A McKay	3	3	6	1	2
Brunswick	4	4	8	1	2
EF McKay	0	0	0	0	0
McFee	20	20	40	7	14
Heaton	0	0	0	0	0
Inventory Total	2303	2303	4606	768	1536

*Estimated gravel counted in 1 m^2 increments. Gravel counts include both the stream listed and tributaries, High Female coho estimate is based on small coho redd size of 0.8 m^2 in Burner (1951), Low FML coho estimate is based on Gordie Reeves, (1989)

** Adult Carrying Capacity is based on multiplication of estimated spawning gravel counts by redd size requirements and assuming a 1:1 M/FML ratio.

The (High) estimated adult capacity presented in Table 7 is a generous estimate that utilizes a minimum redd size of 1 m^2 for all tributaries, well below normal for coho redd observations (2 m^2 minimum). We elected to drop the minimum to 1 sqm because tributaries contained very few 2 m^2 patches of gravel yet coho were present in significant abundance suggesting utilization. The (Low) estimate was calculated utilizing a maximum redd size of 3 m^2 (Reeves, 1989). In most of

the inventoried systems the (high) estimated adult carrying capacity was well above the estimated adult coho escapement value which was based on expanded juvenile abundance documented during the inventory. However, several inventoried reaches did present a deficiency in spawning gravel abundance in relation to juvenile rearing capacity. This seasonal habitat limitation will be further reviewed in individual stream sections.

The hypothesis that the abundance of spawning gravel could potentially limit the Tualatin Basin's capacity for producing wild coho smolts appears to be viable. As previously stated, the range of variance inherent in estimating the abundance of viable spawning gravel is likely to be significant (no replicate inventories have been conducted to quantify variance). Understanding that a potential limitation may exist for the incubation life history stage informs the development of future monitoring and restoration planning.

Additionally, the observed spawning gravel limitations were calculated on a very high adult escapement year for wild coho (estimated 24,257 adult coho over Willamette Falls in 2021) suggesting that our assessment has likely highlighted the most probable locations where lack of access to high quality spawning gravel is functioning as a limiting factor for coho production.

Beaver Dam Inventory

A 100% sample of all beaver pools was conducted to quantify the contribution of juvenile salmonid rearing in beaver augmented pool habitats to the total juvenile salmonid population. Though this type of sampling was not conducted in previous years (2013 & 2014), total numbers of beaver dams encountered during inventories was recorded in those years. This allows for a comparison of year-to-year beaver dam abundance and distribution.

In 2022, 4.07% of the total coho population estimate was documented rearing in beaver dam pools while they accounted for 1.82% of the total number of pools within the inventoried reaches.

Where beaver occupation was observed, their habitat augmentation was substantially increasing the rearing capacity of pool habitats. This will be discussed in more detail in individual stream profiles.

The results show a significant reduction in beaver dams throughout most of the replicated inventoried reaches. The most severe reduction was documented in the WF Dairy and McKay subbasins where there was a 73.6% (WF) and 69.2% (McKay) loss of dams. There was no apparent cause for this substantial decline in beaver abundance.

Table 8: Tualatin River and Tributaries Beaver Dams

Stream	2022	2014	2013
Gales			1
Side Channel A Gales	4	4	NS
Beaver	16	22	24

Stream	2022	2014	2013
Beaver Trib B	9	1	6
Beaver Trib C		11	8
Beaver Trib E			1
Coffee	3	1	1
Finger	5		3
Iler	3	6	3
Low Divide		2	
NF Gales			2
Prickett		1	
EF Dairy	11	7	10
Side Channel D EF	3	12	NS
Campbell		4	
2022/2014/2013 Subtotal	**54**	**71**	**59**
WF Dairy	5	NS	10
Burgholzer	1	NS	2
Paisley		NS	5
Garrigus	4	NS	22
Mendenhall	5	NS	15
Sadd	1	NS	13
Whitcher		NS	3
Williams	3	NS	6
McKay		NS	2
Brunswick	4	NS	5
EF McKay		NS	6
2022/2013 Subtotal	**23**	**NA**	**87**
McFee	7	7	NS
Heaton	13	13	NS
2022/2014 Subtotal	**20**	**20**	**NA**

*Only streams with beaver presence in at least one of the three inventoried years listed.

Upper Tualatin Subbasin

Table: 2013 Upper Tualatin expanded fish number estimates. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Tualatin Mainstem	2,430		1,085		130		220	
Roaring	1,128		1,760				405	
Subbasin Total	**3,558**		**2,845**		**130**		**625**	

Table: 2022 Upper Tualatin expanded fish number estimates. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Tualatin Mainstem	810	35.9	215	27.0	65	1	175	37.6
Roaring	1,446	64.1	580	73.0			290	62.4
Subbasin Total	**2,256**		**795**		**65**		**465**	

Tualatin River

The Tualatin River mainstem inventory began at RM 62.25 (the old Highway 47 Bridge) and extended 11 miles upstream to Haines Falls, a permanent barrier to adult passage, which terminates anadromous distribution at USGS RM 73.3. This inventory included 1 side channel and 1 tributary (Roaring Creek).

Very low fish numbers were observed in the 12 miles inventoried below Haines Falls. Salmonid abundance for all inventoried species exhibited a significant decrease in abundance in 2022 from 2013. This will be discussed in further detail below. Interestingly, mountain whitefish and one adult spring Chinook were documented in 2022. Neither of these fish species were observed in the 2013 inventories. Their presence is likely related to low summer temperature profiles maintained from flow supplementation from Barney Reservoir.

The inventoried reach of the upper Tualatin mainstem spans a dramatic gradient shift and transitions through three different river morphologies. 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 1.3 ft/mile (0.02%).

In an effort to improve water quality parameters (lower temperatures, decrease phytoplankton growth, increase dissolved oxygen), increase volumes for municipal consumption, and reduce thermal loading from wastewater treatment facilities, the natural summer flow of the Tualatin River mainstem is augmented during the summer months from two reservoir sources (Hagg Lake and Barney Reservoir). Clean Water Services, Joint Water Commission, and ODFW have

rights to the stored waters in Barney Reservoir and Hagg Lake. During the dry season Clean Water Services' releases from Hagg Lake and Barney Reservoir can account for more than half of the flow in the Tualatin River in the 15-mile stretch between the Spring Hill Pump Plant (where water is withdrawn for municipal and irrigation uses) and Highway 219, where Dairy Creek enters the Tualatin River (Tualatin River Flow Management Technical Committee 2021 Annual Report). Stored winter rains were discharged from Barney Reservoir (Trask River Drainage) beginning May 7th and extending through October 24th in 2021. Augmentation from this facility for this period ranged from 20 to 50 cfs, with peak releases through August and September. This augmentation program (that includes supplemental flow from the Rock Cr treatment facility) increases summer flow profiles as much as 33% above the Tualatin's natural summer flow (Tualatin Watershed Atlas, 2001). This has the desired effect of decreasing summer water temperatures, while also increasing summer river levels and velocities.

The Fisheries Instream Flow Analysis (FIFA) for the Upper Trask and Tualatin Rivers, (CH@M 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 Gove 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 FIFA. Temperatures recorded at RM 67.83 (South Rd Bridge, Cherry Grove) from the 2012 Annual Flow Management Report suggest that summer temperature profiles have been highly variable with some years not exceeding 14 C°

In both inventoried years (2013, 2022), similar fish distribution patterns and habitat limitations were observed. Based on the extremely low abundance of salmonid juveniles in the inventoried reach between Gaston and Haines Falls in both surveyed years, we believe conditions exist that may be negatively influencing juvenile salmonid abundance. 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 compromise the abundance of high-quality summer rearing habitat for juvenile salmonids because of the reduction low velocity pool habitats and sub optimum summer rearing temperatures. Fish are cold blooded, so the seasonal warming of aquatic systems is necessary for eliciting the physiological response required for rapid growth and the storage of fats. Optimum summer temperatures (17 -19 deg C, will ensure no more than a 20% reduction from maximum growth, Sullivan, 2000) are required for maximizing juvenile salmonid growth rates. It is also likely that the augmentation program is having a significant positive impact for salmonids 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 2022 RBA inventory).

The channel morphology of the upper Tualatin mainstem detailed in Figure 2 (below) 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 and 2022 RBA survey extended from USGS RM 62.25 to USGS RM 73.3 in Figure 2. Essentially, there is a 9-mile stream segment for the entire 78-mile Tualatin mainstem that contains all of the critical 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.

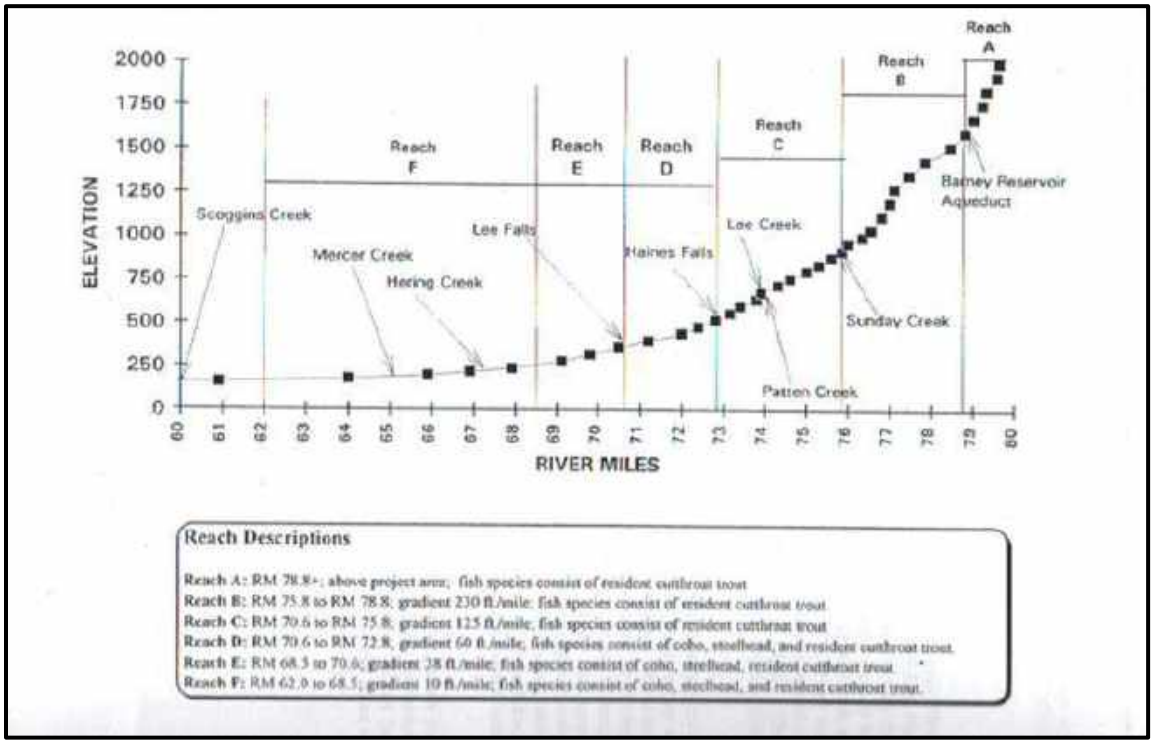


Figure 2: Fisheries Instream Flow Analysis for the Tualatin River

Below USGS RM 64 field notes confirmed a decrease in gradient, lack of gravel, and very little distinction between pool and riffle habitats (no hydraulic controls). 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 salmonid 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).

The most productive coho habitat for both inventoried years (2013, 2022) began just below the basalt/alluvial transition and extended through the upper portion of the Patton Valley (RM 66 - 67.5). 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 incision was also noted in this section.

Photo 1 Upper Tualatin River, channel incision and erosion.

Above USGS RM 68, near the confluence of Roaring Cr, a noted gradient increase occurs. Proceeding upstream to USGS RM 69, surveyors 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. In 2022, mountain whitefish and one wild adult spring Chinook were observed in this reach below Little Lee Falls (USGS RM 70.1). In both inventoried years steelhead and cutthroat abundance increases 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. In both inventoried years (2013, 2022) 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.

Shortly above this peak in fish production the canyon tightens with a gradient increase over bedrock and boulder and at USGS RM 73.3 anadromous potential is terminated at Haines Falls, a 15 ft bedrock sill.

Photo 2 Haines Falls, Upper Tualatin River

Anchor Sites:

One low functioning anchor site was observed above Lee Falls starting at USGS RM 71.6 extending for 1000 ft. The site lacks complexity and gravel but exhibited characteristics of a broad floodplain with low terrace heights. Side Channel A enters and exits within this anchor providing high complexity and low velocity refuge from the mainstem.

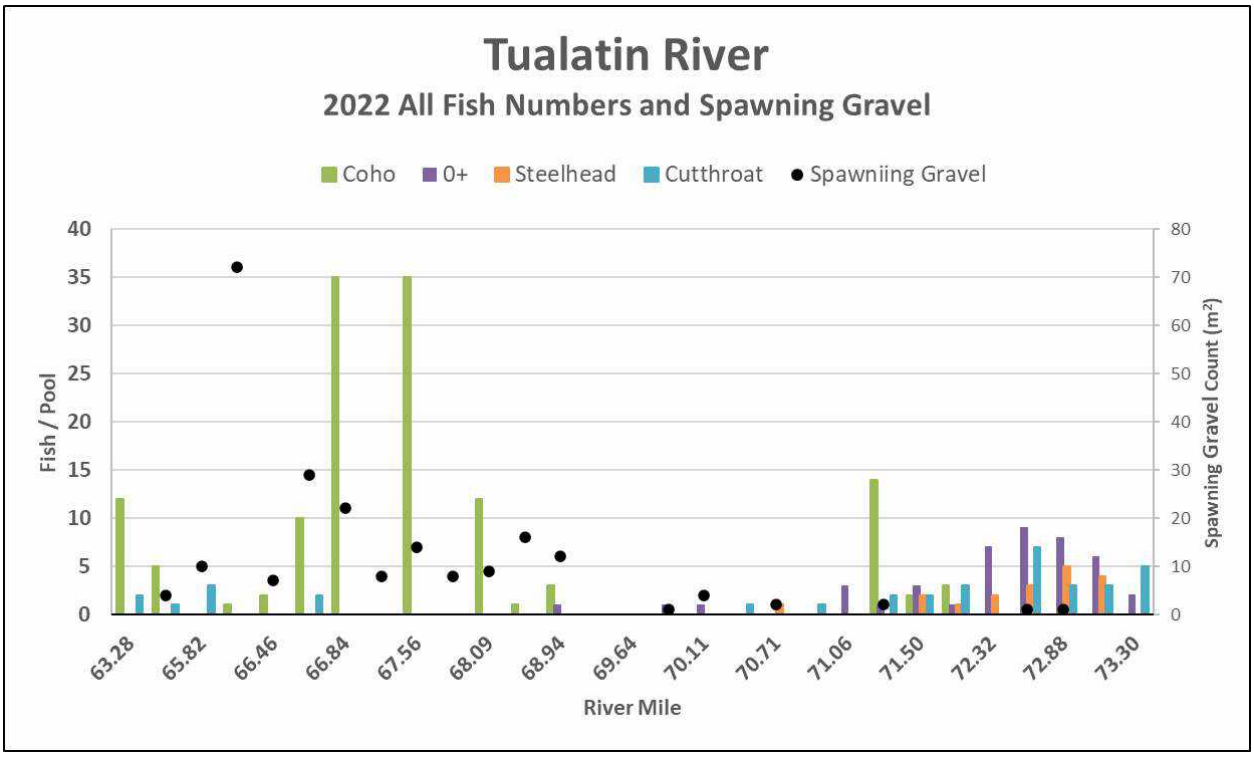


Figure 3: Tualatin River All Fish Numbers with spawning gravel 2022

Coho

Coho abundance was extremely low in both inventoried years. Abundance throughout the peak production zones expanded to 1,446 fish/mile from USGS RM 66— 67.5 in 2013 and 533 fish/mile from USGS RM 66.7 — 67.6 in 2022.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, adult coho escapement (combined male and female) to the upper Tualatin mainstem was 22 coho in 2013 and 8 coho in 2022. Estimated adult coho capacity based on spawning gravel availability was 70 — 208 coho. In 2022 the Upper Tualatin River was functioning far below its current habitat capacity and limited by inadequate summer temperature profiles, high velocity rearing habitat, and low adult escapement.

Steelhead

Steelhead abundance was 50% lower than the 2013 estimate. This is likely the result of lower adult returns of winter steelhead over Willamette falls in 2021. In both inventoried years, very little pool presence was observed below Little Lee falls (RM 70.1). Abundance throughout the peak production reach from Lee Falls (USGS RM 71.5) to Haines Falls (USS RM 73.3) expanded to 56 fish/mile in 2013 and 47 fish/mile in 2022.

Cutthroat

Cutthroat abundance was 20.5% lower than 2013, with an average density of 0.01 fish/m². In both inventoried years, very little pool presence was observed below Little Lee falls (RM 70.1). Abundance throughout the peak production reach from Lee Falls (USGS RM 71.5) to Haines Falls (USGS RM 73.3) expanded to 94 fish/mile in 2013 and 64 fish/mile in 2022.

0+ Trout

0+ trout abundance was 80.2% lower than the 2013 estimate. This reduction is likely the result of lower adult returns of winter steelhead into the upper Tualatin and/or a decreased abundance in the fluvial component of the cutthroat population utilizing the upper basin for spawning.

0+ trout abundance was very low with sporadic pool presence observed below RM 71.06 Abundance throughout the peak production reach from (USGS RM 71.06 — 73.3) expanding to 374 fish/mile in 2013 and 90 fish/mile in 2022.

Chinook

Juvenile Chinook were not observed. Inventoried habitats were suitable for chinook occupation. One wild adult spring Chinook was observed. Low summer temperatures profiles maintained from flow supplementation from Barney Reservoir have likely contributed to the increased viability of summer habitat for resting spring Chinook.

Table 9: Tualatin River - Expanded Fish Counts for all Salmonid Species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	2,430	0.05	1,085	130	220	0
2022	810	0.03	215	65	175	0

Roaring Creek

Roaring Creek enters the Tualatin River at RM 68.4. The inventory extended 2.2 miles upstream where a gradient increase and ephemeral wood barriers limit further anadromous spawning and rearing potential.

The stream habitat was primarily characterized by a forested riparian canopy of deciduous and coniferous trees; moderate gradient (avg. 2.8%); low wood complexity in the lower half of the inventory with increased complexity in the upper half comprised of predominantly deciduous material with some natural conifer recruitment; and dominant substrates of small boulder, cobble, and gravel with reaches of scoured bedrock.

At the time of the inventory a 2.6°C temperature differential was recorded between Roaring Creek and mainstem Tualatin (Roaring 15.3°C, Tualatin 12.7°C). The unseasonably low mainstem Tualatin temperature is a result of augmentation from Barney Reservoir. In 2013, a pattern of upstream juvenile migration into Roaring Creek from the Tualatin mainstem was documented. This density profile was not observed in 2022.

Anchor Sites:

No anchor sites were documented in Roaring Creek. Stream habitats were hillslope confined throughout the inventoried reach.

Photo 3: Roaring Creek

Coho

Coho abundance was low in both inventoried years (2013, 2022) with average pool densities of 0.48 coho/m^2 (584 fish/mile) in 2013 and 0.39 coho/m^2 (634 coho/mile) in 2022. The dominant density peak of 0.9 coho/m^2 was observed at RM 1.3.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson /Lawson Coho model, combined male and female coho escapement to Roaring Creek was 10 coho in 2013 and 14 coho in 2022. Estimated adult coho capacity based on spawning gravel availability was 6 –20 coho. In 2022 Roaring Creek was functioning near its current habitat capacity indicating that in years of higher adult escapement a spawning gravel limitation may function as a limiting factor for coho production.

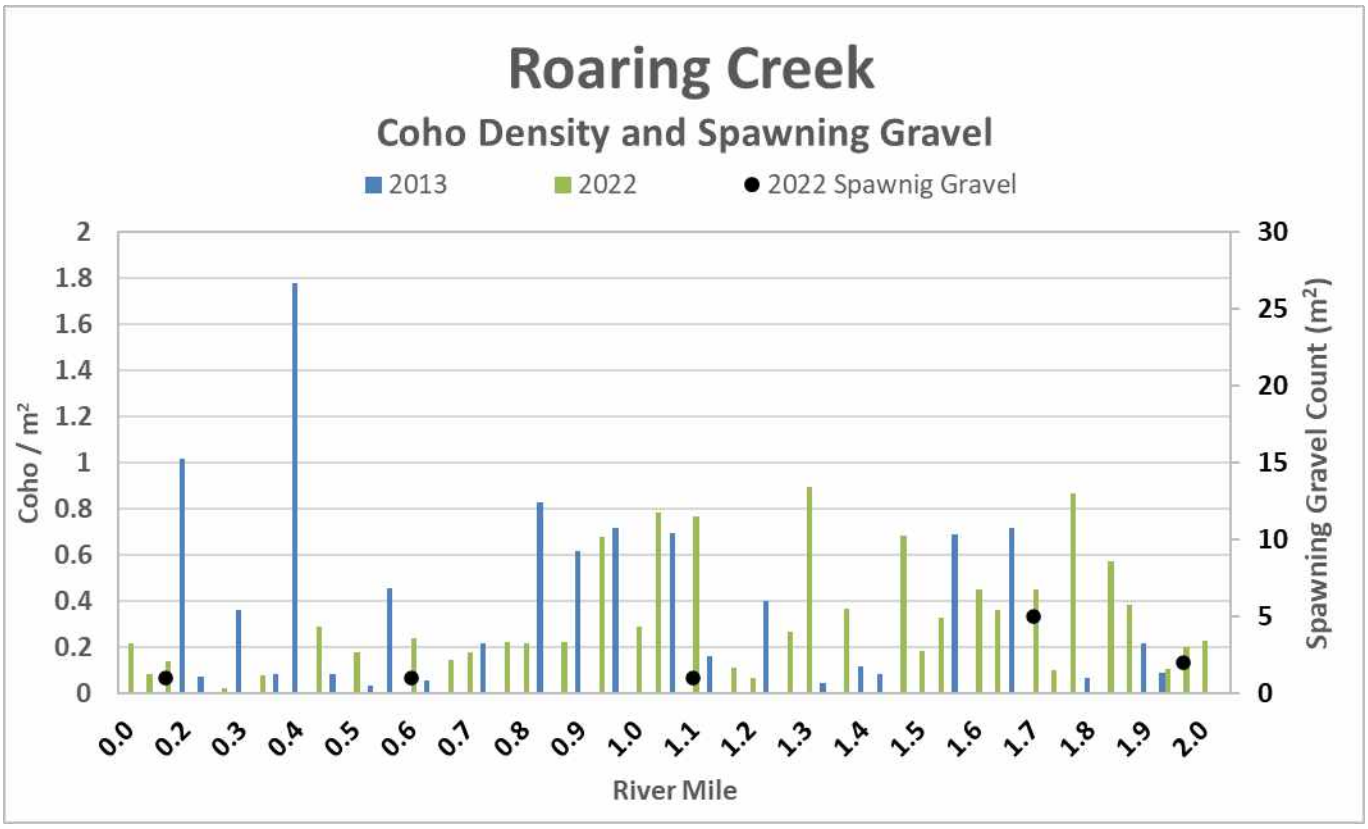


Figure 4: Roaring Creek Densities 2013, 2022

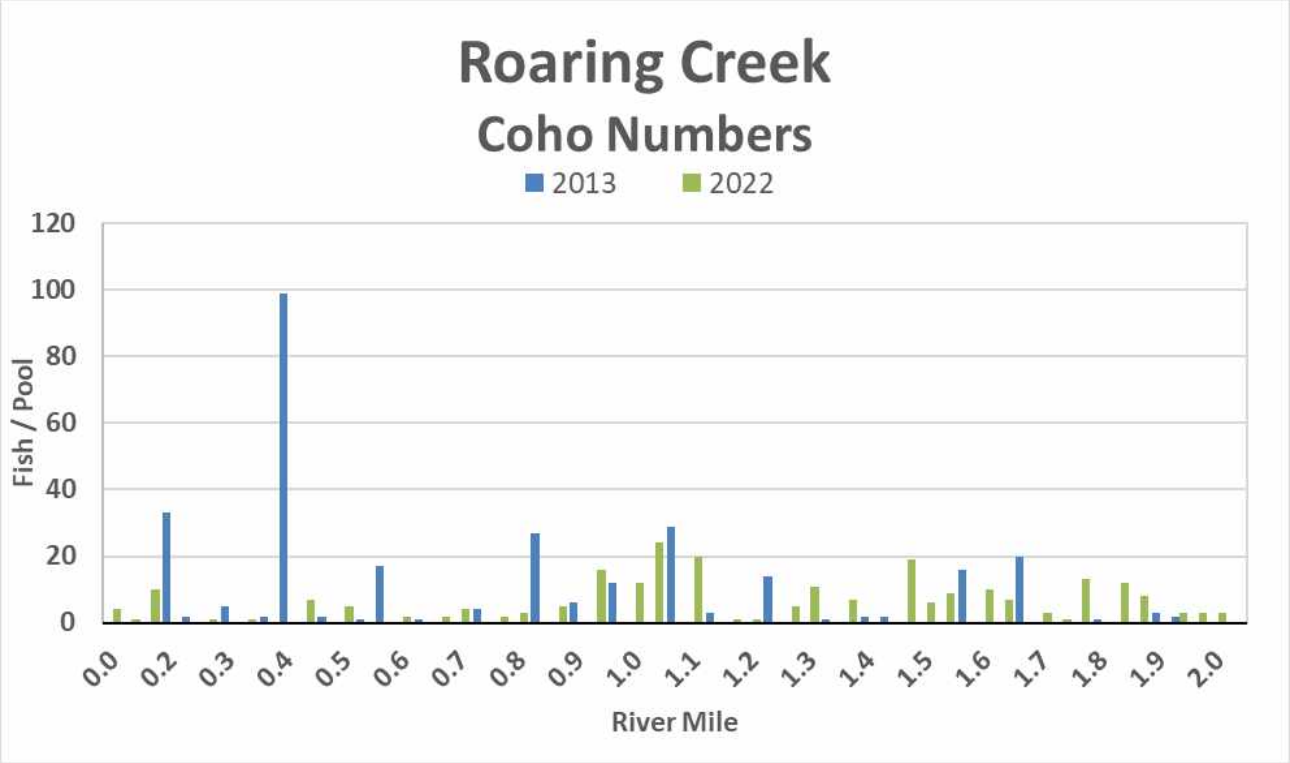


Figure 5: Roaring Creek Coho Numbers 2013, 2022

Steelhead

Steelhead were not observed. Stream habitat was suitable for steelhead occupation.

Cutthroat

Cutthroat abundance in 2022 was low with an average density of 0.12 fish/m² (127 fish/mile). A 28.4% reduction in cutthroat abundance was documented from 2013 – 2022.

0+ Trout

0+ trout abundance was moderate in 2013 and low in 2022 with average densities of 0.65 fish/m² (876 fish/mile) in 2013 and 0.21 fish/m² (254 fish/mile) in 2022.

A 67.1% reduction in 0+ trout abundance was documented from 2013 – 2022.There may be unknown cumulative effects on cutthroat production associated with increased summer flows and temperature reductions as a result of the mainstem flow augmentation. These effects may be altering fluvial migration patterns of cutthroat resulting in decreased abundance in the resident cutthroat population of Roaring Creek and as a result a reduction in young of the year fry.

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 10: Roaring Creek Expanded Fish Counts for all Salmonid Species.

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat
2013	1128	0.48	1,760	0	405
2022	1446	0.39	580	0	290

Gales Creek Subbasin

Gales Creek enters the Tualatin River from the Northwest at USGS RM 56.8 just south of Forest Grove. The drainage covers 77.9 sqm and is the 2nd largest subbasin within Tualatin.

In 2022 the Gales Creek subbasin contained 46.1 miles of inventoried stream habitat that exhibited anadromous potential. This total included 12 significant tributaries. The tributary habitats were observed rearing 91.5% of all coho observed in 2013; 82.7% in 2014; and 83% in 2022 while contributing about 55% of the total stream miles and far less of the total rearing capacity within the subbasin. The opposite was true for Steelhead where in 2013 only 33.8%; in 2014, 38.8%; and in 2022, 25.8% of the subbasin totals were observed rearing in tributary habitats. Each of the tributaries will be reviewed separately below.

Salmonid distribution profiles and abundances varied significantly between the 2013, 2014, and 2022 inventoried years.

Steelhead abundance estimates were similar for 2014 and 2022 exhibiting a 32.15% basin wide decline from 2013. Steelhead distribution profiles in 2013 and 2014 were similar with 66.1% (2013) and 61.2% (2014) of the production in mainstem Gales Creek, while in 2022 it was 74.2%.

0+ trout abundance was the lowest of the three inventoried years exhibiting a 75.1% basin wide decline from 2013, the highest abundance year. This reduction in abundance is likely the result of either hydrologic events adversely affecting trout spawning and/or egg to fry survival; a reduction in spawning events as a result of diminished adult winter steelhead returns; and/or decreased abundance of resident cutthroat populations. Given the low abundance of steelhead in the basin, a majority of the documented 0+ trout parr are likely the progeny of resident cutthroat trout.

Mainstem Gales cutthroat trout abundance varied between the three inventoried years, with 2022 estimates between those of 2013 and 2014, while tributary production in 2022 was the lowest of the three inventoried years. This reduction in abundance was a trend observed in all tributaries except for Bateman, Coffee, NF Gales, and SF Gales. This is interesting given that these four tributaries are the most significant cold-water contributions of the upper Gales Creek basin. Further trend analysis will be discussed in individual stream profiles.

Coho distribution and abundance exhibited significant year to year differentiation as well. Total basin wide coho production was the highest of the three inventoried years, 89% higher than 2013 (the lowest abundance year) with Gales Creek mainstem contributions matching 2014 (the 2nd highest abundance) at 16.9% with 2013 at 8.5%. Coho production in lower mainstem Gales matched 2014 more closely as well with a large percentage of the population (60% in 2022, 77.5% in 2014, and only 8.2% in 2013) documented rearing downstream of Balm Grove Dam (USGS RM 12.7). In 2022, Coho distribution profiles above the dam more closely matched 2013 with similar endpoints in Gales mainstem, Beaver Creek, NF Gales, and SF Gales.

Year to year differences in significant fall rain events likely have considerable impacts on westside Willamette adult coho populations. In years of late or limited fall rain events stream

levels can remain quite low in the upper reaches of the watershed restricting access to adult coho for the duration of the peak spawning period.

Coho distribution profiles in 2014 suggested that some level of access restrictions was present. Higher abundances were observed rearing in lower mainstem Gales as well as tributaries that enter below Balm Grove Dam (Clear and Iler) and distribution above the dam terminated lower in a majority of inventoried reaches including Gales mainstem, Beaver Creek, and NF Gales.

Coho distribution profiles in 2022 exhibited some signs of access restrictions to the upper mainstem though higher production was observed throughout mainstem Gales as well as increased production in most tributary habitats above and below Balm Grove Dam with the exception of NF Gales, SF Gales, and White Creek.

Table 11: Gales Creek Subbasin 2013 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Gales	2,184	8.5	8,205	44.	430	66.1	1,585	39		
Bateman	168		250	1.4			115	2.8		
Beaver	12,192	47.4	425	2.3			360	8.9		
Clear	5,477	21.3	3,025	16.	140	21.5	605	14.9		
Coffee			325	1.8			45	1.1		
Finger	150		45				30			
Iler	2,556	9.9	3,770	20.	25	3.8	735	18.1		
Low Divide			110							
NF Gales	972	3.8	935	5.1	50	7.7	220	5.4		
Prickett			70				55	1.4		
Roderick			40				5			
SF Gales	630	2.4	1,040	5.7			210	5.2		
Trib A			25		5					
White	1,404	5.5	75				90	2.2		
Subbasin Total	**25,733**		**18,340**		**650**		**4,055**			

Table 12: Gales Creek Subbasin 2014 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Gales	4,146	13.3	3,000	50	270	61.2	1,005	24.5	5	50
Side Channels	1,095	3.5	1		1		10			
Bateman	36		65	1.1	20	4.5	30			
Beaver	9,929	31.7	100	1.7			620	15.1		

Stream	Coho	%	0+	%	Sthd	%	Cut	%	Chin	%
Clear	7,323	23.4	710	11.8	135	30.6	665	16.2		
Coffee			195	3.2			60	1.5		
Finger			30				30			
Iler	6,900	22.1	675	11.2	5	1.1	885	21.5	5	50
Low Divide			40				15			
NF Gales	132		510	8.5			295	7.2		
Prickett	30		20				15			
SF Gales	420	1.3	630	10.5	10	2.3	325	7.9		
White	1,266	4	25				155	3.8		
Subbasin Total	**31,280**		**6,001**		**441**		**4,110**		**10**	

Table 13: Gales Creek Subbasin 2022 Expanded Fish Counts for all Salmonid Species.

Stream	Coho	%	0+	%	Sthd	%	Cut	%		
Gales	7,692	15.8	2,260	49.6	330	74.2	1,365	38.		
Side Channel A	554	1.1								
Side Channel B	67									
Bateman	36		75	1.6	5	1.1	40	1.1		
Beaver	14,092	29.0	20				168	4.8		
Beaver Trib B	2,092	4.3	20				82	2.3		
Beaver Trib C	1,758	3.6					55	1.6		
Beaver Trib E	468	1.0								
Beaver Trib F	78									
Clear	12,708	26.2	703	15.4	80	18.0	468	13.		
Coffee	1,056	2.2	270	5.9			169	4.8		
Finger			21				9			
Iler	6,641	13.7	601	13.2	30	6.7	617	17.		
Low Divide			75	1.6			30			
NF Gales	102		190	4.2			265	7.5		
Prickett	240		15							
SF Gales	234		170	3.7			210	6.0		
Trib A Gales	24		85	1.9			5			
White	792	1.5	55	1.2			30			
Subbasin Total	**48,634**		**4,560**		**445**		**3,513**			

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

- Percentages are of total within the subbasin

Gales Creek

In 2014 and 2022, the Gales Creek mainstem inventory began at USGS RM 7 (the Stringtown Rd crossing). In 2013, the inventory extended an additional 3.4 miles downstream to the crossing of SW Ritchey Rd. Due to severe temperature limitations limiting summer rearing potential, lack of spawning gravel, and poor visibility, replicate inventories were not conducted on this 3.4-mile section and no additional inventories extending to the confluence with the Tualatin were conducted. In all inventoried years, the mainstem survey terminated at a bedrock falls at USGS RM 27.1 serving as a permanent anadromous barrier.

The Gales Creek 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 linear 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.

Steelhead distribution extended to USGS RM 24.1 in 2013, USGS RM 25 in 2014, and USGS RM 25.1 in 2022 with no adult barriers to passage observed. Coho distribution extended to USGS RM 22.5 in 2013, USGS RM 21.9 in 2014, and USGS RM 22.4 in 2022 leaving some of the highest quality fish habitat in the basin underutilized with no definitive barriers to adult passage observed. These are unusual distribution patterns 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 and/or favorable river level flow patterns during peak spawning periods, these headwater habitats would be more completely utilized for spawning and rearing.

The first several miles of the inventory exhibited average gradient of 0.45%; bedrock, cobble, and gravel dominated substrate with silt deposition in the larger pools; high solar exposure with primarily deciduous riparian; and temperature profiles recorded at the time of the inventories ranging from 18.5 ˚C – 22.6 ˚C in 2014 and 16.5 ˚C – 23.6 ˚C in 2022. Notes indicated clean sorted gravel in tailouts and long cobble riffles in between pools. In 2013 and 2014 steelhead are first observed just above Stringtown road at USGS RM 7.5, while in 2022 steelhead were not observed until the confluence of Clear Creek at USGS RM 10.7. Redside shiners, Northern pikeminnow, speckled dace, and largescale suckers were abundant in this reach. Western pearlshell mussels were observed near the startpoint.

There were 3 significant tributaries offering potential cold water refugia in the temperature transition zone between USGS RM 6 and USGS RM 13: Pricket Cr enters at USGS RM 6.5, 2.2˚C cooler (in 2014) than the mainstem with a seasonal irrigation dam just above the first pool blocking any upstream temperature dependent migration of salmonids; Clear Cr enters at USGS RM 10.7 with an average (2014-2022) temperature differential 3˚C cooler than the mainstem above with the first few pools exhibiting coho and cutthroat densities among the highest observed in the entire Tualatin basin (behavior exhibiting a desire to seek thermal refugia); and

Iler Cr enters at USGS RM 11.4, with an average (2014, 2019, 2022) temperature differential 1.6˚C cooler than the mainstem above with a series of concrete steps (see Iler Creek discussion) impeding any further upstream juvenile migration 1300ft above its confluence with Gales. At USGS RM 11.8 Anchor Site #1 was documented extending 770ft. One large backwater pool exhibiting a thermocline with a 3.1°C temperature differential was providing thermal refugia. An adjacent high complexity deep pool also exhibited high abundances of coho and cutthroat. This pool was sampled in previous inventoried years with similar high salmonid abundances.

Photo 4: Gales Creek mainstem treatment logs functioning as scour vectors

Upstream temperature dependent migrations within the mainstem of Gales Creek were terminated just below Parsons Rd at USGS RM 12.7 at Balm Grove Dam. Density spikes of steelhead, cutthroat, and coho were observed at the base of the falls in all inventoried years. The highest mainstem coho density for all inventoried years was observed in 2022 at 1.4 fish/sqm in this pool. This density is still below full seeding levels (1.7 fish/sqm, ODFW). 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. The highest temperature in the basin (23.6°C) was also recorded in this pool. 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) and may complicate passage for adult coho arriving before significant fall rain events. Coho distribution profiles in 2014 suggested that in years of inadequate fall rains the Balm Grove dam limited adult access to the upper basin and its tributaries. The removal of this dam was a high priority restoration action that was completed shortly after our 2022 inventory.

Photo 5: Gales Creek coho congregating in alcove providing thermal refugia

Around Balm Grove channel characteristics transition to more exposed siltstone/sandstone bedrock and small boulder/cobble dominated substrate. At USGS RM 13.1 Anchor Sites #2 and #3 extended back-to-back for 1600ft exhibiting a broad complex interactive floodplain and contained Side Channels A and B. Side Channel A was the only significant side channel sampled in 2022. It provided high complexity off channel habitat extending approximately 1000 ft. Downstream connectivity was maintained with low flows exhibiting a 2°C temperature differential from Gales mainstem. Several beaver dammed pools were documented with thermoclines of cold stratified water with temps as low as 15.4°C offering thermal refugia to salmonids. High coho densities averaging 1.9 fish/sqm were observed in the four sampled pools containing coho. Very few salmonids were documented in the adjacent mainstem habitat. Due to year-to-year differences in landowner access Side Channel A was not sampled in 2013 but in 2014 it contributed some of the highest quality habitat in the Gales basin though it lacked a temperature differential due to upstream connectivity to mainstem Gales surface flows. In both 2014 and 2022, temperatures taken at the time of the inventories peaked at 19.8°C in this reach.

White Cr enters at USGS RM 14.4 as a cold-water contribution 2˚C cooler (in 2014) than the mainstem above. 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.

Bateman Creek enters at USGS RM 16.25 as a cold-water contribution 2.4˚C (2014), 3.1˚C (2022) cooler than the mainstem upstream of its confluence. In all inventoried years coho appeared to also be utilizing Bateman Creek as a source of cold water refugia from the mainstem of Gales Creek. A series of 3-4ft bedrock falls was encountered approximately 1,600 ft (USGS RM 16.6) above the confluence of Bateman Creek in the mainstem of Gales Creek that represent the end of temperature dependent juvenile migrations upstream of Balm Grove dam. 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, White) directly addresses a primary limiting factor for multiple salmonid species. Summer temperature limitations continue further upstream, however the actual transition to a functional summer reach for salmonids is not well bracketed with temperature data.

Photo 6: Gales Creek scoured bedrock

Very low salmonid abundance of all species was observed from Bateman Creek (USGS RM 16.25 to the South Fork (USGS RM 20.7). This reach exhibited channels scoured to bedrock, deep basalt trench pools, and simplified low complexity habitats. This combination of habitat characteristics likely increases predation rates due to the lack of cover and increases juvenile avulsion from the reach due to the lack of velocity refuge. In 2022, temperatures taken at the time of the inventories peaked at 19.7°C. Beaver Creek enters within this reach accessible to temperature dependent upstream migrants at USGS RM 18; however, Beaver Creek enters Gales Creek with a similar summer temperature profile rendering it unfit for upstream temperature dependent migrants in search of thermal refugia. Salmonid distribution profiles in lower Beaver Cr support this conclusion (see Beaver Cr discussion). These habitat conditions extend to another 4ft bedrock falls at USGS RM 19.75. 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. Juvenile salmonids rearing between Bateman and Coffee Cr become isolated from thermal refugia because there are no significant cold-water contributions entering within this reach and natural barriers deny them access 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 by increasing risk of either avian or mammal predation.

The next few miles upstream of Coffee Creek 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. Increases in combined coho, steelhead, and cutthroat abundance were observed in this stretch in all inventoried years.

Landowners restricted access to a few thousand feet of Gales Creek above the confluence of Finger Creek. Surveyors reentered at Anchor Site #4 with 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 (thermal refugia). Coho distribution in 2014 ended shortly above this reach at USGS RM 21.9. Cutthroat numbers begin to climb in this reach with a noticeable increase in abundance of older age class cutthroat observed. The gradient throughout this peak production reach averaged 1.5%.

At the confluence of NF Gales at USGS RM 21.7 a series of Large Woody Debris (LWD) treatment reaches begin in mainstem Gales Creek. A broad and interactive gravel floodplain with treatment logs has matured with high channel complexity braiding and deep bedload aggradation. 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 USGS RM 22.5 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 2013 and 2022. High functioning Anchor Sites #5 - #7 were documented in this reach.

A decrease in gradient to 1% was noted around the confluence of Low Divide Cr (Gales Creek campground). Extensive channel braiding, increased wood complexity, and mature riparian canopy were all noted throughout the next 2 miles with a final increase in gradient to 2.2%. Anchor Sites #8 and #9 were documented in this reach.

Trib A enters at USGS RM 23.5 with high flow, cold water and very low numbers of steelhead parr in 2013 and 2022. In 2014 steelhead were not observed in Trib A. In 2013 Steelhead distribution terminated shortly above Trib A at USGS RM 24. In 2014 and 2022 Steelhead distribution extended an additional mile to USGS RM 25. No definitive barriers to steelhead passage were observed near the end of their distribution though decreased surface flows were observed in all inventoried years above USGS RM 25.

Photo 7: Gales Creek Anchor Site #8

The inventory extended a few miles above the observed end of anadromous distribution with some high-quality summer rearing habitat documented. In the last 1.5 stream miles, pools became more isolated from each other and are summer linked only hyporehicly. Cutthroat and 0+ trout densities climbed throughout this reach. This effect was not nearly as severe in 2022 when late season rainfall kept flows higher during our inventory timing.

Mainstem flows quickly dissipated with each tributary contribution. In all inventoried years peak cutthroat and 0+ trout densities were recorded in this reach. In 2013 and 2014 some of these values represented fully seeded pool capacities, though the lack of riffle habitat concentrated the fish populations in pool habitats boosting summer density profiles. Gradients near the end of the surveyed stream reach continue to increase to an average of 3.7%. Decreased pool

complexity and limited spawning gravel were observed with an increase in boulder and cobble dominated substrate. In all inventoried years the survey terminated at a 6-8ft bedrock falls above a canyon pinch at USGS RM 27.1.

Anchor Sites:

Nine anchor sites were documented in Gales mainstem. Only two sites were located in the lower mainstem downstream of Bateman Creek (USGS RM 16.25). These two anchors were given a functionality rating of 3 (low) due to inadequate wood complexity and temperature limitations. All additional anchors were located between USGS RM 20.5 and 24.5. Peak salmonid production for most species during most inventoried years overlapped this reach. All but one of these anchors (#7) was given a functionality grade of 2 (Medium) due to inadequate wood complexity. Anchor #7 was given a high (1) functionality rating. Anchors #5 - #8 have been previously treated with LWD though most of the stream habitat could benefit from additional wood complexity.

Photo 8: Gales Creek, high functioning Anchor Site #7

Coho

Coho abundance in 2022 was the highest of the inventoried years with increases in mainstem production of 338.1% from 2013 and 178.5% from 2014. Distribution profiles in 2022 exhibited production increases in the lower 8 miles of inventoried habitat (USGS RM 7 – 15), like those observed in 2014, accounting for 78.7% (2022), 85.4% (2014), and only 39.2% (2013) of the total population estimates.

The 2022 average pool density of 0.15 fish/m² was documented expanding to 1207 fish/mile throughout the peak production two-mile reach from Clear Creek to Balm Grove Dam. The dominant density peak of 1.67 fish/m² was observed at RM 12.7 in the pool below Balm Grove Dam. Density peaks in 2013 and 2014 were observed higher in the basin at 0.72 fish/m² (USGS RM 21) in 2013 and 0.33 fish/m² (USGS RM 21.5).

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to Gales mainstem was 22 coho in 2012, 50 coho in 2013, and 78 coho in 2021. Estimated adult coho capacity based on spawning gravel availability in the range of distribution was 438 – 1312 coho. In all inventoried years, Gales Creek was functioning far below its current habitat capacity and limited by inadequate adult escapement, summer temperature limitations, and inadequate channel complexity.

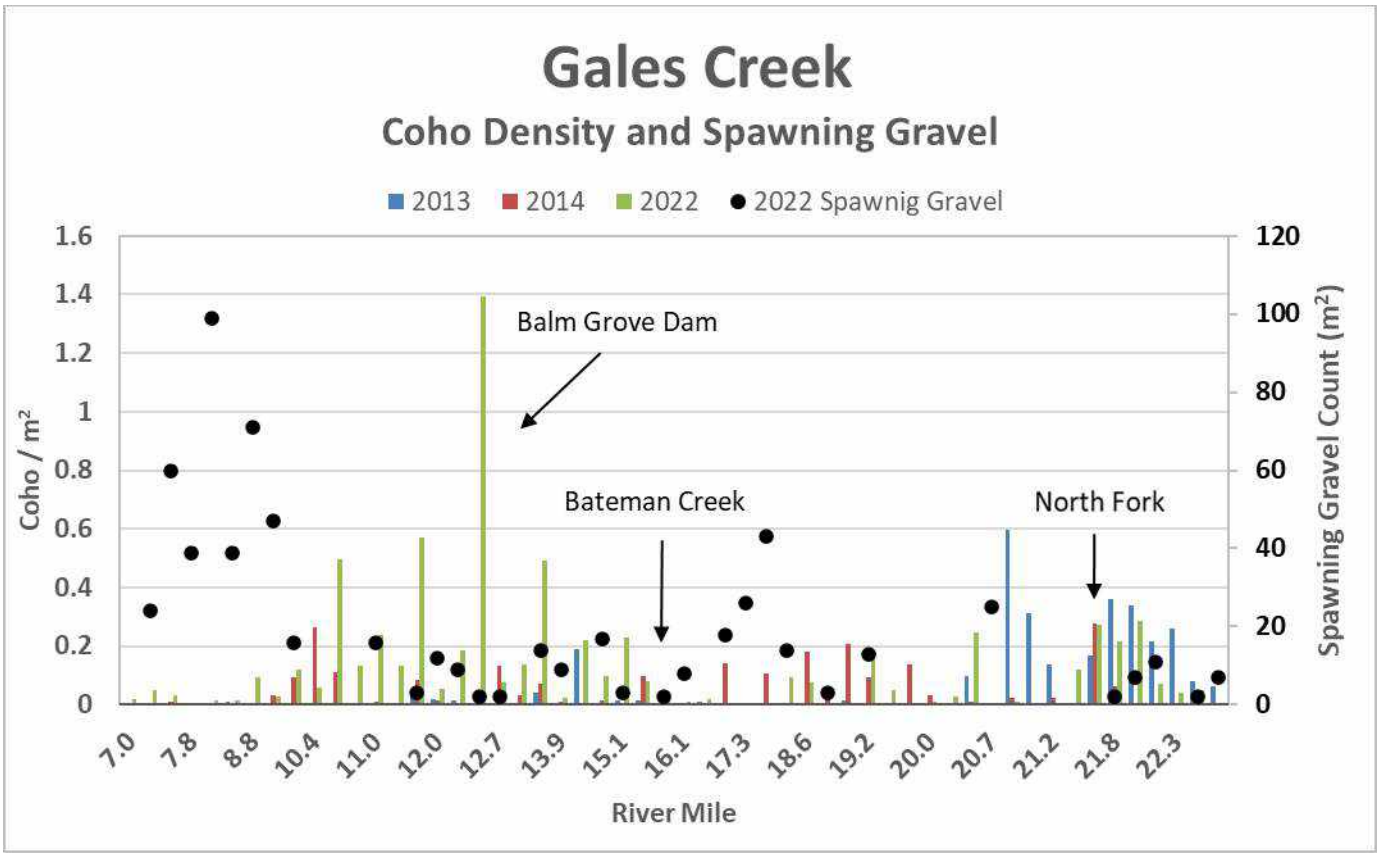


Figure 6: Gales Creek Coho Densities with Spawning gravel 2013, 2014, 2022

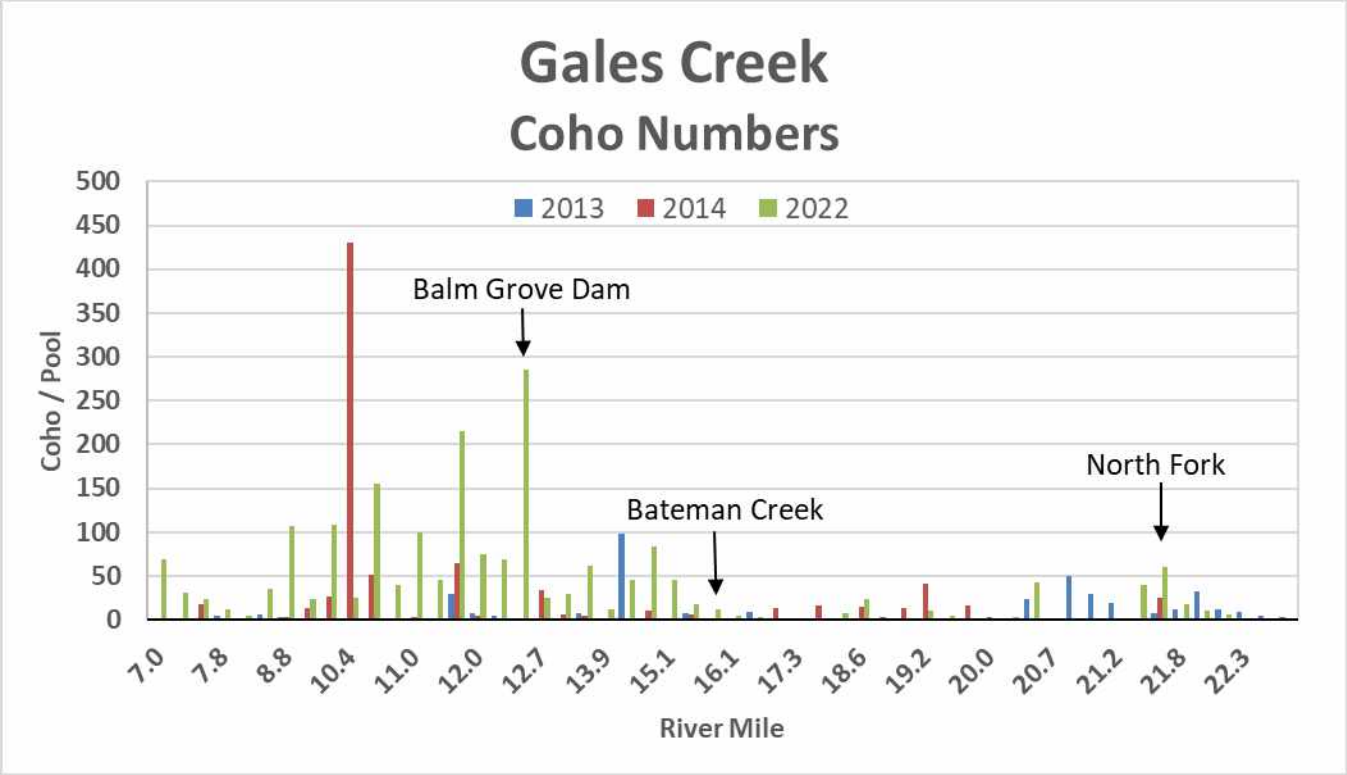
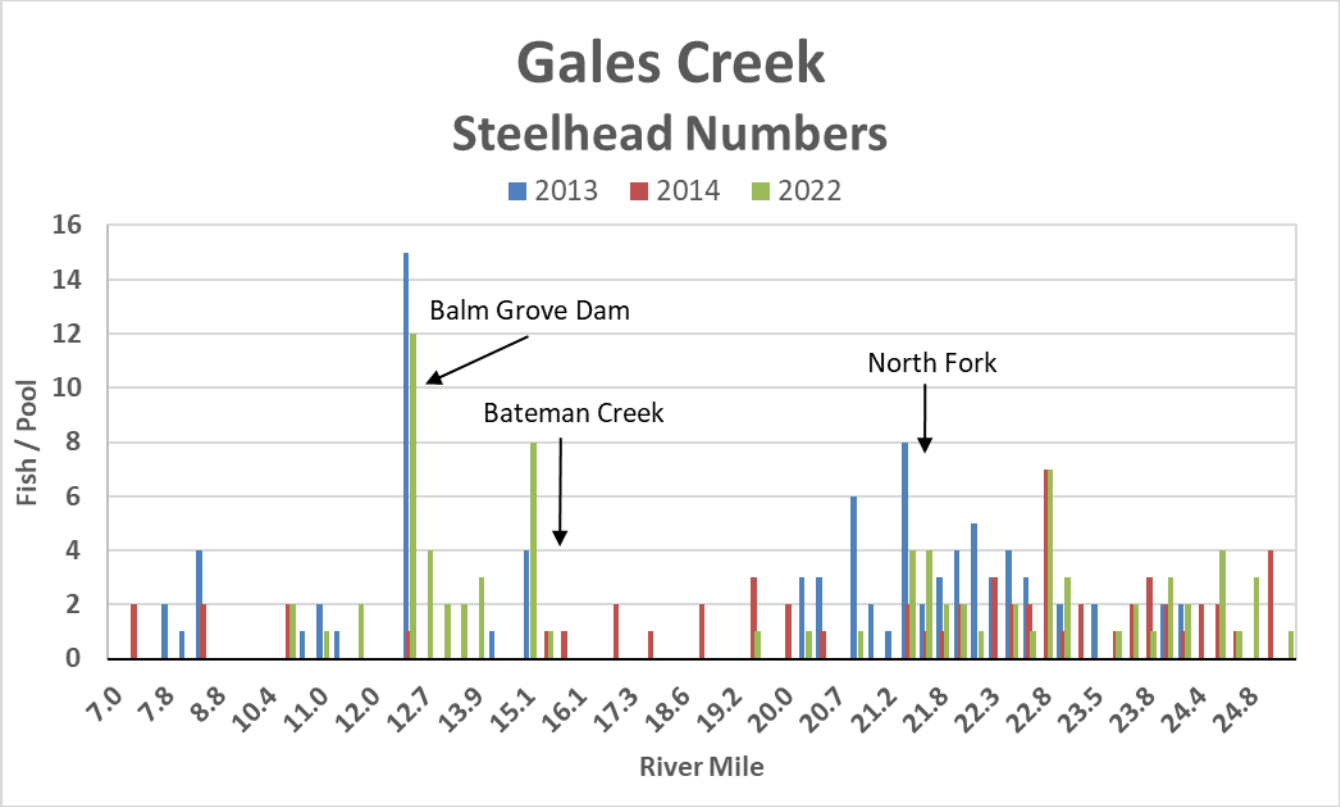


Figure 7: Gales Creek Coho Numbers 2013, 2014, 2022

Steelhead

Steelhead abundance was low in all inventoried years with 2022 estimates near the average. Similar distribution profiles were observed in all years with abundance concentrated downstream of Bateman Creek (USGS RM16.25) upstream of the South Fork (USGS RM 20.7) extending to the end of observed anadromy around USGS RM 25.

Average rearing densities in the shared peak production reach (USGS RM 21.5 – 22.8) were 0.07 fish/m² (126 fish/mile), 0.05 fish/m² (80 fish/mile), and 0.05 fish/m² (87 fish/mile) in 2022. These values remain well below full seeding capacity.



Cutthroat

Cutthroat abundance was low in all inventoried years with 2022 estimates near the average. Increased production in all inventoried years was observed from just below the North Fork (USGS RM 21.5) to Low Divide Creek (USGS RM 22.8), overlapping Anchor Sites #5 - # 7 and LWD treatments. In all years, very little abundance was documented from Bateman creek (USGS 16.25) to the falls below Coffee Creek (USGS RM 19.8).

Average rearing densities in the shared peak production reach (USGS RM 21.5 – 22.8) were 0.14 fish/m² (280 fish/mile), 0.13 fish/m² (335 fish/mile), and 0.12 fish/m² (238 fish/mile) in 2022. These values remain well below full seeding.

Peak densities in 2013 and 2014 were observed high in the basin where pools became isolated from each other, summer linked by hyporheic flows. Though the values represented fully seeded pool capacities, the lack of riffle habitat concentrated the fish populations in pool habitats boosting summer density profiles. This was not observed in 2022 due to late season rains augmenting summer flow levels at the time of the inventory.

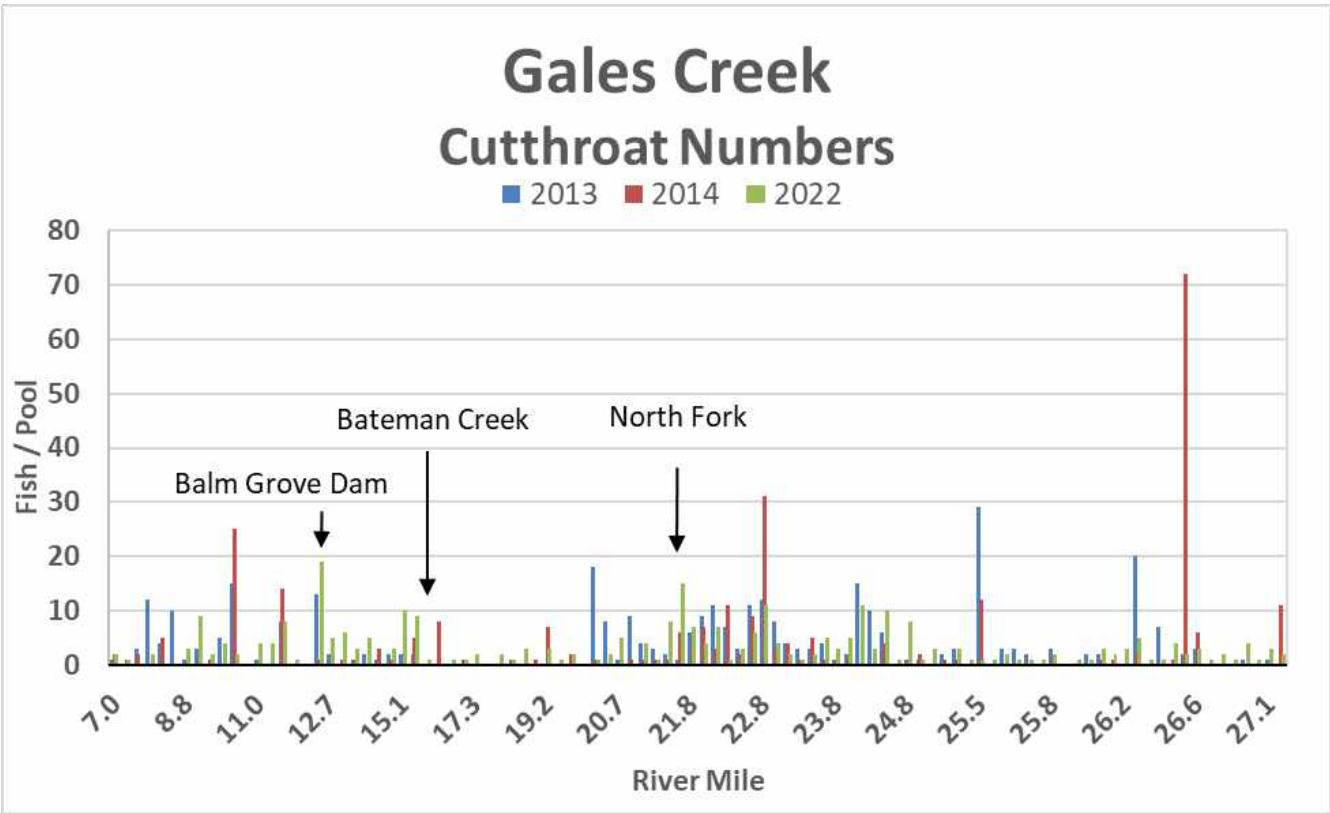


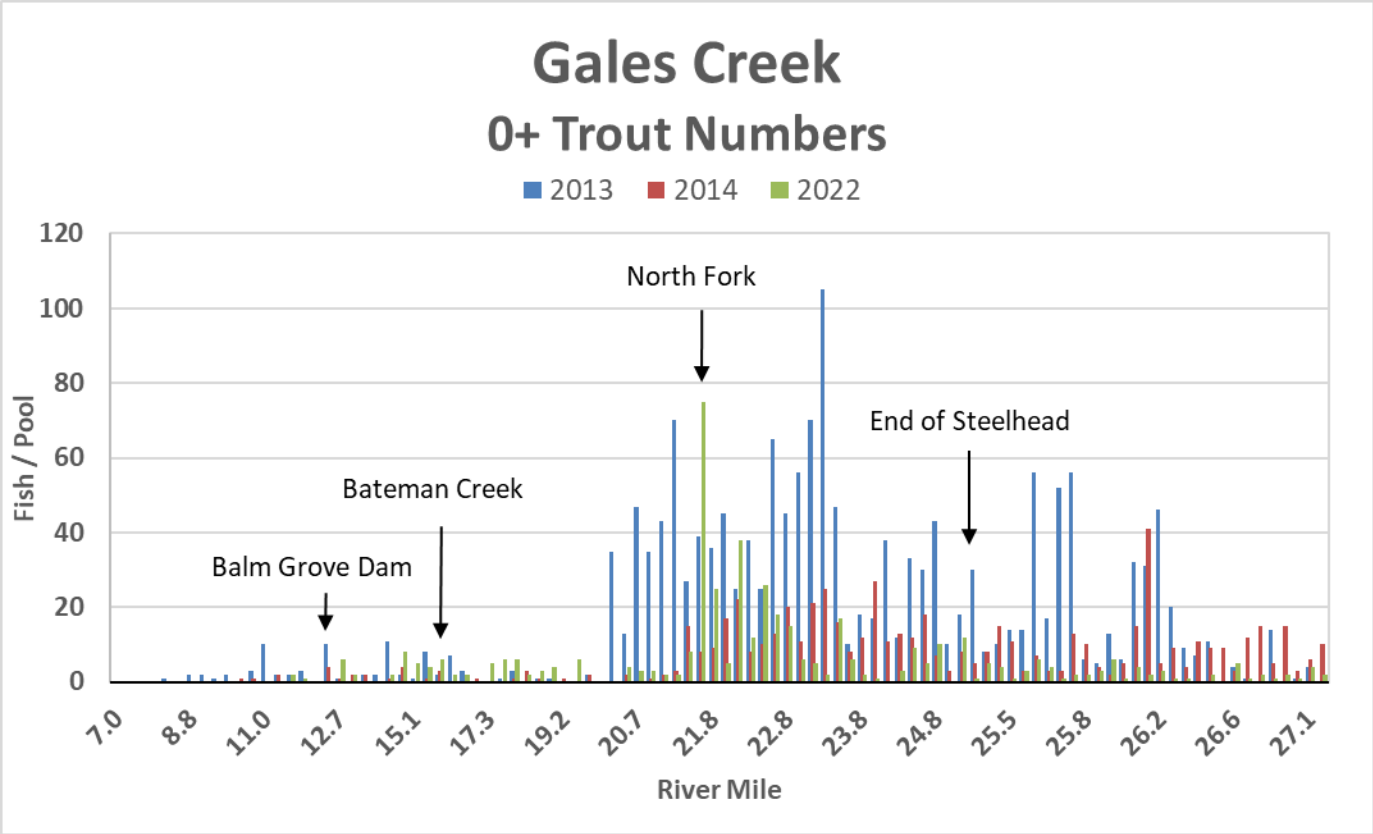
Figure 8: Gales Creek Cutthroat Numbers 2013, 2014, 2022

0+ Trout

0+ trout abundance in 2022 was the lowest of the three inventoried years, 76.5% lower than 2013 (the highest abundance year). Average densities were 0.59 fish/m² in 2013, 0.32 fish/m² in 2014, and 0.15 fish/m² in 2022.

Similar distribution profiles were observed in 2014 and 2022 with very low densities documented below the North Fork confluence at USGS RM 20.7. In 2013, higher production extended downstream to the falls below Coffee Creek (USGS RM 19.8).

Peak production in all three years overlapped Anchor Sites #5 - # 7 and LWD treatments. In 2013, peak production was observed over a 3.5-mile reach (USGS RM 19.8 – 23.3), expanding to 1,230 fish/mile. In 2014 and 2022 peak production extended from the North Fork (USGS RM 21.7) to Low Divide Creek (USGS RM 22.8), with abundance expanding to 815 fish/mile in 2014 and 829 fish/mile in 2022. In 2022, abundance declines rapidly above Low Divide Creek while in 2013 and 2014 substantially higher production levels extended to USGS RM 26.2.



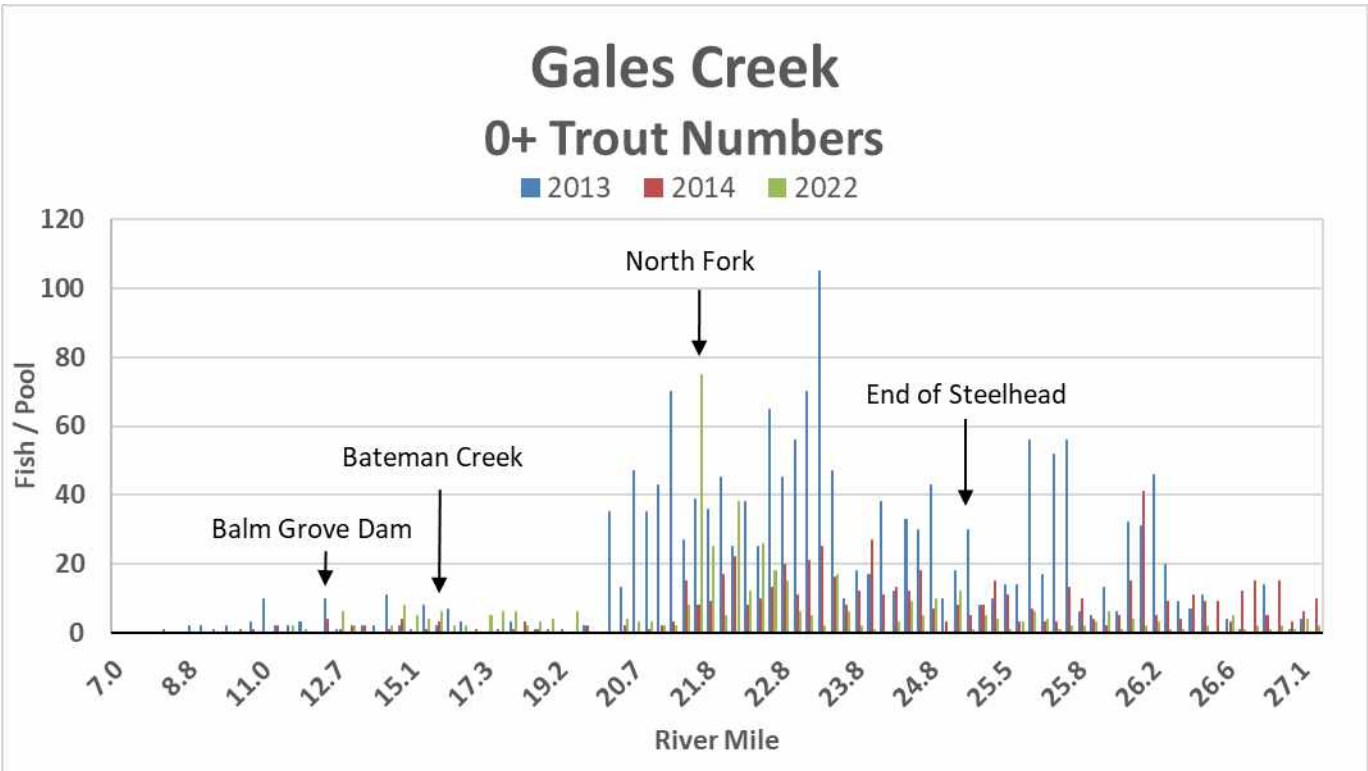


Figure 9: Gales Creek 0+ Trout Numbers 2013, 2014, 2022

Chinook

Chinook were not observed in 2022. Very low abundances were observed in 2014. Inventoried habitats throughout most of Gales mainstem were suitable for chinook occupation.

Table 14: Gales Creek - Expanded fish counts for all salmonid species by year.

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	2,184	0.12	8,205	430	1,585	0
2014	5,242	0.08	3,000	270	1,005	5
2022	8,313	0.18	2,260	330	1,365	0

Minor Tributaries of Gales Creek

Finger

Finger Cr joins the mainstem at USGS RM 20. Low flows over a low gradient pitch of cobble and small boulders describe the confluence. The survey extended 0.6 miles. Silt dominated substrates and a lack of spawning gravel limit anadromous spawning potential.

In 2013, coho were present in low abundance with a peak density of 0.65 fish/m^2 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. No coho were observed in 2014 or 2022. Low cutthroat and 0+ trout abundances with sporadic pool presence were observed in all three inventoried years.

Five beaver dams were observed in 2022, three in 2013, and none in 2014. Dam heights in 2022 were 3ft to 7ft tall. Beaver augmentation was substantially increasing rearing capacity of pool habitats providing an estimated 84.5% of pool surface area while constituting 11.1% of the total pool count.

Photo 9: Finger Creek beaver dam

Low Divide

Low Divide Creek enters Gales Creek at USGS RM 22.9 within Anchor Site #7. The 2022 inventory extended 0.14 miles. Field notes indicated a low gradient confluence, medium flow with a cool water contribution (Low Divide 12.9°C, Gales 14.3°C), and well sorted spawning gravel. Gradient increases with cobble dominated substrates once Low Divide leaves the Gales floodplain, limiting further anadromous spawning and rearing potential. Steelhead or coho were not observed in any inventoried year.

Prickett

Pricket Cr enters Gales Creek at USGS RM 6.5. The inventory extended 0.65 miles where landowner access denial ended the inventory. A seasonal irrigation dam just above the first pool was blocking any upstream temperature dependent migration of salmonids. Most of the

inventoried reach was ditched along the roadside. The inventoried reach of Pricket Creek exhibited low salmonid potential due to heavy agricultural impacts, shallow pools, and lack of spawning gravel. Pricket Creek was a valuable cool water contribution (Pricket 15.4°C, Gales 17.6°C)

Low abundances of coho were observed in 2014 and 2022. Coho were not observed in 2013. In all inventoried years, low abundances and sporadic distribution of cutthroat and 0+ trout were observed. Juvenile Chinook were observed in the confluence plume of Pricket Creek in Gales mainstem in 2014.

Tributary A

Trib A enters Gales Creek at USGS RM 23.5 with high flow, high gradient, and cold water (Trib A 11°C, Gales 13.1°C). Very low numbers of steelhead parr were observed in 2013. In 2014 and 2022, steelhead were not observed. Coho were not observed in any of the three inventoried years. Limited anadromous potential existed due to high gradient, high complexity, and lack of spawning gravel. Trib A is a valuable high-volume, cold-water contribution.

Bateman Creek

Bateman Creek enters Gales Creek at RM 16.25. The survey extended 0.32 miles with anadromous fish distribution extending above the endpoint. 2013 and 2014 inventories extended an additional 0.3 miles upstream. The 2022 survey ended just downstream of the construction site for a culvert removal which was identified as a juvenile barrier in previous surveys. The stream habitat was characterized by silt and cobble dominated substrates, lack of well sorted spawning gravel, shaded riparian canopy. Turbidity from the culvert removal compromised visibility, reducing confidence in any year-to-year fish abundance comparisons from previous inventories.

A 3.1°C temperature differential (Bateman 15.9°, Gales 19°C) was documented at the time of the inventory. The presence of a series of natural bedrock sills in the mainstem of Gales Creek 1,600 ft upstream from the confluence of Bateman amplifies the importance of this creek as cold water refugia for juveniles rearing in mainstem Gales Creek. Fish distribution patterns indicate that Bateman Cr is serving as cold water refugia for juveniles migrating out of mainstem Gales. Its lack of sorted gravels 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.

Anchor Sites:

No anchor sites were observed. Stream habitats were hillslope confined throughout the inventoried reach.

Coho

Coho abundance was low for all inventoried years with average pool densities 0.36 fish/m² (311 fish/mile), 0.5 fish/m² (73 fish/mile) in 2014, and 0.29 fish/m² (112.5 fish/mile) in 2022

Low abundance estimates indicate the population in 2014 and 2022 was likely comprised of upstream temperature dependent migrants with no spawning events occurring. Low coho numbers above a definitive juvenile barrier in 2013 indicate that a single pair of coho spawned in Bateman Creek.

Spawning Gravel and Adult Escapement:

Lack of sorted spawning gravel and low juvenile numbers indicate that there was no adult escapement into Bateman Creek in 2013 or 2021. A single pair of coho spawned in 2012.

Steelhead

Steelhead abundance was low with pool presence observed in two sample pools in 2014 and one sample pool in 2022. The habitat was appropriate for juvenile steelhead rearing.

Cutthroat

Cutthroat abundance was moderate in 2013 and 2022 and low in 2014. Average densities were documented at 0.22 fish/m² (188 fish/mile) in 2013, 0.26 fish/m² (61 fish/mile) in 2014, and 0.32 fish/m² (125 fish/mile). in 2022.

0+ Trout

0+ trout abundance was low for all inventoried years. Average densities were documented at 0.45 fish/m² (410 fish/mile) in 2013, 0.3 fish/m² (114 fish/mile) in 2014, and 0.42 fish/m² (234 fish/mile) in 2022.

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 15: Bateman Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	168	0.36	250	0	115	0
2014	36	0.51	65	20	30	0
2022	36	0.29	75	5	40	0

Beaver Creek

The entire Beaver Creek subbasin contains at least 9.6 miles of stream habitat accessible to anadromous fish. This includes 6 tributaries labeled A – F. All tributaries will be reviewed separately below. Beaver Creek and its tributaries were the largest producer of coho in the Gales Creek subbasin for all inventoried years, contributing 47.4% (2014), 31.7% (2013), and 37.9% (2022) to the total population estimate while accounting for 20.8% of inventoried linear miles of stream habitat.

Beaver Creek enters the mainstem of Gales Creek at USGS RM 18. Beaver Creek is the largest of the Gales Creek tributaries and exhibited mainstem anadromous distribution extending 6.5 stream miles in 2013, 5.8 miles in 2014, and 6.6 miles in 2022. Coho distribution in 2013 and 2022 terminated at a series of ephemeral sill log barriers. In 2014, coho distribution terminated below a 1.5ft beaver dam with reduced subsurface flows observed in the stream habitat above. Anadromous potential continues above the 2014 and 2022 barriers.

The stream habitat was characterized by low gradient (averaging 0.6%), siltstone/sandstone dominated channel morphology with well sorted gravel, high wood complexity, mature riparian canopy, low summer temperatures (16.9°C), and beaver occupation. These are ideal conditions for successful coho production.

Photo 10: Beaver Creek small beaver dam

16 beaver dams were present in the Beaver Creek mainstem. This was a 33.3% reduction from 2013. Nine of the top 12 highest coho pool counts and 16.6% of the total coho estimate for Beaver Creek was documented in beaver dammed pools. In 2022, beaver augmented pools were providing approximately 20.52% of the pool surface area while representing only 4.9% of the total number of pools within the inventoried reach.

Heavy tannins resulted in poor visibility in the lower mainstem and in many of the larger beaver pools, 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.

Anchor Sites:

No anchor sites were observed in the Beaver Creek subbasin. Channel entrenchment with disconnected, wide historic floodplains were observed throughout the inventoried reach.

Photo 11 Beaver Creek beaver dam

Coho

The 2022 coho abundance estimate was 61.1% higher than the 2013 estimate which was the second highest in abundance but similar to the 2014 estimate (see table below).

Average pool densities were 0.37 fish/m² (1,292 fish/mile) in 2013, 0.32 fish/m² (1,347 fish/mile) in 2014, and 0.79 fish/m² (2,135 fish/mile) in 2022.

The dominant density peaks were 1.86 coho/m² at RM 6.2 in 2013, 0.84 coho/m² at RM 5.3 in 2014, and 7.26 coho/m² at RM 6.9 in 2022.

In all inventoried years, though the density peak was high in the basin (associated with spawning locations), the peak production spanned the middle half of the distribution range. In 2022 nearly twice as many fish/mile were observed between RM 1.5 and RM 5.2 (2,648 fish/mile) than from RM 5.2 – 6.6 (1,489 fish/mile).

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to Beaver Creek was 80 coho in 2013, 74 coho in 2014, and 132 coho in 2021. Estimated adult coho capacity based on spawning gravel availability was 209 – 628 coho. In all inventoried years, Beaver Creek was functioning far below its current habitat capacity and limited by inadequate adult escapement.

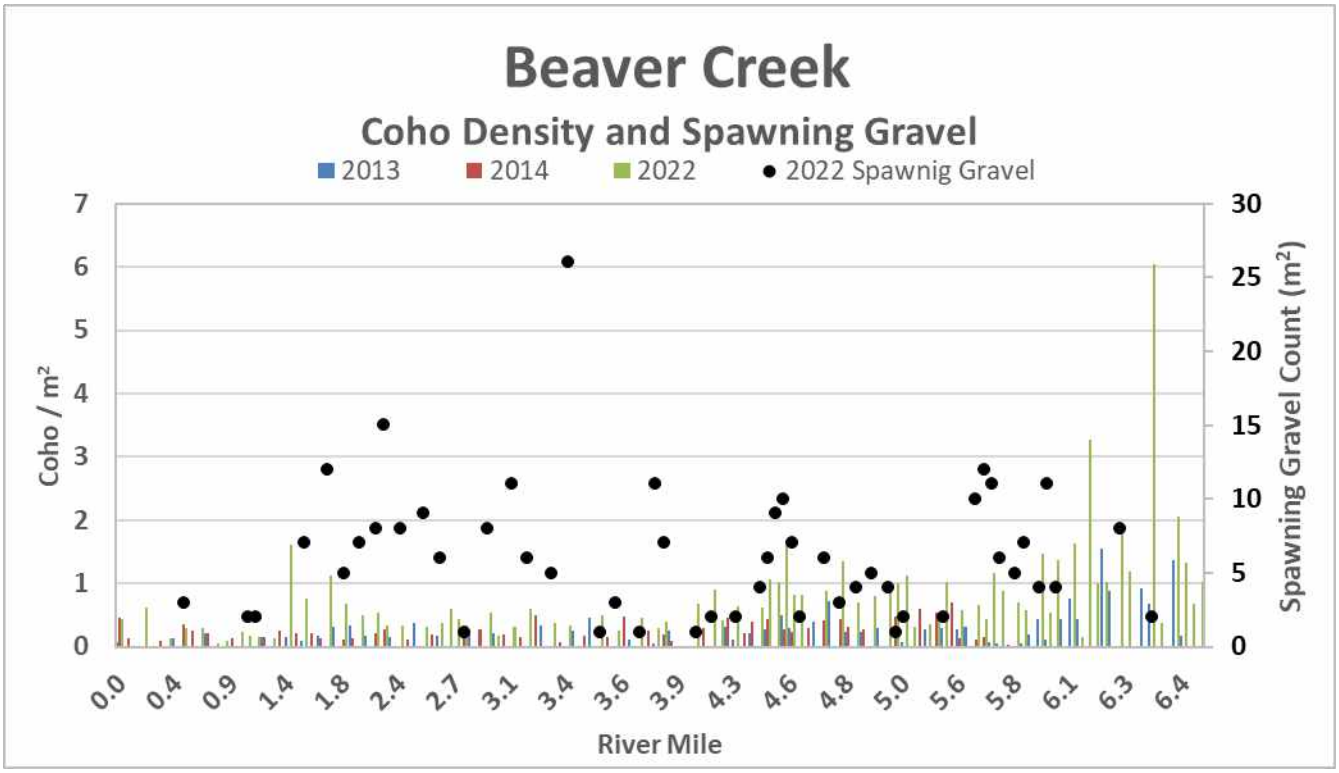


Figure 10: Beaver Creek Densities 2013, 2014, 2022

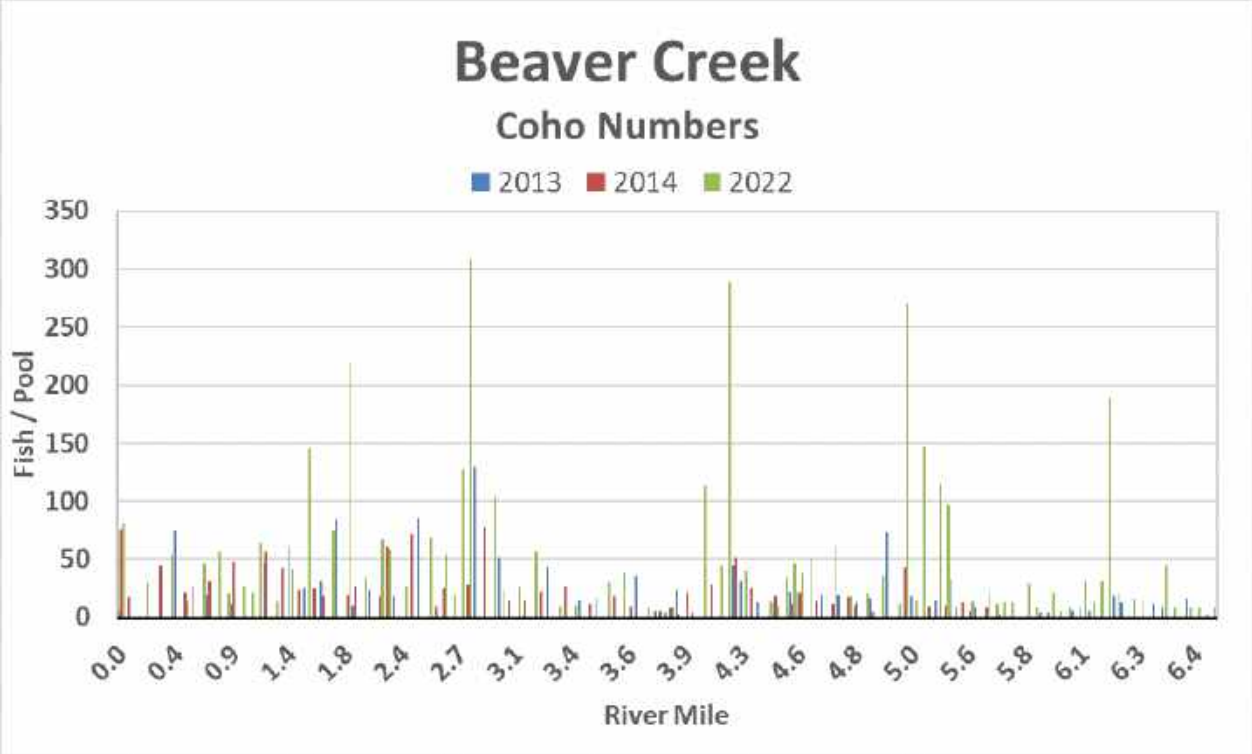


Figure 11: Beaver Creek Coho Numbers 2013, 2014, 2022

Steelhead

Steelhead were not observed. The available habitat favored the niche exploited by coho and cutthroat. The large cobbles and higher gradients preferred by steelhead were not present.

Cutthroat

Cutthroat abundance was very low with intermittent pool presence at an average density of 0.03 fish/m². Abundance expanded to 26 fish/mile throughout the range of significant distribution.

0+ Trout

In 2022,0+ trout abundance was the lowest of the inventoried years with presence in only 4 inventoried pools.

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 16: Beaver Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	8,400	0.38	310	0	225	0
2014	7,812	0.32	35	0	435	0
2022	14,092	0.88	20	0	168	0

Minor Tributaries of Beaver Creek

Tributary A

Landowner access limitations prevented a full inventory of Trib A in 2013 and 2014 and no access was granted in 2022. In 2013 and 2014, the inventory extended 0.3 miles upstream. Coho potential extends approximately an additional 0.4 miles. Stream habitats were characterized by low flows, low gradient, sinuous channel meander, high wood complexity with sorted gravel, and shaded riparian canopy. High beaver activity with legacy beaver flats was also documented.

Tributary D

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 restricting further access upstream.

Tributary E

Trib E enters at RM 5.9 and contributes approximately 40% of the flow at its confluence. In 2013 coho were only observed in the pool below a rusted-out culvert perched 1.5ft above the stream channel just above the confluence. In 2014 coho were not observed in Trib E. In 2022 coho distribution extended 0.3 miles upstream.

Tributary F

Trib F enters at RM 6.4. Low abundances of coho parr were observed utilizing the lower 0.2 miles of stream habitat in 2013 and 2022. Hyporheic flows, low quality pool habitats, and debris jams ended their distribution and limit rearing potential. In 2014 coho were not observed in Trib F.

Beaver Creek Trib B

Beaver Creek Trib B enters Beaver Creek at RM 3.3. Inventories in all years extended about 1.2 miles. Anadromous potential further upstream is diminished due to channel confinement, gradient increase, and cobble dominated substrate. No adult barriers to passage were observed.

The stream habitat was characterized by low gradient, sinuous channel meander with gravel dominated substrate, high wood complexity, and high beaver occupation. The upper end of current distribution transitions to a cobble dominated stream bed and a more confined channel. Stream temperatures taken at the time of the inventory were 15.8 °C, 0.8°C cooler than Beaver mainstem.

Peak coho production in 2013 and 2022 overlapped areas with high beaver occupation (no beaver dams observed in 2014). Six active beaver dams were documented in 2013 and Nine beaver dammed pools were documented in 2022 which were rearing 30.3% of the coho estimate for Trib B. In 2022, beaver pools accounted for the 8 highest pool counts and were providing an estimated 38% of the pool surface area while representing only 9% of the total number of pools within the inventoried reach.

Photo 12: Beaver Creek Trib B beaver dam

Coho

Coho abundance in 2022 was the highest of the three inventoried years with an average pool density of 0.8 fish/m² expanding to 1,902. fish/mile. The dominant density peaks were 3.1 fish/m² at RM 0.75 in 2013, 0.77 fish/m² at RM 0.2 in 2014, and 2.47 fish/m² at RM 0.9 in 2022.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 20 (combined male and female) coho escaped to Trib B (Beaver) to spawn in 2022. Estimated adult coho capacity based on spawning gravel availability was 19 – 58 coho. In 2022 Beaver Creek was functioning below its current habitat capacity and limited by inadequate adult escapement.

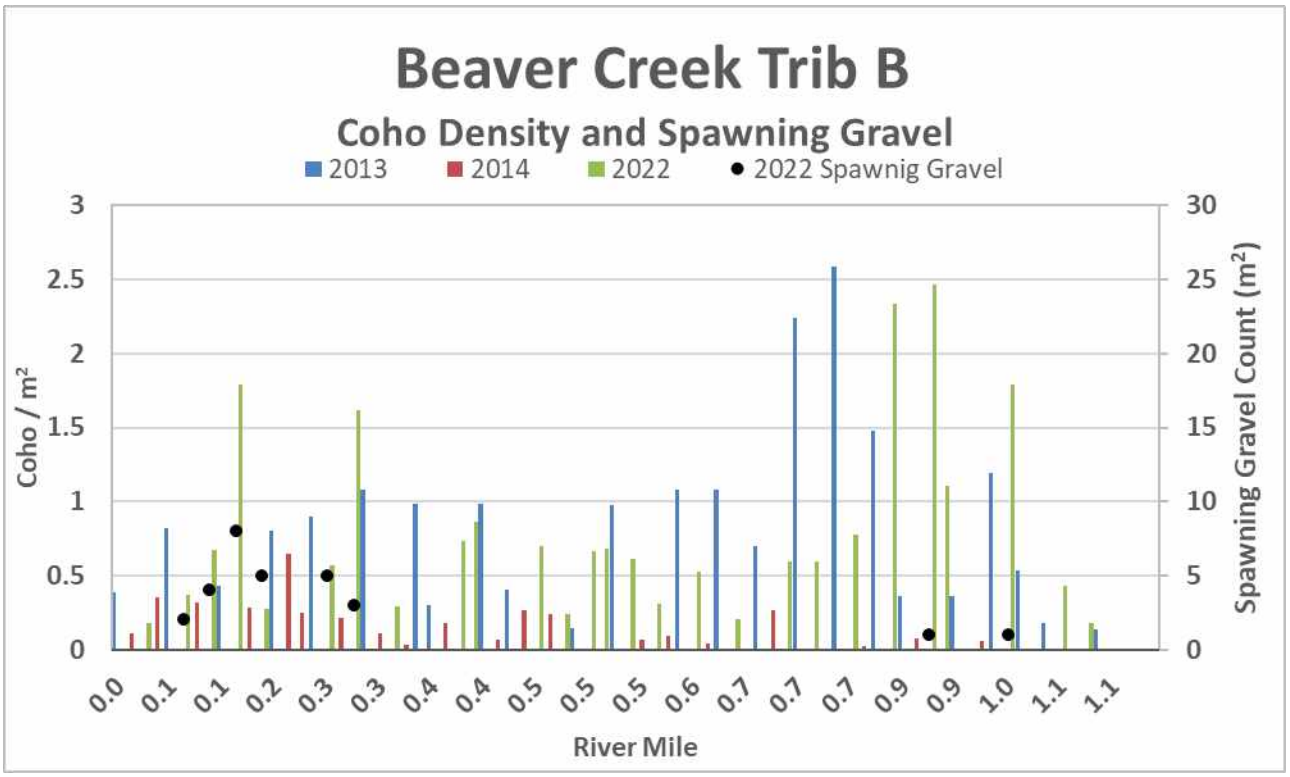


Figure 12: Beaver Creek Trib B Coho Densities 2013, 2014, 2022

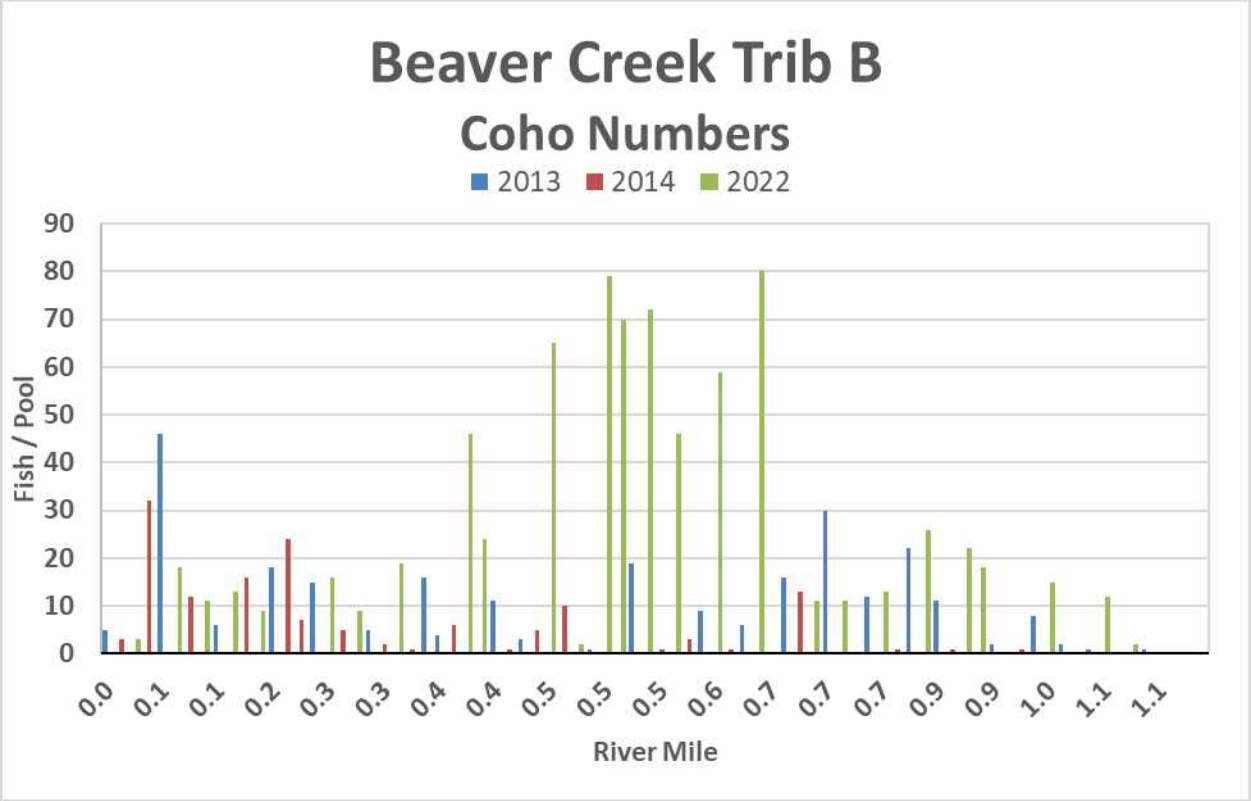


Figure 13: Beaver Creek Trib B Coho numbers 2013, 2014, 2022

Steelhead

Steelhead were not observed. Stream habitats were not suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was low in all inventoried years with intermittent pool presence expanding to 42 fish/mile in 2013, 98 fish/mile in 2014, and 75 fish/mile in 2022.

0+ Trout

0+ trout abundance was extremely low in all inventoried years with sporadic pool presence.

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 17: Trib B (Beaver Creek) - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	1,614	1.01	65	0	50	0
2014	870	.22	35	0	110	0
2022	2,092	.96	20	0	82	0

Beaver Creek Trib C

Beaver Creek Trib C enters Beaver Creek at RM 3.5. The inventory extended 1.3 miles to the end of coho distribution. Increased gradient and reduced flows limit further anadromous rearing potential upstream. No adult barriers to passage were observed.

The stream habitat was characterized by low gradient (avg. 2.6%), sinuous channel meander with wide exposed floodplain, and cobble/gravel dominated substrate. High beaver activity was observed in previous inventories with 11 active dams documented in 2013 and 12 in 2014. No beaver activity was documented in 2022 with a resultant reduction in floodplain connectivity and increased terrace heights observed.

Temperatures taken at the time of the inventory recorded a 2.1°C differential (Trib C 15.7°C, Beaver Creek 17.8°C).

Coho

Coho abundance in 2022 was the highest of the three inventoried years with an average pool density of 1.16 fish/m² expanding to 1,352 fish/mile. The 2022 dominant density peak of 2.58 fish/m² was observed at RM 0.18 with a secondary peak of 2.18 at RM 0.78. In 2013, the density peak of 3.36 fish/m² was observed at RM 0.9 (Trib C1 in 2013) and in 2014 the highest coho density of 1.56 fish/m² was observed at the confluence at RM 0.7

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to Trib C was 14 coho in 2012, 11 coho in 2013, and 16 in 2021. Estimated adult coho capacity based on spawning gravel availability was 7 – 20 coho. In 2021, Trib C was functioning near its current adult capacity.

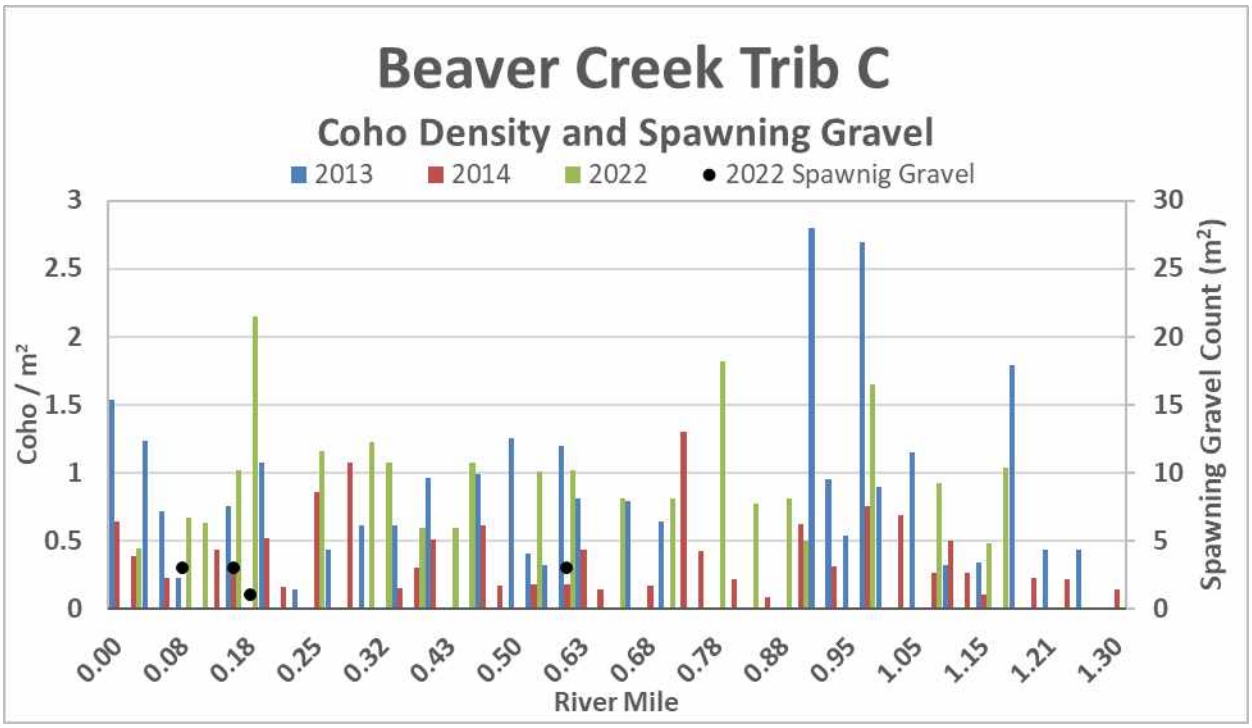


Figure 14: Beaver Creek Trib C Densities 2013, 2022, 2022

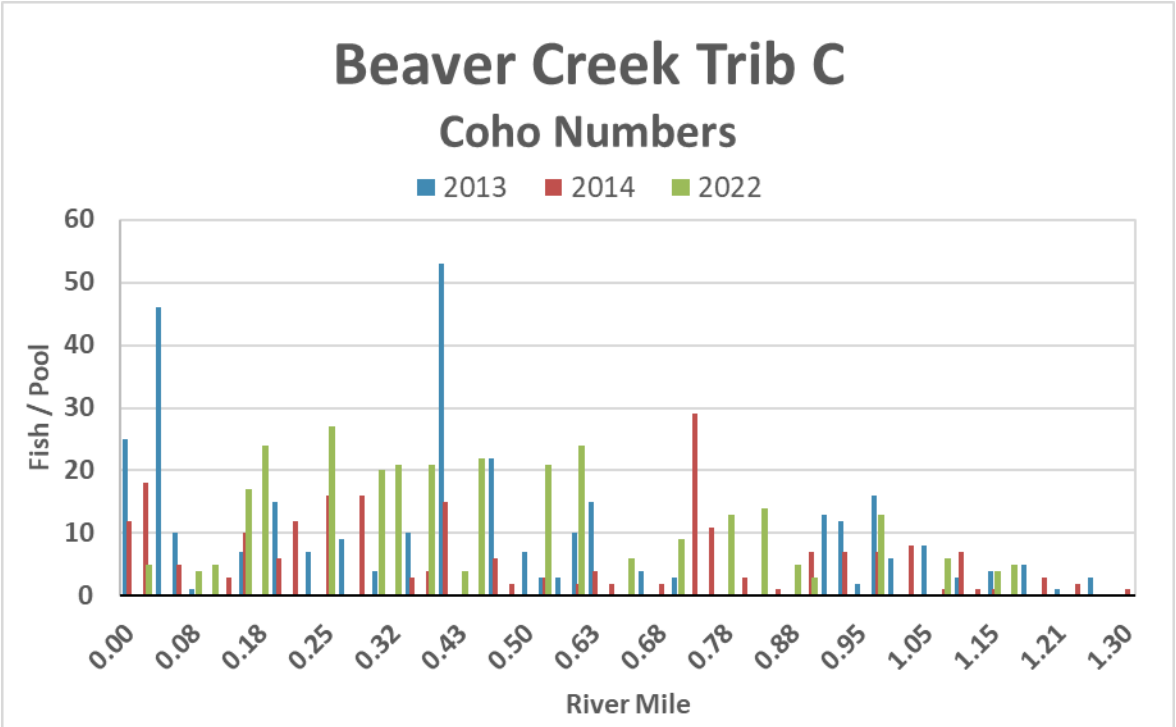


Figure 15: Beaver Creek Trib C Counts 2013, 2022, 2022

Steelhead

Steelhead were not observed. Stream habitats were not suitable for steelhead occupation.

Cutthroat

Cutthroat abundance remained low for the three inventoried years with intermittent pool presence. Average density in 2022 was 0.11 fish/m². Abundance expanded to 42 fish/mile throughout the range of significant distribution.

0+ Trout

0+ trout abundance was low for the three inventoried years with sporadic pool presence.

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 18: Trib C (Beaver Creek) - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	1,614	0.93	40	0	55	0
2014	1,200	0.48	25	0	35	0
2022	1,758	1.16	0	0	55	0

Clear Creek

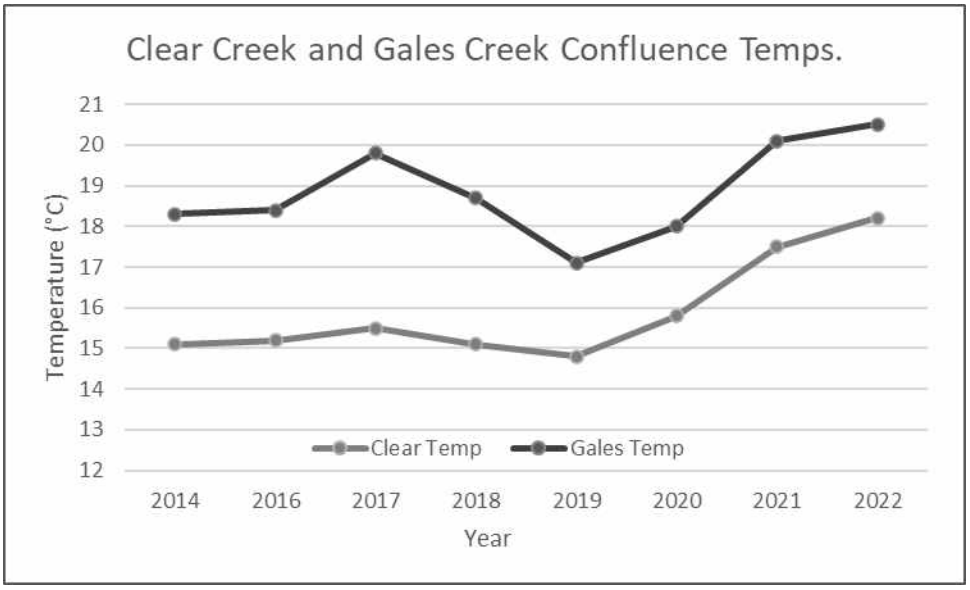
Clear Creek enters Gales Creek at USGS RM 10.7. The survey reach extended from the confluence with Gales Creek 3.3 miles upstream to an 8-10ft bedrock cascade functioning as a permanent barrier to anadromous salmonids.

Clear Creek was a top producer of salmonids for all inventoried years contributing to the total Gales Creek subbasin population estimate a three average of 23.6% of coho, 14.6% of 0+ age class trout, 23.4% of steelhead, and 14.8% of cutthroat while accounting for 7.2% of inventoried linear miles of stream habitat.

The stream habitat was characterized by cool summer temperature profile with steady summer flows; low gradient (avg. 2.2%); Small boulder, cobble, and gravel dominated substrates with sections of exposed bedrock, well forested riparian corridor of mature deciduous and coniferous trees; and moderate to high channel complexity (LWD treatments).

The confluence of Clear Creek exists within the temperature limited reach of the Gales Creek mainstem. The spatial location of Clear Creek identifies it as an important source of thermal refugia for juvenile salmonids during the summer temperature pinch period. High densities of salmonids have been documented utilizing the lower 0.25 miles of Clear Creek in all inventoried years.

Temperatures were recorded at the time of the inventory for eight of the nine inventoried years (Figure 17 below). Though Clear Creek has always maintained a significant temperature differential averaging 3°C cooler than mainstem Gales, over the past three years Clear Creek exhibited the highest temperature profiles and the past four years have shown the smallest temperature differentials.



* All temperatures were recorded between 7/29 and 8/29, 10:05 am to 11:25 am

Figure 16: Temperature profiles at Clear Creek confluence with Gales Creek

Restoration Projects

Post project snorkel inventories of Clear Creak have been conducted for nine years (2013, 2014, 2016, 2017, 2018, 2019, 2020, 2021, 2022). These surveys have monitored the efficacy of instream wood placement projects in Clear Creek completed in 2012, 2018, and 2021 extending from the Gales Creek confluence upstream to RM 2.3. The large woody debris (LWD) placements were designed to improve water aquatic habitat quality and quantity for all species of salmonids.

These full spanning wood jams will continue to trap and accumulate migratory bedload increasing the quality and abundance of sorted spawning gravel. This lift of gravel protects a hyporheic lens of stream flow from air and solar exposure and consequently influences the cumulative temperature profile downstream. Woody debris accumulation around log structures provides refuge for fish, increasing their survival rates against predation. As a result, Clear Creek continues to increase both adult spawning and juvenile rearing capacity providing high quality habitat to salmonids within a system with severe water quality limitations downstream. With ongoing protections and additional restoration activities, we expect to see continued improvements to the aquatic habitats within this system.

Clear Creek provides a municipal water supply to the city of Forest Grove. The concrete diversion and intake dams on Clear Creek and Roaring Creek exist within the range of anadromous fish distribution. The Clear Creek structure is outfitted with a fish ladder for passing adult salmonids. The progeny of both coho and steelhead have been observed rearing above the diversion dam indicating successful passage. The concrete dam on Roaring Creek 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.

Photo 13: Clear Creek, 2021 LWD treatment with gravel accumulation

Gales Creek Confluence Pool

From 2013 to present, we have consistently observed distribution trends indicating upstream thermal migration out of Gales Creek and into Clear Creek during peak temperature summer flow regimes. For the past few years, though this trend has been strongly observed with coho distribution, it has not been as evident with cutthroat distribution. Additionally, for the first four inventoried years we observed high numbers of salmonids, predominantly older age class cutthroat, congregating in the cold-water plume at the confluence where Clear Creek enters mainstem Gales Creek.

Historically this pool contained high complexity habitat with deep scour and undercut banks. In recent years, loss of bedload retention resultant from the blowout of an impounding wood jam at the pool's tailout has simplified the habitat, greatly reducing its rearing capacity. Since 2019 this pool has been nearly empty with only a few coho and 0+ age class trout observed. This reduction in rearing capacity may also be contributing to the decreased abundance of cutthroat observed in the lower reach of Clear Creek.

This pool functioned not only as a thermal refugia but as staging ground for upstream thermal migration into Clear Creek. The pool habitat simplification and lack of refuge in the form of cover

not only reduce the rearing capacity of the pool habitat but also increase exposure of temperature dependent migrants to predation possibly reducing and/or deterring the abundance of fish entering Clear Creek.

Late season rainfall in 2022 resulted in increased flows and low stream temperatures extending later than usual into the summer season. This coupled with high coho production in lower Gales mainstem highlighted temperature dependent migration within mainstem Gales. This pool was sampled once on 7/13/22 and again on 7/29/22. On 7/13 there were 155 coho, 2 steelhead, and 2 cutthroat with temperatures recorded at 15.3°C (Clear) and 18.2°C (Gales). On 7/29 only 1 cutthroat remained in the pool with temperatures of 18.2°C (Clear) and 20.5°C (Gales). Over this two-week period dramatic warming occurred with air temperatures from 7/24 - 7/29 averaging 28.3°C and peaking at 38.3°C.

Anchor Sites:

No anchor sites were observed.

Photo 14: Clear Creek, 2012 LWD treatment

Coho

Coho abundance in 2022 was high with an average pool density of 2.2 fish/m² expanding to 3,851 fish/mile. The dominant density peak of 14.7 fish/m² was observed in a treated structure pool just above the Gales Creek confluence. This was the highest density documented basin wide in all inventoried years.

Though 2022 abundance estimates exhibited a 25.5% decrease in abundance from 2021 it remained 56.9% above the eight-year average from 2013 to 2021 and was the second highest of the inventoried years.

Over the post-project inventoried years, as discussed above, we have observed the continued maturation of the 2012 and 2018 treatment reaches. This has been most evident in the response of the Clear Creek coho population.

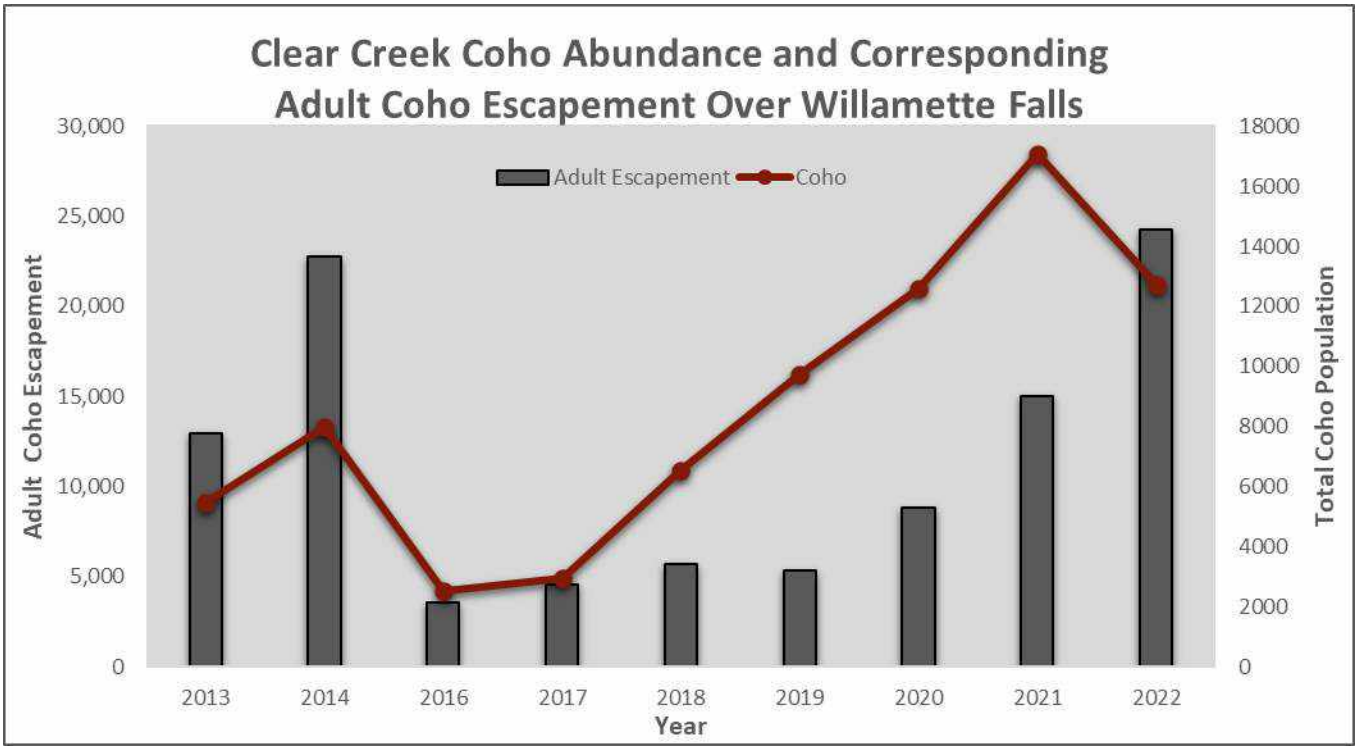


Figure 17: Post project Clear Creek coho abundance and corresponding adult coho escapement over Willamette falls from 2013-2022

When comparing the coho population estimates over the past eight years with the corresponding adult escapement over Willamette Falls (See Figure 18 above), the two numbers track up to 2017 through a range of the highest and lowest adult escapement years. From 2017 to present, the Clear Creek coho population exhibits a significantly more dramatic increase in abundance when compared with the increases in corresponding adult escapement. The five-years post project (2013-2018) appears to have been the period for the maturing structures to sufficiently increase the habitat's functionality, allowing responses from multiple cohorts of returning salmon. These increased adult returns may also have allowed expansion from this

high priority reach to populate the untreated sections downstream, increasing the overall production of the system.

In 2022, the value of these restoration actions was again highlighted with the two highest coho densities of the Tualatin basin recorded within the lower treatment reach (14.7 and 8.39 coho/m²) (See Figure 19 below). Additionally, peak coho production and the dominant spawning peaks were observed within the 2012 restoration project reach in all years except 2022. Though coho production was high within this reach in 2022, peak coho production was observed lower in the basin within the 2021 project reach.

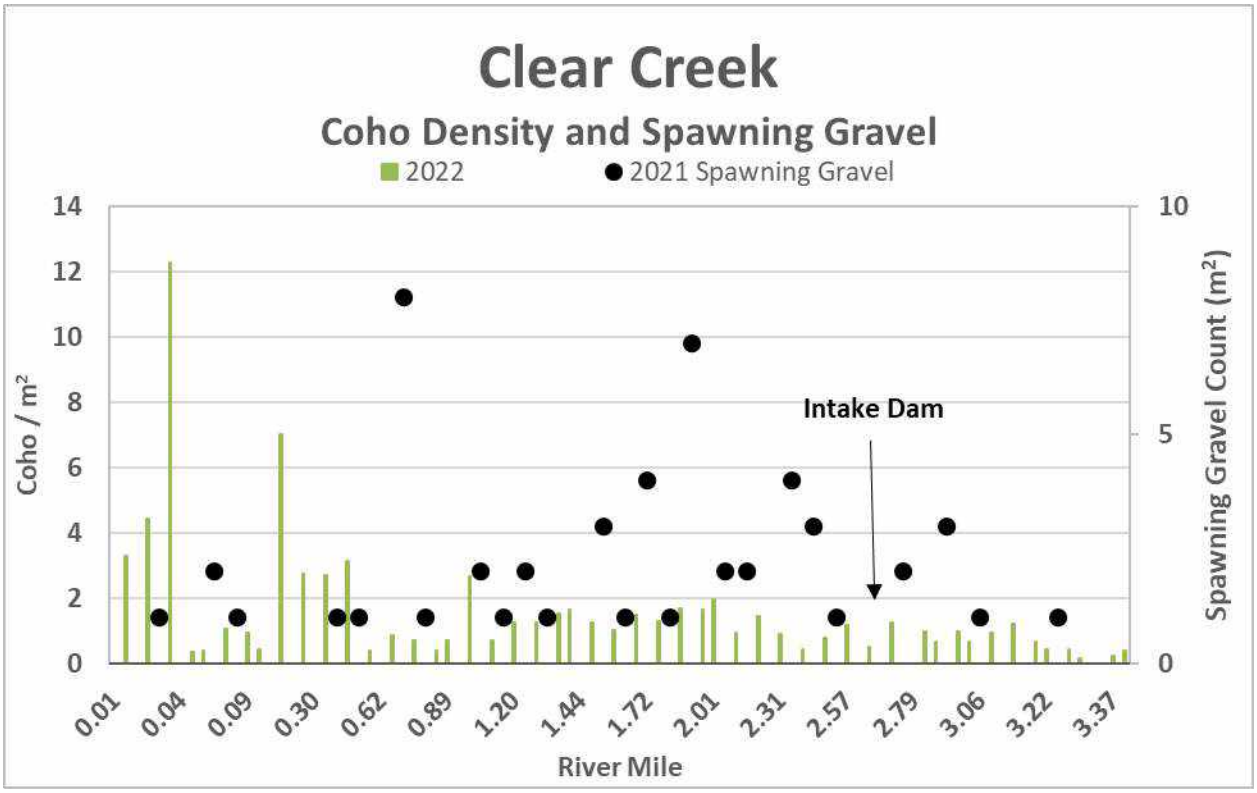


Figure 18: Clear Creek Densities 2022

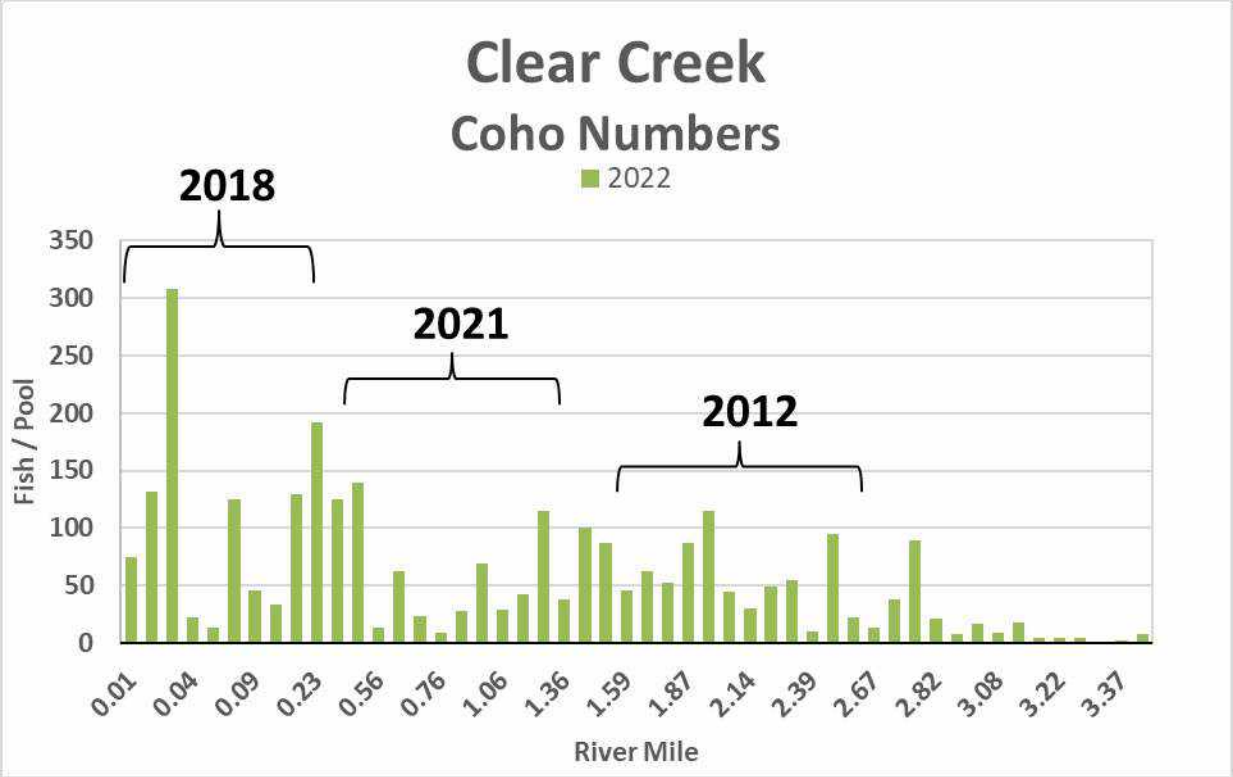


Figure 19: 2022 Clear Creek Coho Numbers with treatment reaches bracketed

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 113 adult (combined male and female) coho escaped to Clear Creek to spawn in 2021. Estimated adult coho capacity based on spawning gravel availability was 38 –112 coho. In 2021, Clear Creek was functioning near its current spawning habitat capacity. This proximity of estimated adult escapement (based on back calculation of current parr production) to modeled adult potential (based on gravel abundance) indicates that spawning gravel may have functioned as a limiting factor to coho production for the 2021 brood year. However, based on the significantly higher juvenile abundances documented in summer 2021, we know that the spawning habitat capacity exceeds the modeled adult potential.

(Note) Due to the LWD treatment of the lower section of Clear Creek accumulating a significant amount of sorted spawning gravel over the winter of 2021/2022, much of which was not available to adult spawners of the season, the previous year's spawning gravel estimate was used as a surrogate for analysis.

Steelhead

In 2022, steelhead abundance was the second lowest of the nine inventoried years and 44.6% lower than the eight-year average from 2013 to 2021.

Though juvenile steelhead abundance has remained low throughout the inventoried years, it is encouraging that winter steelhead have maintained a consistent presence in Clear Creek given the low number of adult returns over Willamette Falls when compared with historic abundance.

Cutthroat

2022 Cutthroat abundance was low with an average density of 0.1 fish/m² expanding to 141 fish/mile.

In 2022, resident cutthroat abundance was 31.6% lower than the eight-year average from 2013 to 2021. This decrease in abundance is likely related to differences in annual migration patterns of the fluvial component of the population in addition to basin wide decreases in cutthroat abundance.

0+ Trout

2022 0+ trout abundance was low with an average density of 0.17 fish/m² expanding to 213 fish/mile.

In 2022, 0+ trout abundance was 46.95% lower than the eight-year average from 2013 to 2021. This decrease in abundance is likely a result of low winter steelhead adult returns and reductions in resident cutthroat abundance.

Chinook

Low abundances of Chinook parr were only observed in one inventoried year (2019).

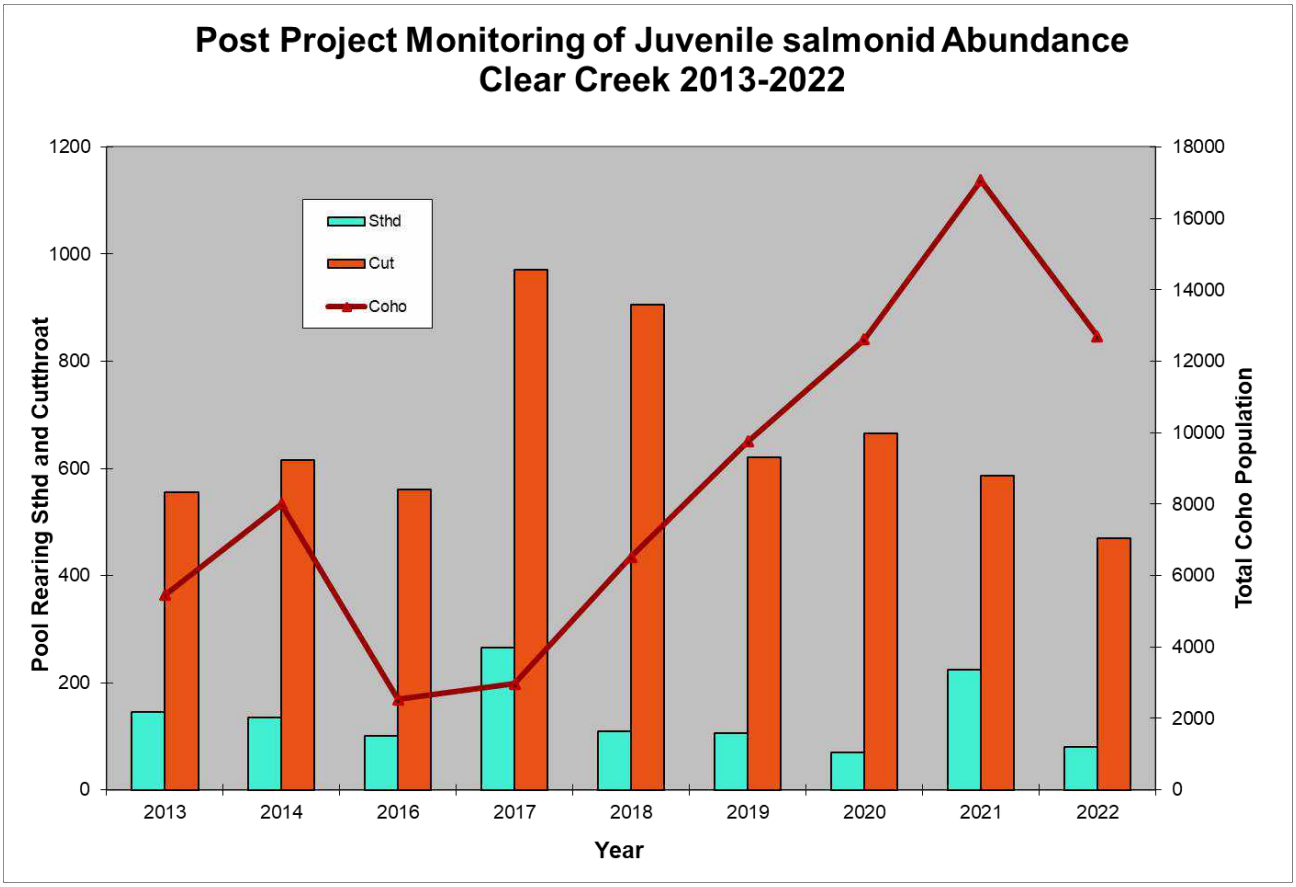


Figure 20: Clear Creek – Expanded fish counts for coho, cutthroat, and steelhead by year

Table 19: Clear Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	5,705	0.75	3,025	145	555	0
2014	7,628	0.79	710	135	615	0
2016	2,532	0.41	1,675	100	560	0
2017	2,964	0.46	1,700	265	970	0
2018	6,522	1.06	1,165	110	905	0
2019	9,750	1.59	1,385	105	620	5
2020	12,606	1.57	740	70	665	0
2021	17,066	2	200	225	586	0
2022	12,708	1.83	703	80	468	0

Coffee Creek

Coffee Creek enters Gales Creek at USGS RM 19.75. The survey extended 1.8 miles. Anadromous distribution was terminated at an ephemeral 4ft mud falls (RM 1.25) with shallow jump pool. Anadromous potential continued above the survey endpoint.

Coho were not documented in 2013 or 2014. Just above the Gales Creek confluence a failing culvert perched above a section of steep boulders likely functioned as a partial barrier to adult passage.

The lower mile of stream habitat was characterized by low gradient (avg.1.57%), sinuous channel meander with low terrace heights, extensive gravel sorting, high wood complexity comprised of remnant legacy wood, mostly hillslope confined canyon, and well shaded riparian canopy comprised of deciduous and coniferous trees. Upstream of RM1 at the confluence of Trib A, the canyon and floodplain widen with grassy legacy beaver flats extending up both forks. Above the barrier mud falls at RM1.25 a massive legacy beaver flat extends an additional 0.25 miles upstream with channel braiding across a wide wetland thick with cattail, sedges, and young alder. Three small beaver dams were documented in this reach. Deep bedload accumulations and abundant gravel were impounded at the upstream end of the flat where hillslope confinement reconsolidated flows.

Coffee Creek exhibited a similar temperature profile to Gales mainstem with small differentials in both 2014 and 2022. In 2022, Coffee was 12.8°C and Gales 12.9°C. Surveys were conducted early in the season (7/15) when water temperatures were still quite low.

Anchor Sites:

Two anchor sites were observed. Anchor #1 extended from RM 0.93 — 1.16 and received a moderate function grade due to inadequate large wood complexity. Anchor #2 was high functioning and extended from RM 1.25 — 1.5.

Photo 15: Coffee Creek end of coho

Photo: 16 Coffee Creek Anchor Site #2

Coho

Coho abundance was moderate with an average pool density of 0.52 fish/m² expanding to 844 fish/mile. The dominant density peak of 1.5 fish/m² was observed at RM 1.25 at the base of the barrier falls.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 10 adult (combined male and female) coho escaped to Coffee Creek to spawn in 2021. Estimated adult coho capacity based on spawning gravel availability was 88 – 266 coho. In 2021 Coffee Creek was functioning far below its current habitat capacity and limited by inadequate adult escapement.

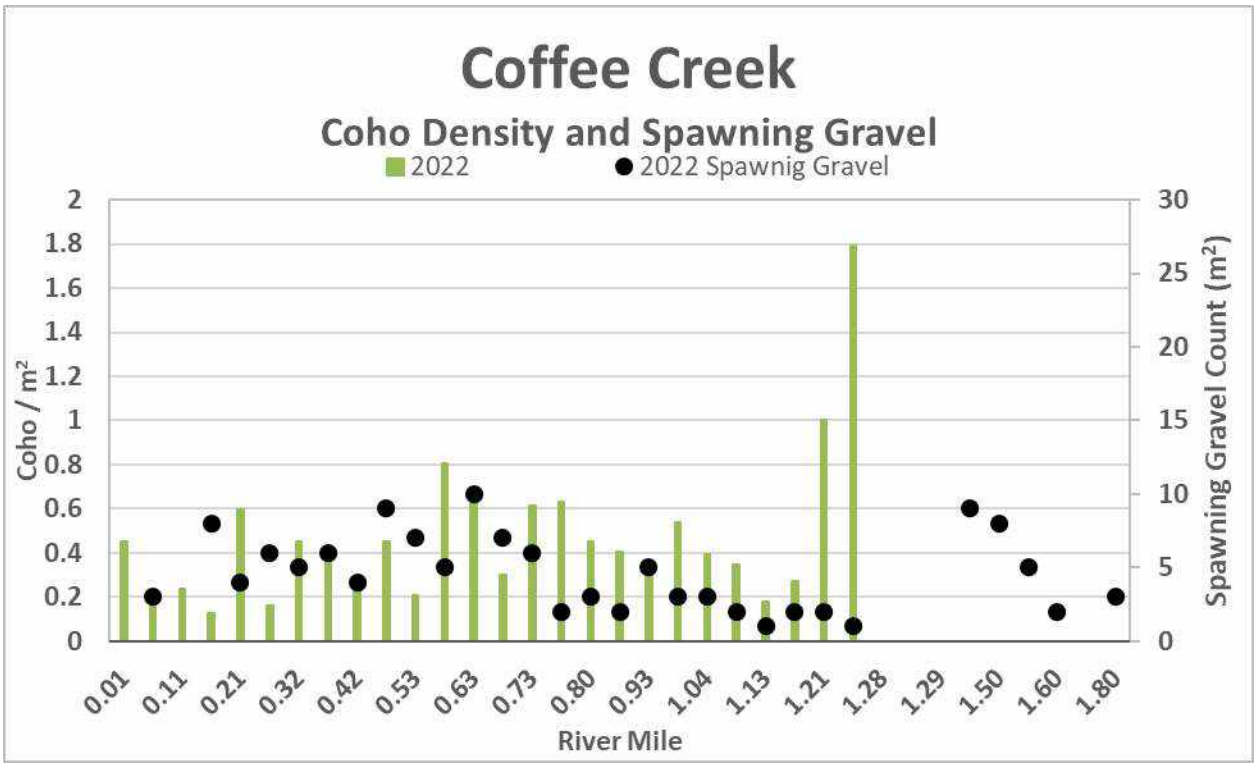


Figure 21: Coffee Creek Densities 2022

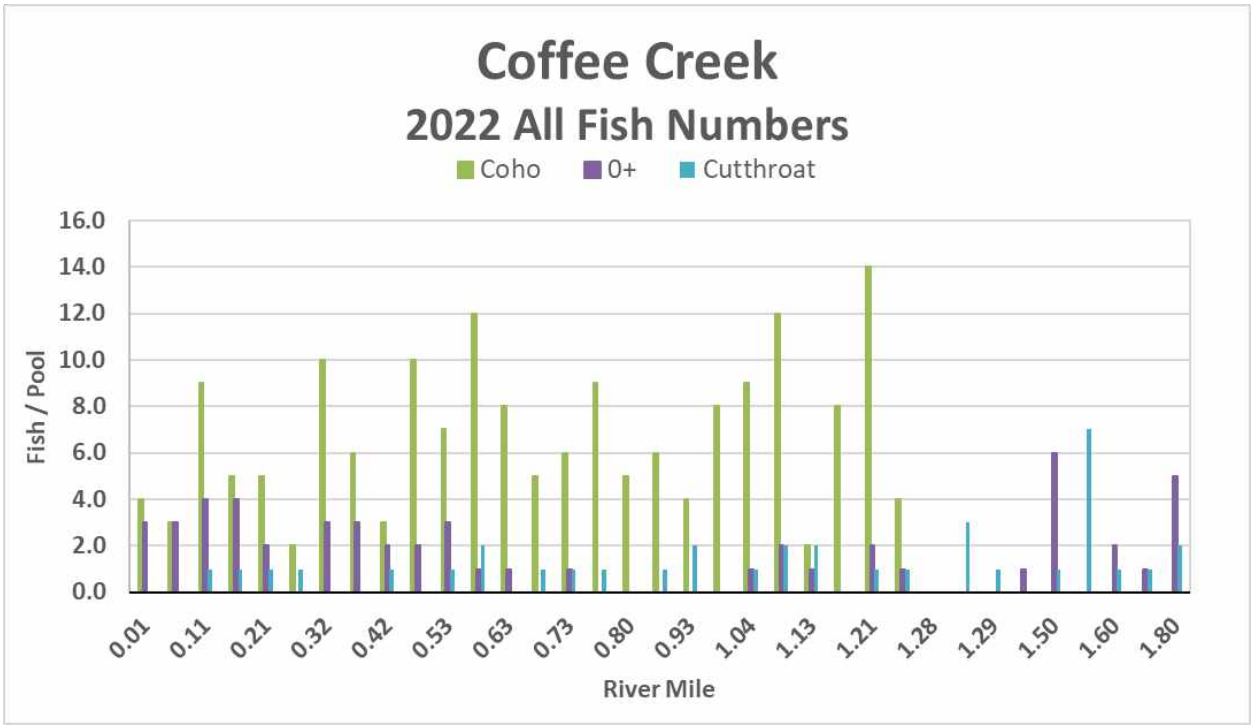


Figure 22: Coffee Creek Fish Numbers 2022

Steelhead

Steelhead were not observed. Stream habitats were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance exhibited a substantial increase in abundance from 2013/2014 – 2022 within the replicated survey reach (the inventory extended an additional 0.75 miles in 2022). Cutthroat abundance for all inventoried years remained low in this reach with average densities of 0.08 fish/m² (38 fish/mile), 0.08 fish/m² (48 fish/mile), and 0.12 fish/m² (84 fish/mile) in 2022.

0+ Trout

0+ trout abundance was similarly low in all inventoried years within the replicated survey reach with average densities of 0.28 fish/m² (271 fish/mile) in 2013, 0.14 fish/m² (157 fish/mile) in 2014, and 0.15 fish/m² (156 fish/mile) in 2022.

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 20: Coffee Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	0	0	325	0	45	0
2014	0	0	195	0	60	0
2022	1,056	0.56	270	0	169	0

Iler Creek

Iler Creek enters Gales Creek at RM 11.33 just below the Timber Rd Bridge. The survey extended 4.14 miles with anadromy reaching 3.48 miles in 2022 where increased gradient, reduced pool scour, and absence of sorted spawning gravel limited further anadromous spawning and rearing potential. In 2013, 2014, and 2019 anadromous distribution was terminated at RM 2.5 by an ephemeral log jam.

Stream habitat was characterized by low gradient (avg.1.9%), sinuous channel with interactive floodplain, moderate wood complexity, gravel sorting in pool tailouts, and a mature riparian corridor composed of deciduous and coniferous trees.

Iler Creek is an important cold-water contribution within the temperature limited reach of mainstem Gales. Stream temperatures at the time of the inventory was 15.6 °C, 1.8 degrees cooler than mainstem Gales Creek. At RM 0.25, a series of 1ft concrete steps serves as a juvenile barrier to upstream thermal migration. In the reach below this barrier, coho densities in high abundance years (2014, 2022) were amongst the highest recorded in the basin. Sub-yearling chinook were also documented in this reach in 2014. The removal of this artificial barrier remains a high priority restoration action because of the spatial relationship of Iler Creek to the summer temperature limited reach of mainstem Gales Creek.

Landowner access restrictions to approximately 0.5 miles of stream in both 2019 and 2022 resulted in an incomplete assay of stream habitat and underestimation of abundance for all salmonids.

Photo 17: Iler Creek concrete steps

Some variation in beaver activity was observed over the four inventoried years with three beaver dams present in 2013, six in 2014, two in 2019, and three in 2022. Rearing capacity was not substantially increased by beaver augmentation in 2022, due to only one dam being high enough (2ft) to increase pool surface area. Other dams were 6in or less.

Anchor Sites:

Three anchor sites were identified on Iler Creek. Anchor sites extended from RM 0.41 — 0.50; RM 0.80 — 0.86; and RM 3.12 — 3.32. All anchors were given a moderate function grade due to lack of adequate wood complexity.

Photo 18: Iler Creek

Coho

Coho abundance varied over the four inventoried years. 2014 and 2022 exhibited similarly high abundance with average pool densities of 1.4 fish/ m^2 (2014) and 1 fish/m^2 (2022) expanding to 2,726 fish/mile (2014) and 2,229 (2022). These values, while still well under full seeding capacity, were among the top three highest averages for all the primary tributaries in the Gales

Creek subbasin for both years. 2013 and 2019 were similarly low with average pool densities of 0.43 fish/ m² (2013) and 0.62 fish/ m² (2019) expanding to 1,020 fish/mile (2014) and 1,245 fish/mile (2013).

The four highest densities in 2022 were observed within the first quarter mile of habitat up to the juvenile barrier with the dominant density peak of 10.06 fish/m² observed in the first pool. These density profiles indicate a robust temperature dependent migration from mainstem Gales.

Of the total Gales Creek subbasin population estimate, Iler Creek contributed 9.9% in 2013, 22.1% in 2014, and 13.7% in 2022. Gales subbasin totals were not available in 2019.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to Iler Creek was in 24 coho 2013, 64 coho in 2014, 24 coho in 2019, and 62 coho in 2021. Estimated adult coho capacity based on spawning gravel availability was 104-314 coho. In all inventoried years, Iler Creek was functioning far below its current habitat capacity and limited by inadequate adult escapement.

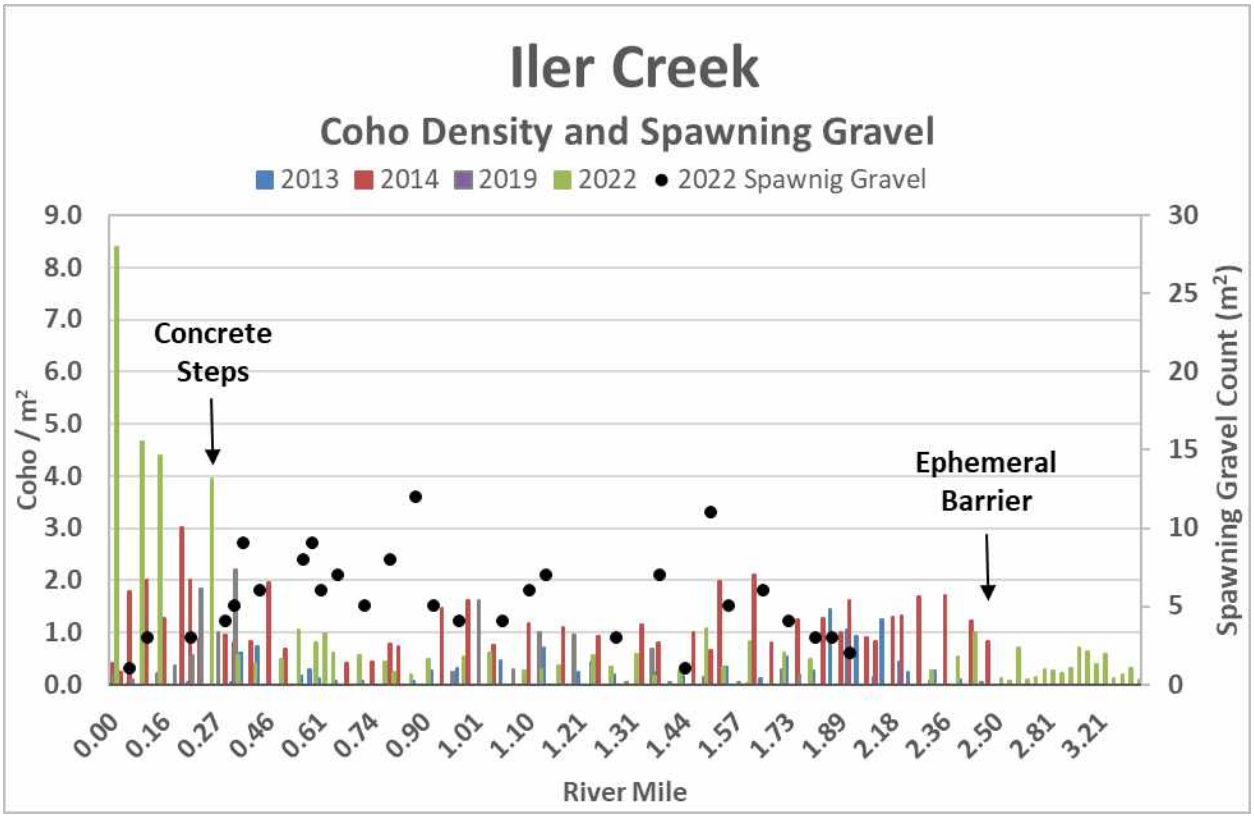


Figure 23: Iler Creek Densities 2022

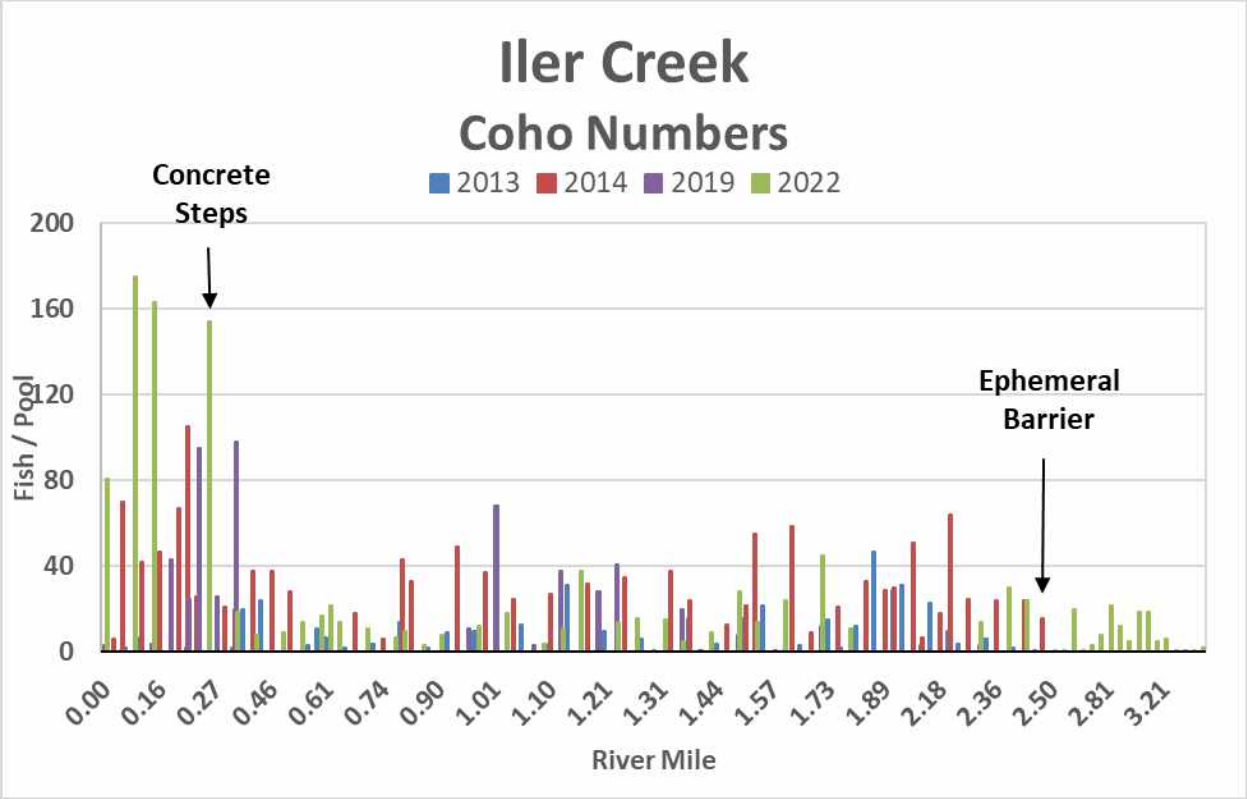


Figure 24: Iler Creek Numbers 2022

Steelhead

Steelhead distribution was sporadic with low densities for all four inventoried years. Given the low adult escapement over Willamette falls it remains encouraging that steelhead were still observed rearing in the system.

Cutthroat

Cutthroat abundance was similarly low in all inventoried years. In 2022, an average density of 0.14 fish/m² was observed expanding to 149 fish/mile.

0+ Trout

0+ trout abundance in 2022 was the second lowest of the inventoried years with an average density of 0.17 fish/m² (142 fish/mile). 2013 exhibited the highest abundance estimate with an average density of 0.6 fish/sqm (805 fish/mile) accounting for 20.6% of the Gales subbasin population estimate. Given that the cutthroat population has been relatively stable over the inventoried years, this was likely the result of increased winter steelhead spawning in the system for the 2012 adult brood year.

Chinook

Chinook were only observed in one sample pool in 2014 below the juvenile barrier at RM 0.25, likely a result of upstream juvenile migration from mainstem Gales. Inventoried habitats were not suitable for chinook spawning.

Table 21: Iler Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	2,550	0.43	3,260	25	635	0
2014	6,816	1.4	595	5	745	5
2019	2,490	0.62	1,610	15	530	0
2022	6,641	1.0	601	30	617	0

North Fork Gales Creek

NF Gales enters Gales Creek at RM 21.7. The survey extended 1.57 miles where reduced stream flow, increase in gradient, and coarse substrate diminishes anadromous potential (spawning and rearing). Anadromous distribution extended to RM 1.14. No adult barriers to passage were observed.

The confluence is within an LWD treatment reach on mainstem Gales. Treatment extended up NF Gales from the confluence to RM 0.6.

Stream habitat was characterized by moderate gradient (2.5% treatment reach, 4.2% remainder anadromous distribution); wide floodplain with low terrace heights and channel braiding; small boulder; cobble, and gravel dominated substrate with siltification of sorted gravel; high wood complexity within treatment reach, low complexity throughout remainder of inventory; well forested riparian canopy of mature deciduous and coniferous trees.

The temperature taken at the time of the inventory was 12.9°C, 0.5 degrees cooler than mainstem Gales Creek.

Anchor Sites:

3 anchor sites were observed. All anchor sites were given moderate function grades due to spawning gravel limitations.

Anchor Site #1 extended from RM 0.04 — 0.26.

Anchor Site #2 extended from RM 0.33 — 0.59.

Anchor Site #3 extended from RM 0.83 — 1.03.

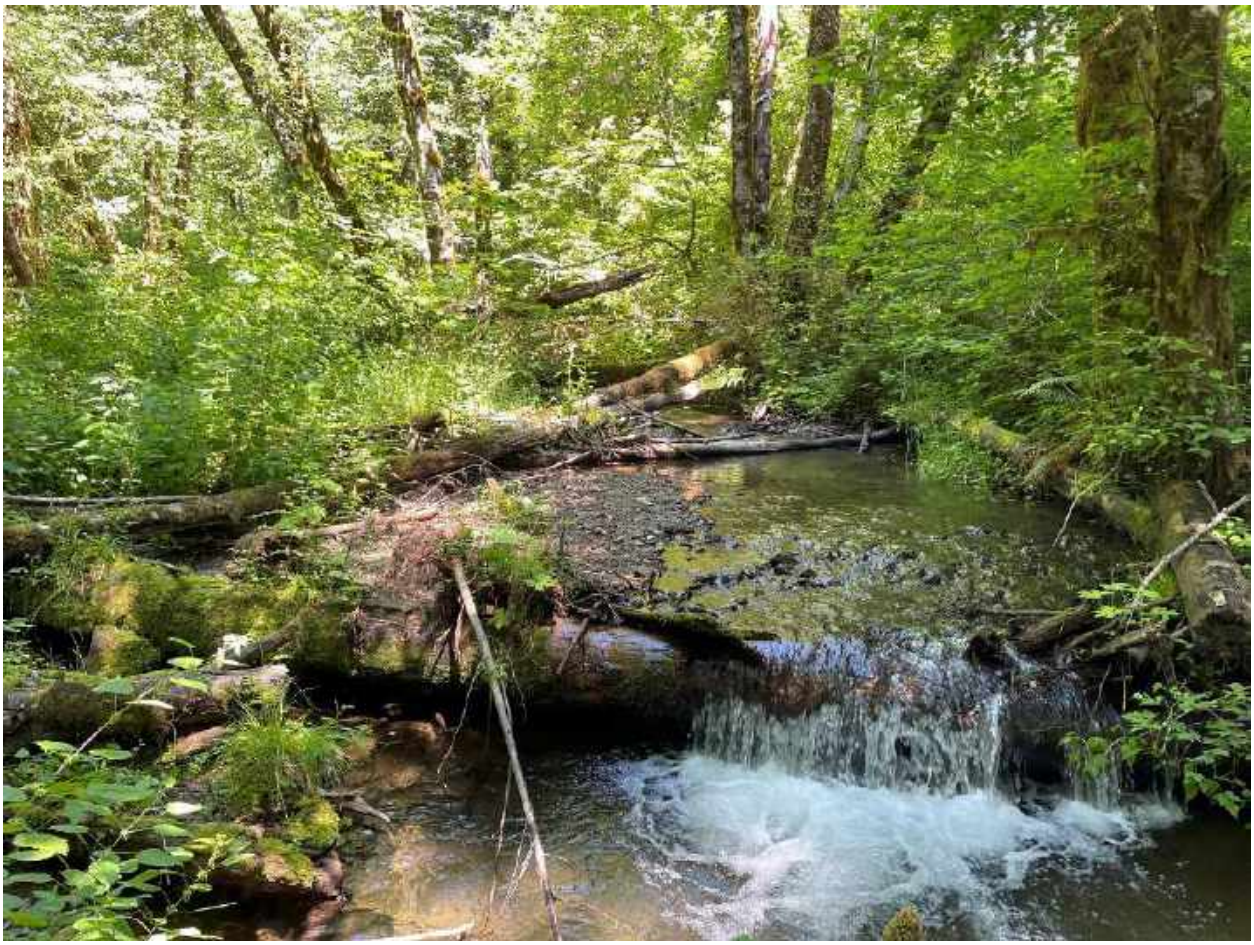


Photo 19: NF Gales Creek treatment reach, Anchor Site #1

Photo 20: NF Gales Creek sedimentation

Coho

2022 coho abundance was the lowest of the three inventoried years with an average pool density of 0.18 fish/m² expanding to 99 fish/mile. The dominant density peak of 0.36 fish/m² was observed at RM 0.04.

In 2013, coho abundance was the highest with distribution terminated by a natural sill log with a 4 ft perch. (ephemeral) at RM 1.3. In 2013, the peak coho density of 2.7 fish/m² was observed within the treatment reach at RM 0.4. In 2013, 79% of the total population estimate for coho in NF Gales was documented rearing within the treatment reach.

In 2014, coho distribution terminated within the treatment reach at RM 0.5. The 2014 peak coho density of 0.7 fish/m² was observed just above the confluence with Gales mainstem.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 2 adult (combined male and female) coho escaped to North Fork Gales Creek to spawn in 2022. Based on abundance this spawning event resulted in low egg to fry survival. In 2013, escapement was an estimated 10 adults (combined male and female) coho. The 2014

distribution profile suggests that the coho population was comprised of temperature dependent migrants from Gales mainstem and that no spawning events occurred in NF Gales.

Estimated adult coho capacity based on spawning gravel availability was 2 — 6 coho. In 2022, North Fork Gales Creek was functioning below its current spawning habitat capacity and limited by inadequate adult escapement. Spawning gravel was likely underestimated due to siltification of the spawning beds from a landslide event on an upper tributary. This event resulted in a temporary reduction in spawning capacity which will likely resolve in subsequent years.

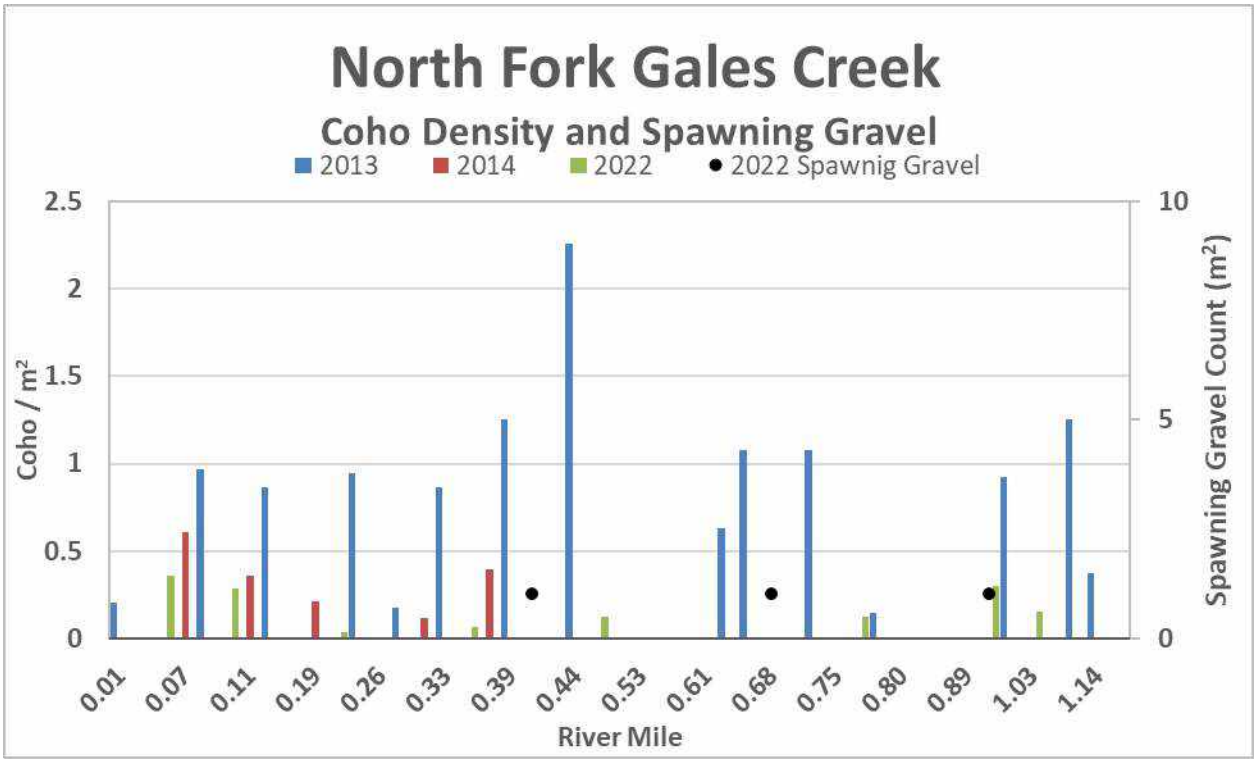


Figure 25: NF Gales Creek Densities 2013, 2014, 2022

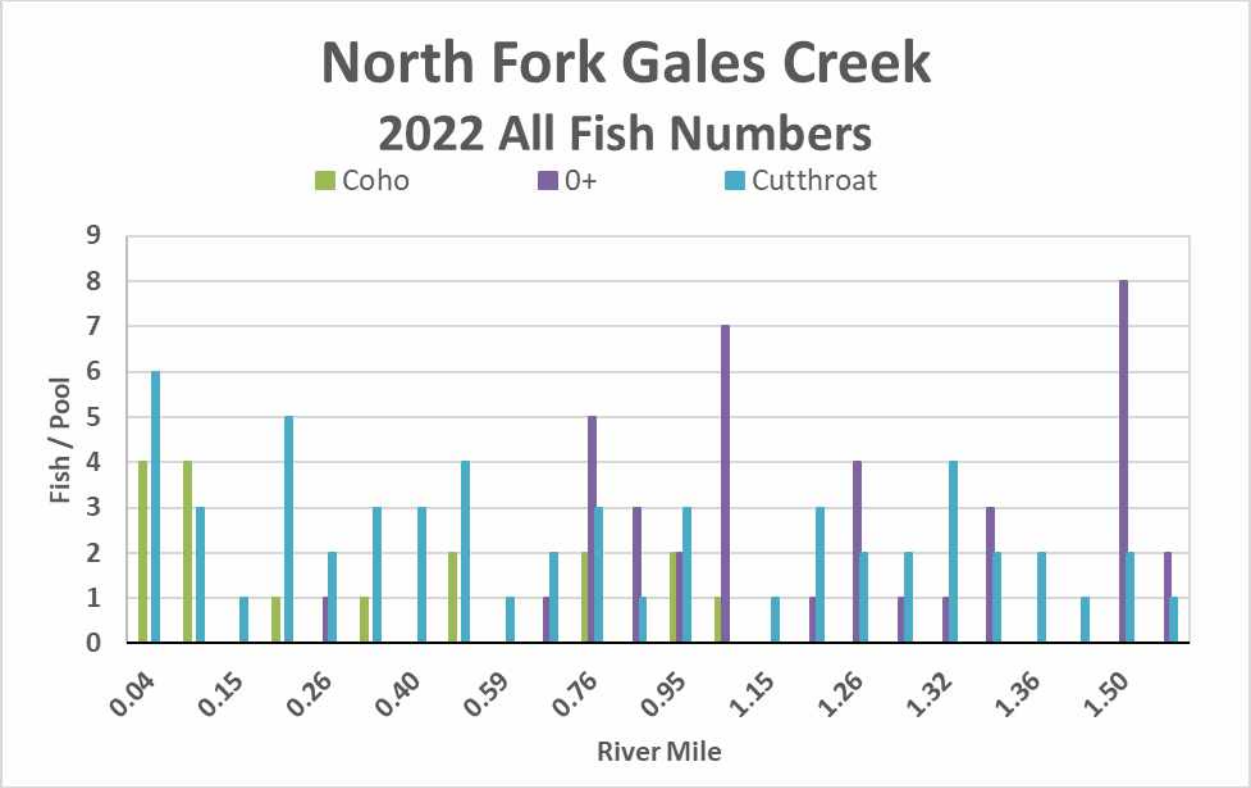


Figure 26: NF Gales Creek 2022 All Fish Numbers

Steelhead

In 2013, steelhead numbers were low and sporadic with distribution extending to RM 0.8. No steelhead were observed in 2014 or 2022.

Cutthroat

Cutthroat abundance was similarly low for all inventoried years with an average density in 2022 of 0.26 fish/m² (169 fish/mile).

0+ Trout

0+ trout abundance in 2022 was the lowest of the three inventoried years, a 79.68% decline from 2013 (the highest abundance year). Average densities for the three inventoried years were 0.7 fish/m² (640 fish/mile) in 2013, 0.78 fish/m² (309 fish/mile) in 2014, and 0.38 fish/m² (121 fish/mile) in 2022.

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 22: NF Gales Creek – Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	972	1.41	935	50	220	0
2014	132	0.41	510	0	295	0
2022	102	0.22	190	0	265	0

South Fork Gales Creek

SF Gales Creek enters Gales Creek at RM 20.7. The survey extended 1.6 miles to a 15ft bedrock/boulder falls functioning as a permanent anadromous barrier. Anadromous fish distribution extended 0.15 miles in 2022, 0.2 miles in 2013, and 0.4 miles in 2014.

SF Gales is a high flow, cold water tributary with a low gradient confluence. Stream habitat was characterized by moderate gradient (avg. 4.9%); dominant substrates of small boulder, cobble, and gravel, high wood complexity; forested riparian of mature deciduous and coniferous trees; and hillslope confinement limiting floodplain width. A LWD treatment reach throughout the lower mile was observed creating high complexity stream habitat and impounding bedload with deep gravel depositions.

The temperature taken at the time of the inventory was 12.4°C, 0.2°C cooler than mainstem Gales Creek. The inventory was conducted early in the summer (7/13) when temperatures were still unseasonably low. This small temperature differential likely grew as the season progressed. In 2014, temperatures taken later in season (8/22) recorded a 0.5°C differential (SF 15.6°C, Gales 16.1°C).

Anchor Sites:

No anchor sites were observed. Stream channel was hillslope confined throughout the inventoried reach.

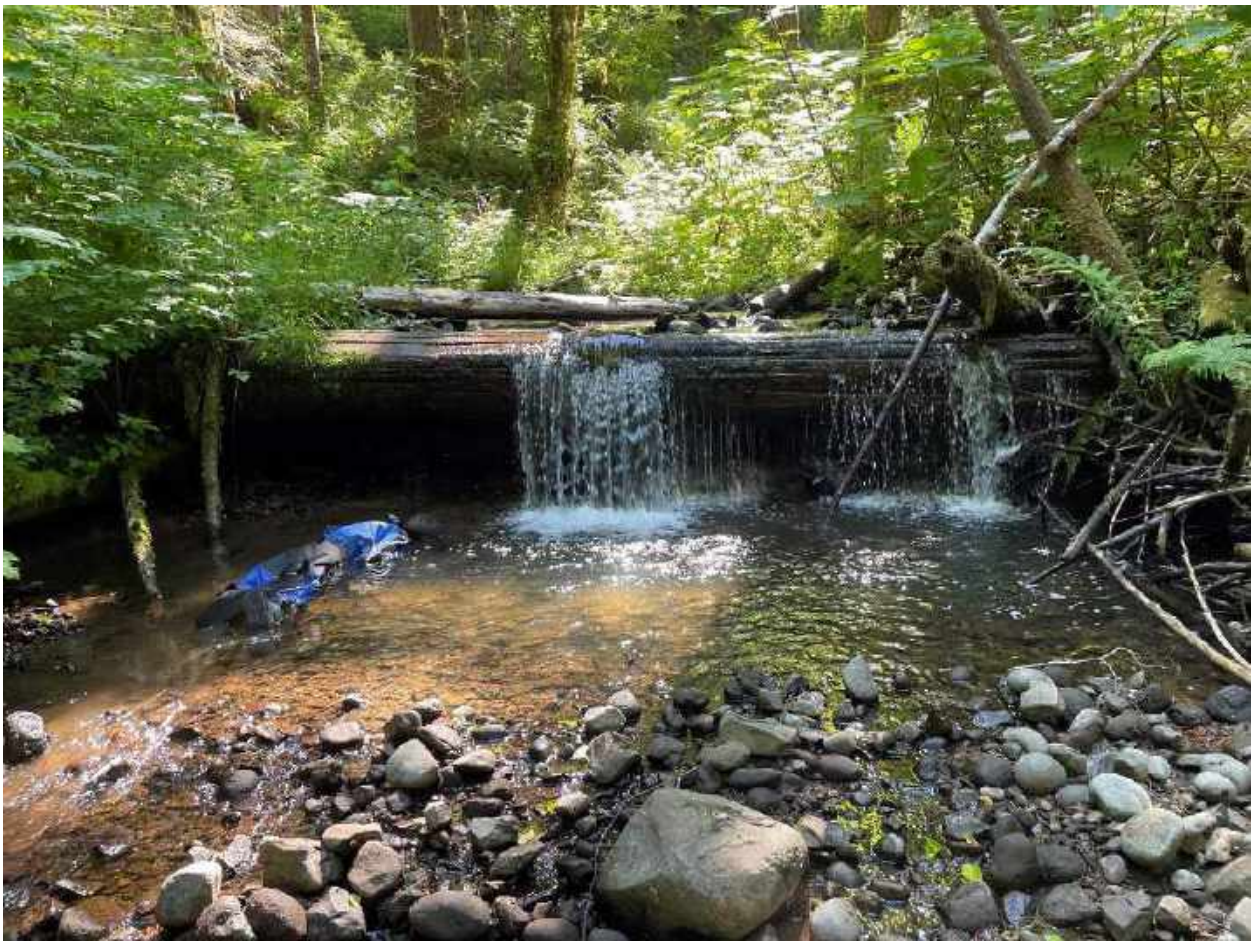


Photo 21: SF Gales Creek snorkeler

Coho

Coho abundance was low in all inventoried years with distribution extending only a short distance upstream from the Gales Creek confluence. These distribution profiles along with the temperature differential, and lack of spawning gravel in the lower 0.15 miles of habitat suggest that no spawning events occurred in the SF Gales. The coho population is likely comprised of upstream migrants from Gales Creek mainstem.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 2 adult (combined male and female) coho escaped to South Fork Gales Creek to spawn. Estimated adult coho capacity based on spawning gravel availability was 20— 60 coho. In 2022 South Fork Gales Creek was functioning far below its current habitat capacity and limited by inadequate adult escapement.

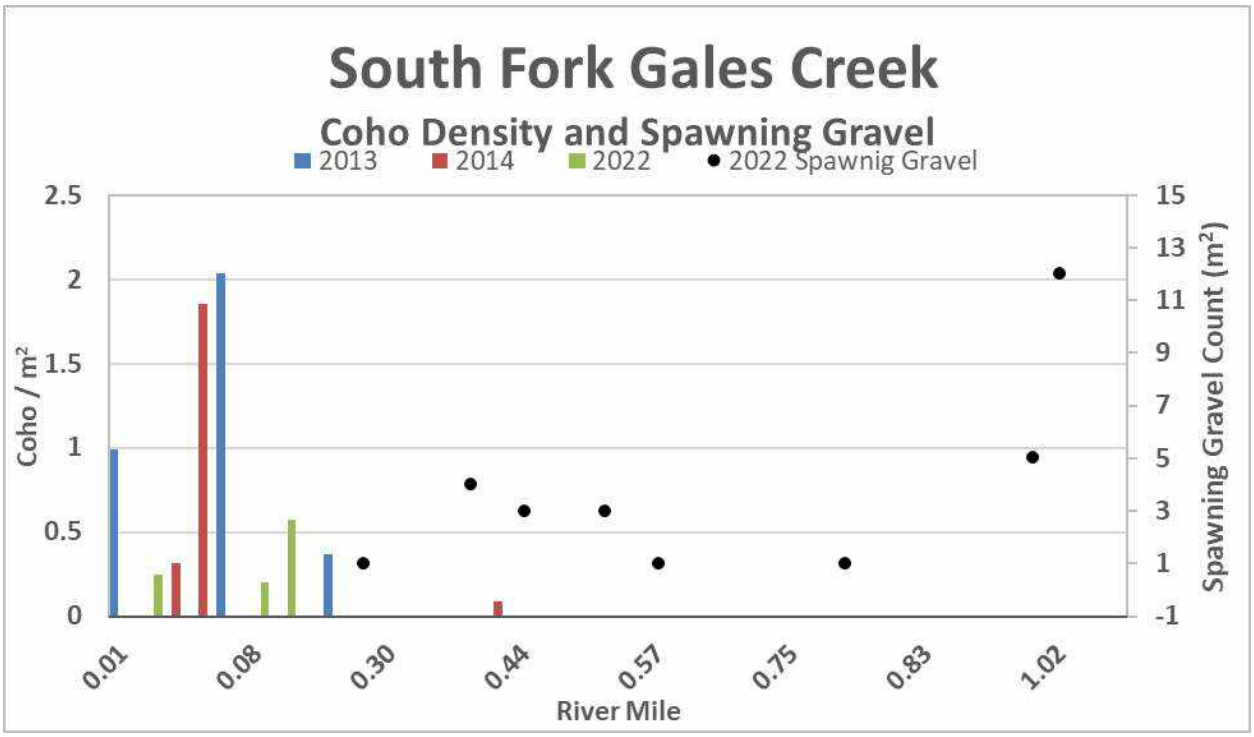


Figure 27: SF Gales Creek Coho Densities 2013, 2014, 2022

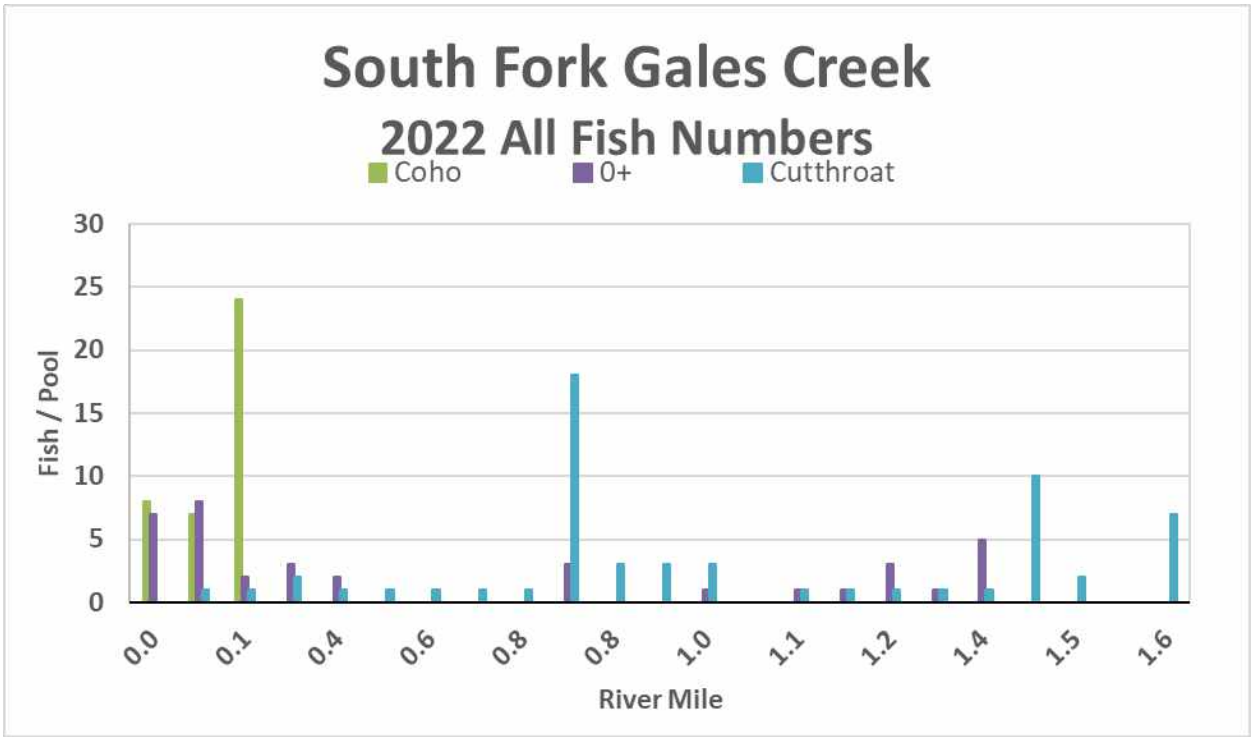


Figure 28: SF Gales Creek fish numbers 2022

Steelhead

Steelhead were not observed in 2013 or 2022. In 2014 steelhead were observed in one sampled pool just above the Gales creek confluence. Stream habitats throughout the inventoried reach were providing high quality steelhead habitat and likely limited by inadequate adult escapement.

Cutthroat

Cutthroat abundance was similarly low in all inventoried years. The 2022 average density was 0.14 fish/m² with abundance expanding to 109 fish/mile.

0+ Trout

2022 0+ trout abundance was the lowest of the inventoried years with an average density of 0.14 fish/m² expanding to 106 fish/mile throughout the range of significant distribution. Abundance estimates for 2022 were 83.7% lower than the highest abundance year (2013). The higher abundances of young of the year fry, at least for 2013, were likely the result of steelhead spawning in the system given that the cutthroat population has remained stable over the three inventoried years..

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 23: SF Gales Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	630	1.35	1,040		205	
2014	420	0.90	630	10	265	
2022	234	0.41	170		210	

White Creek

White Creek enters Gales Creek at USGS RM 14.2. The survey extended 0.8 miles where gradient increase (avg. 5.7%) and lack of spawning gravel limit further anadromous potential (spawning and rearing). Anadromous distribution extended to RM 0.67. No barriers to adult passage were observed.

The stream habitat in the first ½ mile of the inventory was characterized by an exposed stream channel with thin riparian buffer resulting from a legacy of agricultural impacts, low gradient (avg. 2.7%), channel incision with disconnected floodplain, cobble dominated substrate with lack of sorted spawning gravel, and low channel complexity. Riparian cover improves further upstream.

Temperature data collected at the time of the inventories in 2014 and 2022 recorded a 2 – 2.3°C differential with White Creek entering at 16.2˚C in 2014 and 13.7˚C in 2022; and Gales mainstem above the confluence at 18.1˚C in 2014 and 16 ˚C in 2022. Temperatures were recorded at the same time of day (14:00) but at different periods of the season with 2014 (9/1/14) representing late season conditions and 2022 (7/18/22) early season conditions. White Creek's cool summer temperature profile and spatial location within the temperature limited reach of mainstem Gales Creek 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. The high counts of coho in this pool suggest that the culvert is blocking upstream temperature dependent migrations from mainstem Gales Creek.

Anchor Sites:

No anchor sites were observed. Steam habitats were incised and disconnected from historic floodplains.

Photo 22: White Creek upper section

Coho

Coho abundance in all inventoried years was moderate with an average pool density in 2022 of 0.91 fish/m² expanding to 1102 fish/mile. Distribution profiles were similar in all inventoried years with density peaks of 5 fish/m at RM 0.3 in 2013, 4.6 fish/m at RM 0.2 in 2014, and 3.44 fish/m² at RM 0.34 in 2022.

Spawning Gravel and Adult Escapement

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, adult coho (combined male and female) escapement to White Creek was 14 coho in 2013, 12 coho in 2014, and 8 coho in 2022. No suitable spawning gravel was observed. The lack of suitable spawning gravel in White Creek was functioning as limiting factor to coho production in all inventoried years.

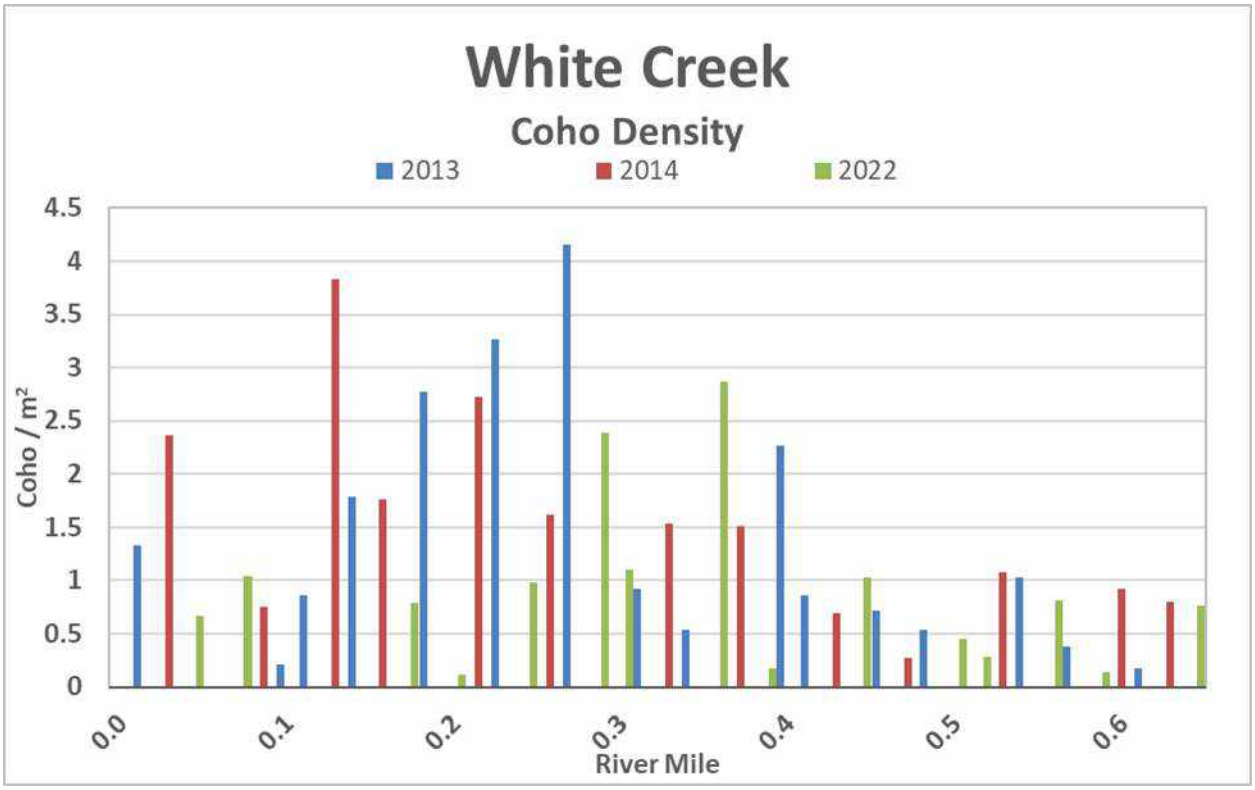


Figure 29: White Creek Densities 2013, 2014, 2022

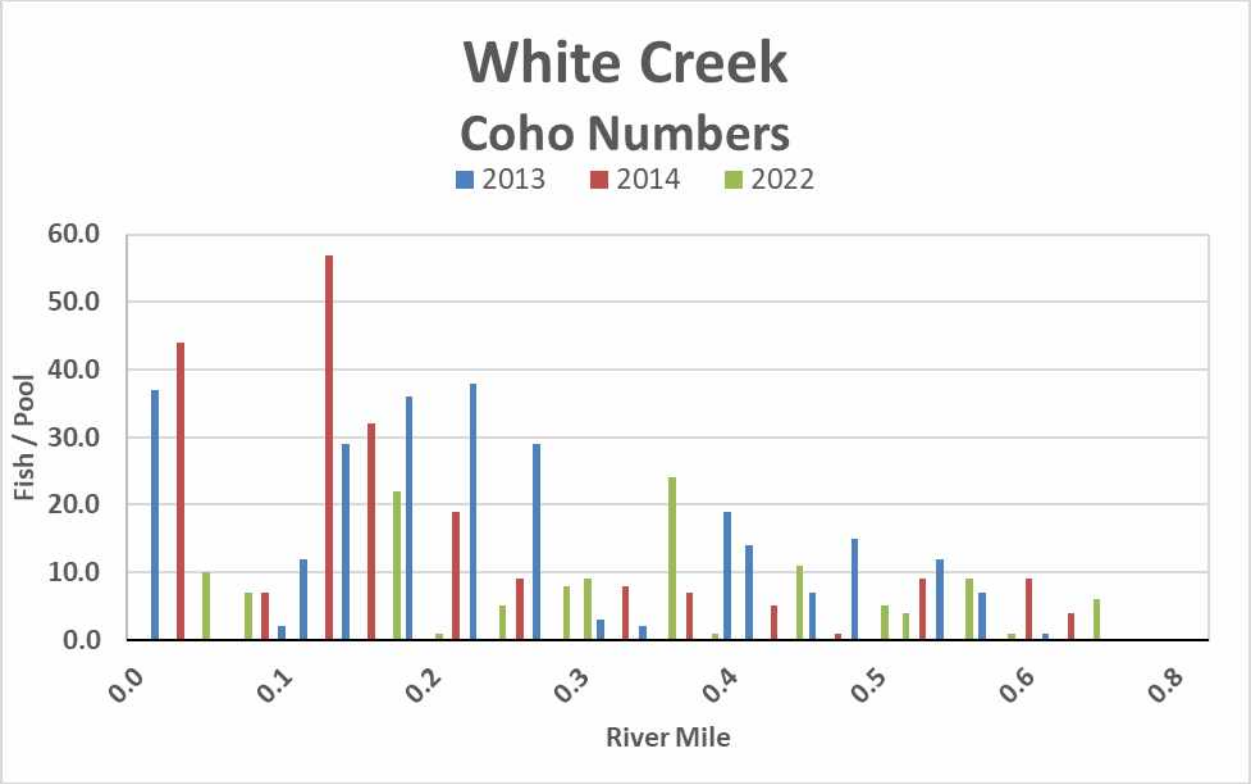


Figure 30: White Creek Numbers 2013, 2014, 2022

Steelhead

Steelhead were not observed. Stream habitats were not suitable for steelhead occupation.

Cutthroat

Cutthroat abundance in 2022 was the lowest of the three inventoried years, an 80.65% decline from 2014 (the highest abundance year). Average densities were 0.16 fish/m² (117 fish/mile) in 2013, 0.46 fish/m² (235 fish/mile) in 2014, and 0.14 fish/m². (38 fish/mile) in 2022.

0+ Trout

0+ trout abundance was low in all inventoried years with 2022 near the average. The 2022 average density was 0.29 fish/m² (69 fish/mile).

Chinook

Chinook were not observed. Inventoried habitats were not suitable for chinook occupation.

Table 24: White Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat	Chinook
2013	1,404	1.64	75		90	
2014	1,266	1.83	25		155	
2022	792	1.09	55		30	

East Fork Dairy Creek Subbasin

The EF Dairy drainage contained 24.95 miles (mainstem and tributaries combined) of inventoried stream habitats in 2022. The use of more accurate methods for measuring stream reach distances in 2022 created substantial differences in year-to-year totals of inventoried linear miles. For data consistency we've calibrated the 2013 and 2014 data to 2022 distances. This was not done with the raw data in the Excel Workbook or Access database.

EF Dairy Creek contained some of the highest quality stream habitat observed in the Tualatin basin and was responsible for a large percentage of salmonid rearing in the basin for all three inventoried years. Though 10 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 Creek 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 Creek. This is an important comparison to the other surveyed subbasins within the scope of this assay whose mainstem reaches were consistently temperature limited and over allocated for withdrawal well up into the range of available spawning habitat.

Despite the increased quality of stream habitat as compared to other Tualatin subbasins, East Fork Dairy mainstem was still cited with several Category 4 and 5 303(d) listings for water quality limitations (see Introduction section). Additionally, temperature profiles observed during the 2022 inventories suggest that summer mainstem temperature regimes have warmed since 2014. Temperature profiles in lower mainstem EF Dairy Creek (from Hwy 26 to Denny Creek) exhibited significant temperature increases from 2014 to 2022. Temperatures recorded during inventories at 13 sites throughout this reach averaged 15.4°C in 2014 and rose to 17.9°C in 2022. Temperatures for both years were recorded at the same locations and at similar times of the year and times of the day. Peak temperatures of 16°C (2014) and 19.5°C (2022) were recorded at similar locations (RM 7.4, 7.9), at similar times (14:40,15:00) and on similar dates (9/3/2014, 9/1/2022).

It's important to note that temperature values used in this analysis were not the result of continuous monitoring and lack comprehensive temperature profiles for the referenced periods of time, it nevertheless appears to be an alarming trend. Furthermore, distribution profiles for coho and steelhead in lower East Fork mainstem appear to reflect this trend. This will be further discussed in stream profiles below.

Table 25: East Fork Dairy Creek Subbasin 2013 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Sthd	%	Cut	%
East Fork Dairy	33,768	94.8	8,180	65.5	1,950	99.2	2635	69.8
Side Channel A	225		9					
Side Channel B	273		25				6	
Side Channel C	72		5					
Big Canyon	156		65				30	
Campbell	372	1	1,280	10.2			280	7.4
Denny	402	1.1	1,205	9.6	5		285	7.5
Murtaugh	144		125	1	10		180	4.8
Panther			130	1			20	
Plentywater	7		135	1.1			40	1.1
Rock	210		1,095	8.8			265	7
Roundy	6		195	1.6			35	
Trib A	6		40					
Subbasin Total	**35,641**		**12,489**		**1,965**		**3,776**	

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

- Percentages are of total within the subbasin

Table 26: East Fork Dairy Creek Subbasin 2014 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Sthd	%	Cut	%
East Fork Dairy	25,140	91	3,595	70.8	2,265	99.5	2,680	78
Side Channel A	578	2.1	3					
Side Channel B	173		22		10		34	1
Side Channel C	118		4				10	
Side Channel D	230		4				27	
Side Channel E	209							
Side Channel F	211		3		1		6	
Campbell			415	8.2			225	6.5
Denny	780	2.8	340	6.7			200	5.8
Murtaugh	84		55	1.1			30	
Panther			65	1.3			60	1.7
Plentywater	84		70	1.4			35	
Rock	18		440	8.7			120	3.5
Roundy			65	1.3			10	

Stream	Coho	%	0+	%	Sthd	%	Cut	%
Subbasin Total	**27,625**		**5,081**		**2,276**		**3,437**	

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

- Percentages are of total within the subbasin

Table 27: East Fork Dairy Creek Subbasin 2022 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Sthd	%	Cut	%
East Fork Dairy	23,156	82.9	2,746	70.1	1,225	97.7	1,827	65.1
Side Channels	416	1.5	24		4		18	
Big Canyon	252		20				10	
Campbell	708	2.5	280	7.2			155	5.5
Denny	1,566	5.6	390	10.0	25	2.0	445	15.9
Meadowbrook	1,116	4.0	40	1.0			70	2.5
Murtaugh	150		10				10	
Panther			25				15	
Plentywater	318	1.1	85	2.2			30	1.1
Rock	198		195	5.0			210	7.5
Roundy	30		50	1.3			10	
Trib A	6		50	1.3			5	
Subbasin Total	**27,916**		**3,915**		**1254**		**2805**	

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

- Percentages are of total within the subbasin

EF Dairy Creek

The EF Dairy inventory began at the Highway 26 crossing (RM 5.7) in all three inventoried years, extending to RM 23.35 in 2013, 23.78 in 2014, 23.75 in 2022. No permanent adult barriers to passage were observed. Gradient increase, reduced flows, and lack of spawning gravel limit further anadromous potential above the 2022 end of coho distribution (RM 23.5).

Representing 25.4% of the total stream miles for the combined Gales and EFD sub-basins, the EF Dairy mainstem was rearing large percentages of the salmonid populations in all inventoried years.

- In 2013: 55% of coho, 24.9% of 0+ trout, 74.6% of steelhead, and 31.4% of cutthroat.
- In 2014: 42.7% of coho, 29.1% of 0+ trout, 83.4% of steelhead, and 34.1% of cutthroat.
- In 2022: 30.8% of coho, 32.7% of 0+trout, 72.34% of steelhead, and 34.55% of cutthroat.

Out of the 10 tributaries inventoried in the EF Dairy subbasin, only 4 appeared to have provided spawning habitat for coho: Denny, Campbell, Meadowbrook, and Panther. The rest exhibited only upstream temperature dependent migrations of juveniles from the mainstem of EF Dairy. These migrations never extended more than 1,300 linear feet (displayed by decreasing densities with increased linear distance from the mouth and fish distribution ending below the first juvenile barrier). This upstream migration pattern displayed in at least 6 of the 10 tributaries of mainstem EF Dairy Creek suggests the need of summer rearing salmonid juveniles to find thermal refugia from the mainstem. Panther, Roundy, and Trib A all exhibited limited anadromous potential. Steep gradient, shallow pools, and lack of spawning gravel were noted as the primary limitations. Tributaries will be discussed in further detail below.

Beaver dam abundance and distribution was similar in the three inventoried years. There were 10 dams in 2013, 7 dams in 2014, and 11 dams in 2022. In all years, beaver activity was concentrated in the lower 2.3 miles of the inventory (below RM 8) and in the upper mile of the survey (above RM 22.7, start of Anchor Site #7). In 2022, beaver pools were providing 84% of the surface are of rearing habitat below RM 8 and 13.7% above RM 22.7. Gradient and velocity profiles in stream habitats between those reaches are likely too high and not conducive to beaver augmentation.

From the start point at RM 5.7 to RM 11 the stream habitat was characterized by low gradient (0.15% avg.), entrenched banks, deep silt deposits, brushy banks with thick debris jams, and beaver occupation. Low densities of coho and cutthroat were present in all inventoried years. A sickly and sluggish coho was observed swimming at the surface in this reach. Abundant Western pearlshell mussel beds were documented throughout this reach in 2013 and 2014. In 2022, hundreds of empty mussel shells were noted with very few living specimens observed.

Photo 23: Lower East Fork Dairy beaver dam

Above RM 11, spawning gravel, balanced pool to rifle ratios and the potential for floodplain interaction during winter flow regimes all begin to set up to form a functional anchor habitat reach. Anchor #1 extends from RM 12.2 – 14.3. The abundance of all salmonid species increased rapidly above this point and continued to improve for several miles. In 2013, salmonid abundances for all inventoried species were higher from RM 11.5 – 14.6, when compared with 2014 and 2022 estimates.

In 2013, peak coho and steelhead production occurred from RM 14.3 – 17.2. In 2014, peak coho production overlapped this zone but started further upstream at RM 15.2 extending to RM 17.1 and peak steelhead production extended from RM 14.6 – 17.1. In 2022, peak coho production extended from RM 14.6 – 17.2 and peak steelhead production began at RM 19, several miles further upstream than 2013/2014, and extended only one mile.

The start of this high production 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. Stream habitats in this reach were characterized by low gradient (ang.1.2%), well sorted gravel in pool tailouts, increased channel sinuosity, and wide floodplains with low terrace heights. Anchor sites #2 and #3, and Side Channels A, B, C, and D

were all within this reach. A thin riparian canopy and a lack of interactive LWD was commonly noted.

Photo 24: East Fork Dairy treatment logs collecting debris and functioning as scour vectors

A rapid decline in coho and steelhead abundance was observed following this first zone of peak salmonid production in all inventoried years. Additional spawning peaks occur upstream, but abundances did not match the lower peak production zone. Upstream of Plentywater Creek (RM 17.34) Anchor Site # 4 extends from RM 17.5 – 18.8 exhibiting wide floodplains and low terrace heights but moderate to low functionality due to limited spawning gravel throughout and inadequate large wood complexity in the upper end. Spawning gravel availability declines upstream of RM 17.7. Denny Creek enters within this anchor at RM 18.3.

Upstream of Anchor Site #4 the canyon tightens, and a series of cobble/boulder/bedrock riffles dominate the next mile of stream corridor to a 3ft bedrock falls at RM 19.3 that terminates upstream juvenile migrations. Upstream of the falls, Anchor Site #5 extends a short reach (0.09 miles). The next 1.6 miles of stream is characterized by confined stream channel; low wood complexity; and bedrock, small boulder, and cobble dominated substrate with limited gravel sorting. Wood complexity increases above Roundy Creek (RM 20.8). Increased gravel sorting

and increased salmonid abundances were documented in this reach in 2013 and 2022. Strangely, in 2013. Anchor Site #6 extended from RM 21.64 – 22.06

Photo 25: East Fork Dairy 3ft falls at RM 19.3

At the upper end of this high production reach coho distribution in 2013 ended at RM 21.9. Shortly above, an increase in gradient (averaging 7.5%) over bedrock with a 1ft bedrock falls (RM 22.13) marked the end of coho distribution in 2013 and steelhead distribution in 2014 and 2022 (this is an insignificant barrier for adults and does not describe the permanent end of anadromy).

Above the partial barrier, the gradient decreased to an average of 3.7% and high-quality stream habitats for salmonid rearing extended for an additional mile. Well sorted gravel, moderate wood complexity, and low interactive floodplain terraces were observed. Anchor Site #7 extended from RM 22.7 – 23. Coho distribution in 2022 utilized this reach of high-quality habitat extending an additional 1.32 miles from the 2014 endpoint to RM 23.45. Divided flows above a tributary confluence, increased gradient, and lack of spawning gravel limit further salmonid potential (spawning and rearing) upstream of the 2022 end of coho.

Photo 26: East Fork Dairy high complexity habitat

East Fork Dairy Creek Side Channels

Though 6 functional side channels were observed, over the three inventoried years, rearing high densities of coho parr, side channel habitats did not appear to be serving a critical function in the EF Dairy Creek mainstem. 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. Temperature data collected during the 2014 and 2022 inventory suggests that very little of the side channel habitats were serving as thermal refugia.

Only Side Channel A (RM16.2) exhibited conditions conducive for hyporheic cold water expression to the surface. Side channel A provided connectivity to the mainstem at the bottom and was delinked from the mainstem at the top. This allowed hyporheic 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 can attract large numbers of salmonid parr in temperature limited stream corridors. Coho densities in side channel A were high at 4.8 fish/m² in 2013 and 5.1 fish/m² in 2014. Side channel avulsed sometime between 2014 and 2022.

Side Channel B entered at RM 16.3 and was observed in all inventoried years functioning like mainstem braid with contiguous surface flows accounting for about 30% of total flow. No hyporheic expression or temperature differential was observed. 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 in 2013 with the peak pool density of 7.3 fish/m² being the highest documented in all the 2013 inventoried reaches of the Tualatin basin. In 2014, coho densities and abundance were lower with an average of 1.5 fish/m² and a peak of 2.3 fish/m². In 2022, an average coho density of 2 fish/m² and a peak density of 2.96 fish/m². With higher flows in 2014 and 2022 the habitat was more attractive to steelhead and cutthroat which both exhibited increases in abundance.

Photo 27: Side Channel B

Side Channel C was located at RM 16.8 exhibiting low summer flow (still mainstem linked) in 2013 and 2014. Although coho densities were high in 2013 and 2014, it consisted of only a few small pools. Side channel C was dry in 2022.

Side Channel D entering from the west at RM 16.4 (across from Side Channel B) provided the highest surface area of habitat and extended the longest at 0.3 miles. This side channel drains an expansive legacy beaver swamp with large high complexity pools and deep thermoclines of

cool water. It was not feasible to sample the entirety of the habitat and visibility was reduced by tannins and turbidity from deep silt deposition. Coho and cutthroat were observed in low densities. Fish abundance estimates likely underestimate the total fish production occurring in this complex of habitat that spans up to 200 ft across at points as it braids through the wetland

Side Channel E and F were both stagnant backwaters associated with historic oxbows observed with shallow thermoclines of cool water. Low abundances of coho were observed in 2013 and 2014. Due to landowner access denial these side channels were not sampled in 2022.

Anchor Sites:

Seven anchor sites were documented in EF Dairy mainstem accounting for a total of 5.07 miles of stream habitat. Anchor sites ranged from moderate to low functionality due to insufficient large wood complexity and spawning gravel limitations. Peak salmonid production zones for all species in all inventoried years were observed within anchor site habitats.

Coho

Coho abundance was high in all inventoried years. Parr distribution trends in all three years indicated that two dominant coho spawning peaks occurred in the EF Dairy mainstem. Changes in distribution profiles were observed from 2013/2014 to 2022. In 2013/2014, dominant density peaks were observed lower in the basin (below RM 17) with secondary spikes documented higher in the basin (above RM 19.2). In 2022, distribution shifted with dominant density spikes observed above RM 19.2 and secondary peaks documented downstream below RM 17. The lower density spikes for all three inventoried years were within Anchor Site #3.

In 2013, the primary density spike of 2.9 fish/m² was documented at RM 17 just upstream of Side Chanel C with the highest pool counts in the basin occurring in the pool habitats just downstream. Abundance throughout the peak production zone (RM 14.3 – RM 17.2) expanded to 5,192 fish/mile. The 2013 secondary spawning peak of 2 fish/m² was documented at RM 21.8 within Anchor Site #6.

In 2014, the primary density spike of 3.28 fish/m² was observed at RM 16.05 with the high pool counts within a similar range. Abundance throughout the peak production zone (RM 15.2 – RM 17.1) expanded to 6,935. The 2014 secondary spawning peak of 2.1 fish/m² was observed at RM 19.93. Strangely in 2014, coho distribution terminated at RM 21.9 within Anchor Site #6

In 2022, the secondary density spike of 1.58 fish/m² was observed at RM 16.3 with the high pool count associated with a high complexity structure pool further upstream at RM 16.9. Abundance throughout the peak production zone (RM 14.6 – RM 17.2) expanded to 3,988 fish/mile. The 2022 primary spawning peak of 5.03 fish/m² was documented at RM 21.65 within Anchor Site #6

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, estimated adult coho escapement (combined male and female) to East Fork Dairy was, 324 in 2012, 252 in 2013 and 222 in 2021. Estimated adult coho capacity based on spawning gravel availability was 108 – 324 coho. In 2021, East Fork Dairy was functioning below its current habitat capacity and limited by inadequate adult escapement. In years of higher adult

escapement like 2012, lack of spawning gravel may have functioned as a primary limiting factor to coho production.

The 2013 and 2022 declines in estimated adult abundance from the 2012 estimate is strange given that corresponding escapement over Willamette falls nearly doubled from 2012-2013 and 2021 was the highest adult escapement of the three inventoried years.

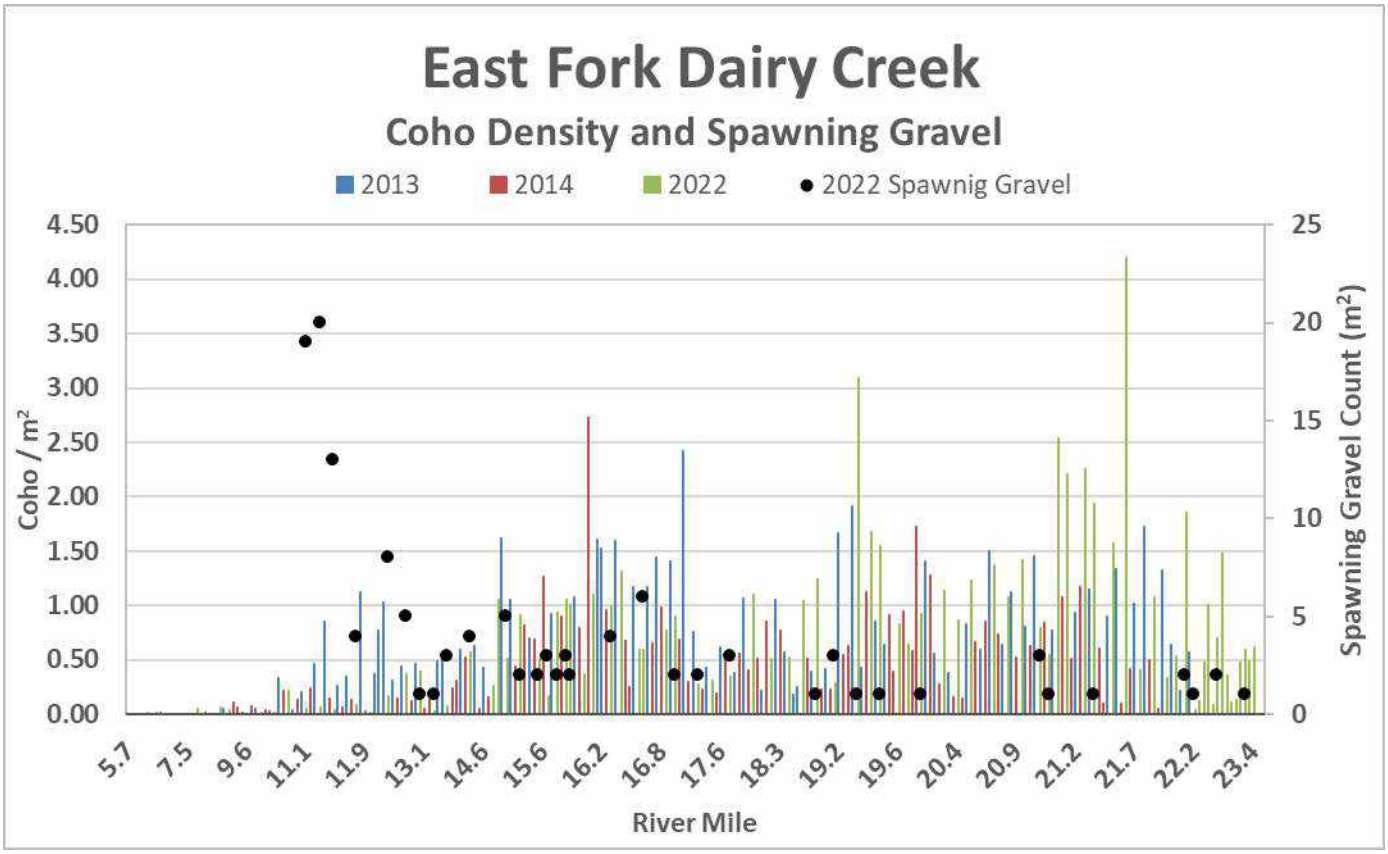


Figure 31: EF Dairy Creek Coho Densities 2013, 2014, 2022

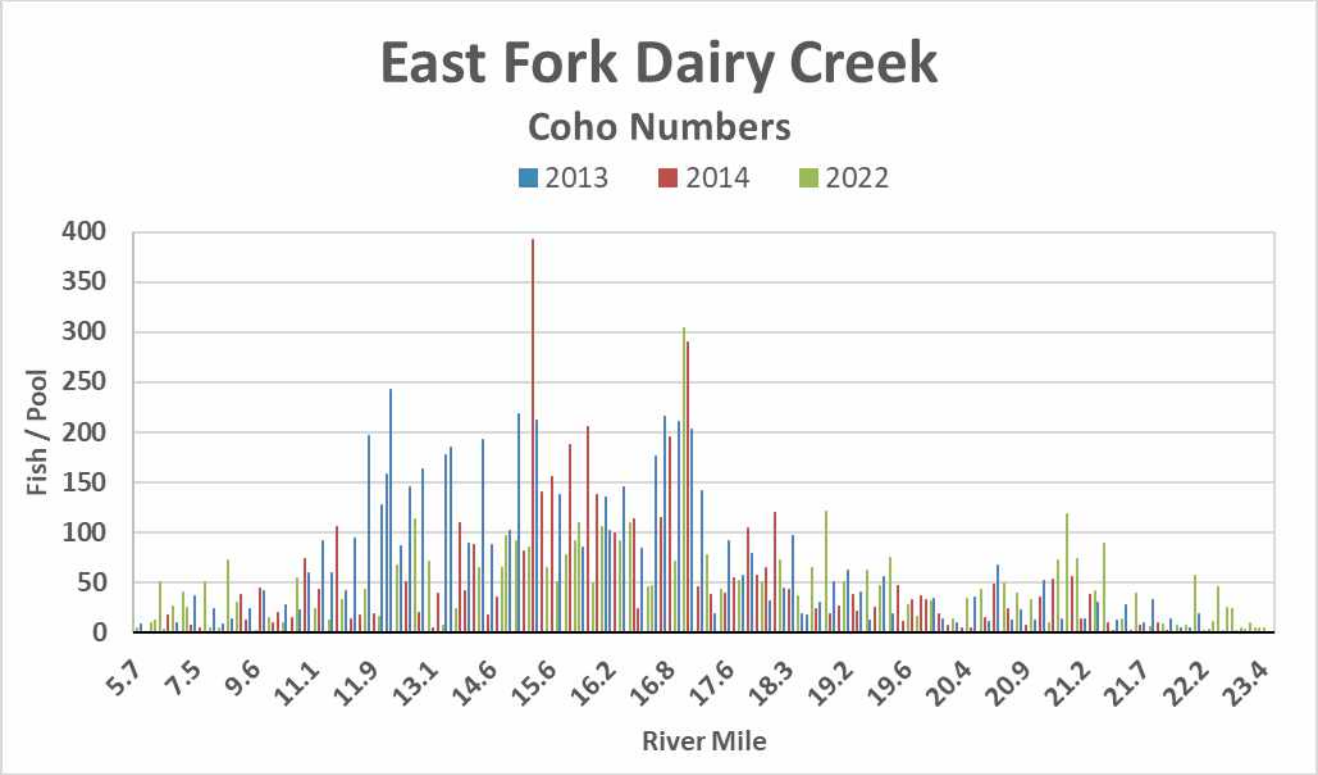


Figure 32: EF Dairy Creek Coho Numbers 2013, 2014, 2022

Steelhead

Steelhead abundance in 2022 was the lowest of the three inventoried years. This is not surprising given corresponding adult escapement over Willamette Falls (2021) was 58.2% (2013) and 72.9% (2012) lower than previous inventoried year's corresponding escapement totals. Additionally, the range of steelhead distribution in 2022 was greatly reduced from previous inventories with 0+ trout distribution profiles mirroring this reduction. Steelhead distribution extended downstream to RM 11.06 in 2013, to RM 10.77 in 2014, and only to RM 14.3 in 2022. With upstream distribution remaining largely the same in all inventoried years this was a 32.7% reduction in habitat usage. This change in the range of steelhead distribution is likely the result of reduced adult escapement; upstream temperature dependent migration; and reduction in mainstem habitability related to increases in temperature profiles during summer flow regimes. Distribution profiles in all inventoried years indicated that there may be upstream movements occurring in EF Dairy mainstem.

In 2013, peak steelhead production mirrored coho with the highest counts recorded from RM 14.3 – 17.2 expanding to 361 fish/mile. The two highest densities observed in 2013 were 0.29 fish/m² below the 3ft falls at RM 19.28 and 0.24 fish/m² below the 1ft falls at RM 22.13. Average steelhead densities for the 11.64 miles of distribution observed in 2013 were 0.08 fish/m².

In 2014, peak steelhead production in 2014 was similar to 2013, extending from RM 14.6 – 17.1 expanding to 457 fish/mile. Increased densities associated with the falls at RM 11.8 were also observed, but a change in pool structure below the falls expanded the pool surface area

lowering the rearing density. The two highest density peaks in 2014 mirrored those of coho with 0.52 fish/m² observed at RM 16.05 and 0.32 fish/m² at RM 19.93. Average steelhead densities for the 11.4 miles of distribution observed in 2014 were 0.09 fish/m².

In 2022, peak steelhead production began significantly further upstream and was reduced in length extending only from RM 19 – 20 expanding to 305 fish/mile. Average steelhead densities for the 7.83 miles of distribution observed in 2022 were 0.13 fish/m².

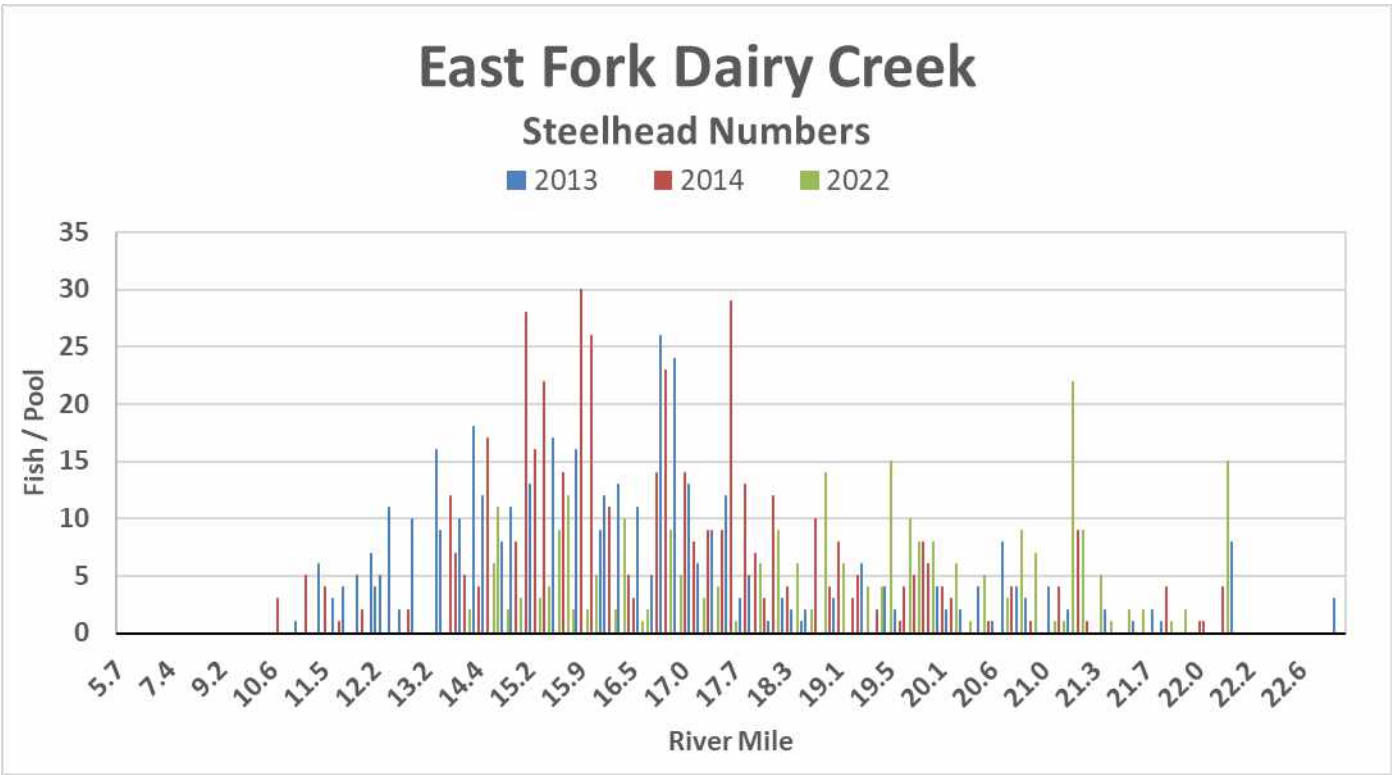


Figure 33: EF Dairy Creek Steelhead Numbers 2013, 2014, 2022

Photo 28: East Fork Dairy steelhead parr

Photo 29: East Fork Dairy steelhead and cutthroat

Cutthroat

In 2013, 2014, and 2022 distribution profiles of cutthroat and 0+ trout resembled those of coho and steelhead with bimodal increases in abundance occurring near the same locations. Cutthroat and 0+ trout densities exhibited similar relationships to the two previously described barriers at RM 19.28 and RM 22.13. In 2022, Cutthroat abundance was the lowest of the three inventoried years, consistent with trends observed in the Gales subbasin.

In 2013, the cutthroat density spike of 0.69 fish/m² was observed below the barrier falls at RM 22.13. Abundance expanded to 210 fish/mile throughout the range of significant distribution (RM 11.06 – 23.35).

In 2014, the cutthroat density spike of 0.87 fish/m² was observed at RM 20.13 (confluence of Panther Cr). Abundance expanded to 256 fish/mile throughout the range of significant distribution (RM 13.89 – 23.78).

In 2022, the cutthroat density spike of 0.65 fish/m² was observed below the barrier falls at RM 19.28. Abundance expanded to 169 fish/mile throughout the range of significant distribution (RM 13.05 – 23.75).

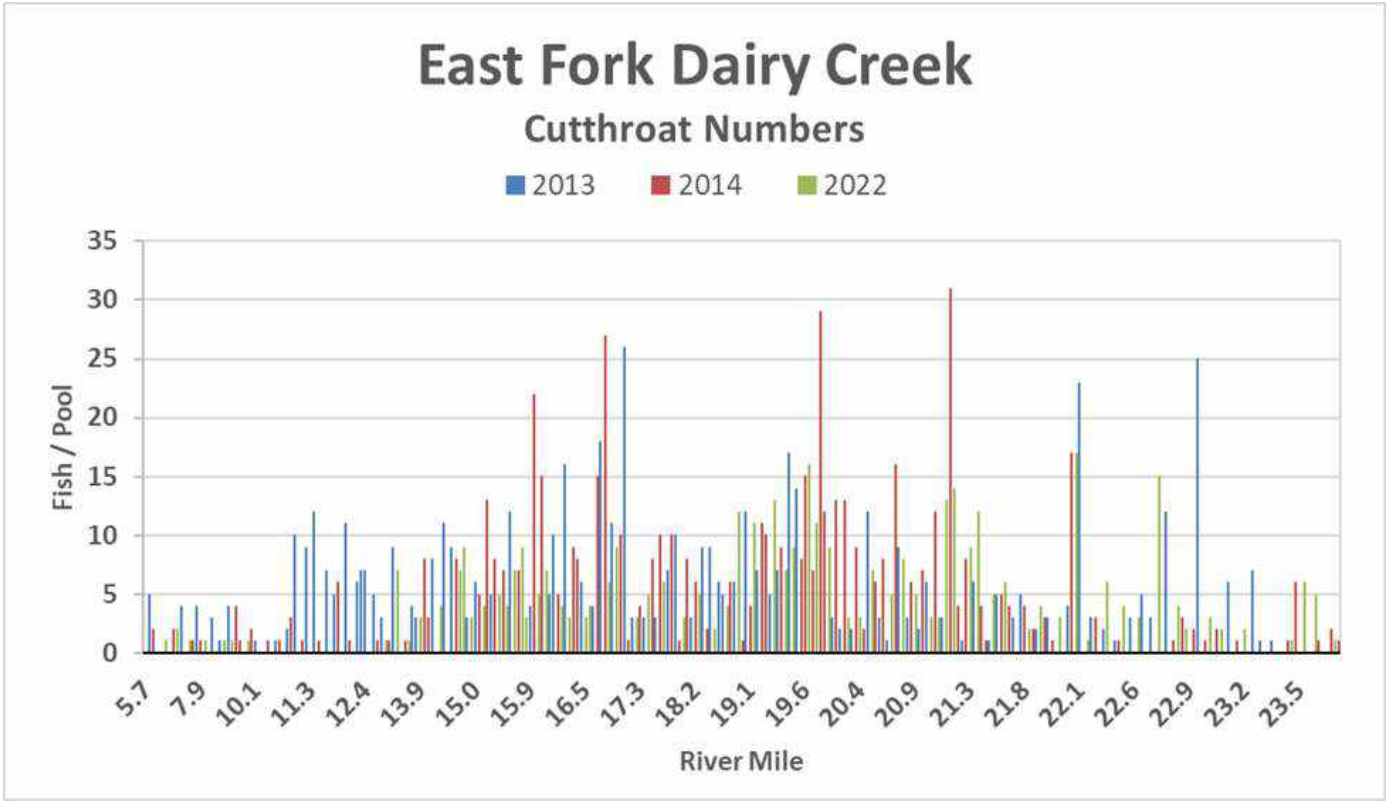


Figure 34: EF Dairy Creek Cutthroat Numbers 2013, 2014, 2022

0+ Trout

In 2022, 0+ trout abundance was the lowest of the three inventoried years with an average density of 0.26 fish/m². Abundance estimates in 2022 were only 33.57% of the 2013 estimate (highest abundance year). This drop in 0+trout abundance is consistent with that observed in the Gales Creek subbasin and likely the result of a reduction in adult winter steelhead escapement into the Tualatin basin.

In 2013, the peak 0+ trout density of 3.1 fish/m². was observed below the barrier at RM 22.14. Abundance expanded to 677 fish/mile throughout the 12.08-mile range of significant distribution (RM 11.27 – 23.35).

In 2014, the peak 0+ trout density of 0.83 fish/m² was observed at RM 21.3 (just above the confluence of Campbell Cr). Abundance expanded to 396 fish/mile throughout the 8.78-mile range of significant distribution (RM 15 – 23.78).

In 2022, the peak 0+ trout density of 1.1 fish/m² was observed below the falls at RM 19.28. Abundance expanded to 249 fish/mile throughout the 10.7-mile range of significant distribution (RM 13.05 – 23.75).

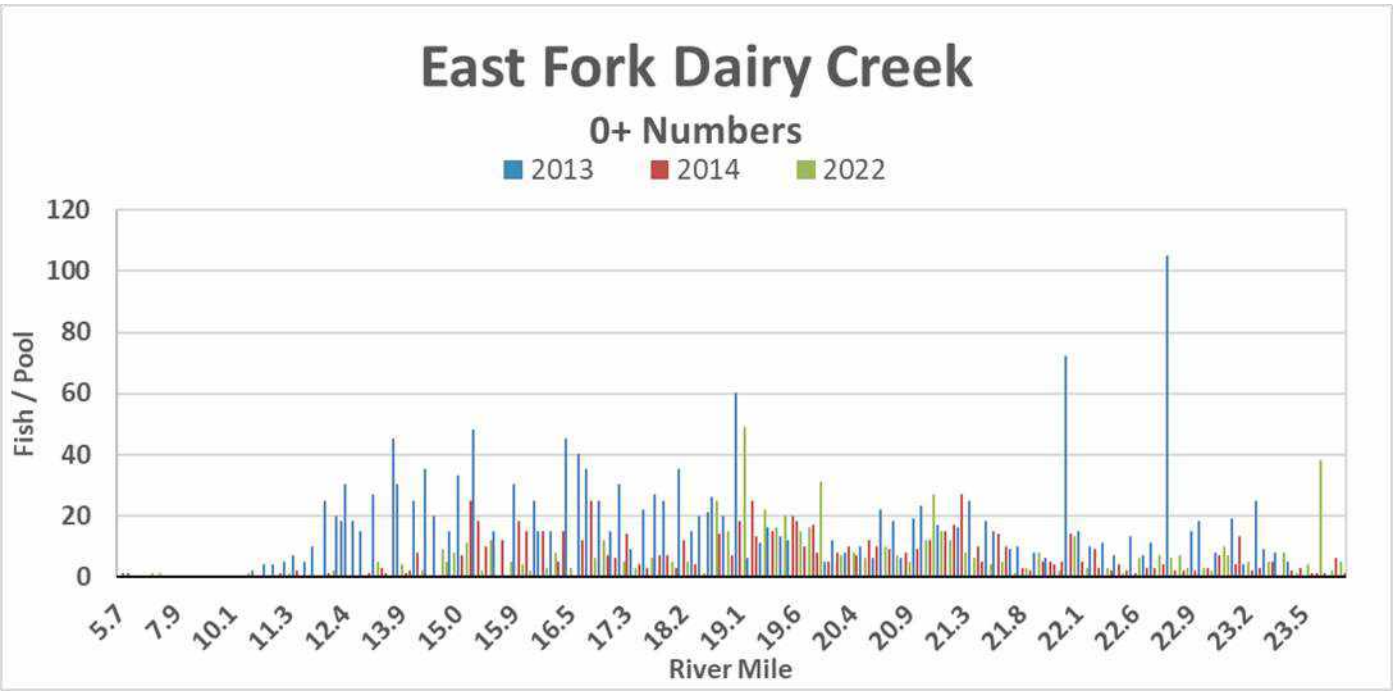


Figure 35: EF Dairy Creek 0+ Trout Numbers 2013, 2014, 2022

Table 28: EF Dairy Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat
2013	33,768	0.91	8,180	1,950	2,635
2014	25,140	0.60	3,595	2,265	2,680
2022	23,156	0.82	2,746	1,225	1,827

Minor Tributaries of East Fork Dairy Creek

Big Canyon

Big Canyon enters EF Dairy at RM 14.5. Coho were observed in low abundances in 2013 and 2022 extending for 0.3 miles where increased gradient and debris jams limit further upstream salmonid potential (Spawning and rearing). No coho were observed in 2014. The stream within the surveyed reach displays a mature coniferous riparian canopy, high wood complexity, shallow pools, and well sorted gravel. Big Canyon Creek is a cool water contribution providing a short reach of high-quality spawning habitat with limited pool surface area for summer rearing. A 1°C temperature differential was measured at the time of the inventory (Big Canyon 16°C, EF 17°C).

Murtaugh

Murtaugh Cr enters EF Dairy at RM 15.7. A 6ft bedrock falls with a shallow jump pool terminated both adult and juvenile migration access at RM 0.16. A short anchor reach extends for 300 ft with a wide floodplain, channel braiding, and low terrace heights. Murtaugh Creek did not appear to be an important cool water contribution due to similar temperature profiles measured at the time of the inventory.

Panther

Panther Creek enters EF Dairy Creek at RM 20.1. The survey extended 0.18 miles with no anadromous fish observed. Spawning and rearing potential is limited due to a high gradient (avg. 12%), confined channel with debris jams complicating passage, shallow pools, and lack of sorted spawning gravel. Panther Creek had high summer flows and was important cool water contribution with a 3.9°C temperature differential measured at the time of the inventory (Panther 12.4°C, EF 16.3°C).

Roundy

Roundy Creek enters EF Dairy at RM 20.87. The inventory extended 0.35 miles. Low abundances of coho were documented in 2013 and 2022. Spawning and rearing potential is limited due to a high gradient (avg. 12.4%), confined channel with high wood complexity complicating passage, and shallow pools. Roundy Creek had high summer flows and was important cool water contribution with a 2.3°C temperature differential measured at the time of the inventory (Roundy 12.7°C, EF 15.3°C).

Trib A

Trib A enters EF Dairy at RM 21.7. The inventory extended 0.2 miles. Low abundances of coho were documented in the first sample pool 2013 and 2022 below a 3ft sill log above a shallow jump pool functioning as a probable juvenile and adult barrier to passage. Spawning and rearing potential is limited due to confined channel with debris jams complicating passage, limited spawning gravel, and shallow pools. Trib A had low summer flows exhibiting a 0.8°C temperature differential measured at the time of the inventory (Trib A 15.4°C, EF 16.2°C).

Campbell Creek

Campbell Creek enters EF Dairy Creek at RM 21.1 through an undersized, rusted out, and undercut 2.5ft perched culvert. The culvert is a definitive juvenile barrier that was passed by adult coho in 2012 and 2021.The survey extended 1.23 miles in 2013, and 1.43 miles in 2014, and 1.11 miles in 2022 with anadromy extending to RM 0.95 in 2022 and RM 0.36 in 2013. No coho were observed in 2014. An unnamed tributary of Campbell Creek entering at RM 0.9 also exhibited anadromous potential extending for approximately 0.25 miles.

Shortly above the survey endpoint, further anadromous potential (spawning and rearing) was limited by canyon confinement, gradient increase, dominant substates of bedrock and boulder, and high wood complexity comprised of large legacy wood.

The stream habitat within the range of anadromy was characterized by moderate gradient (avg.3.07%), boulder and cobble dominated substates with limited gravel sorting, moderate wood complexity, well shaded riparian canopy, and channel meander confined by hillslope.

Campbell Creek had high summer flows and was a cool water contribution with a 0.8°C temperature differential measured at the time of the inventory (Campbell 15.3°C, EF 16.1°C).

Beaver occupation was documented in 2014 with three active dams. No beaver activity was observed in 2022.

Anchor Sites:

No anchor sites were observed. Inventoried stream habitats were hillslope confined.

Photo 30: Campbell Creek perched culvert

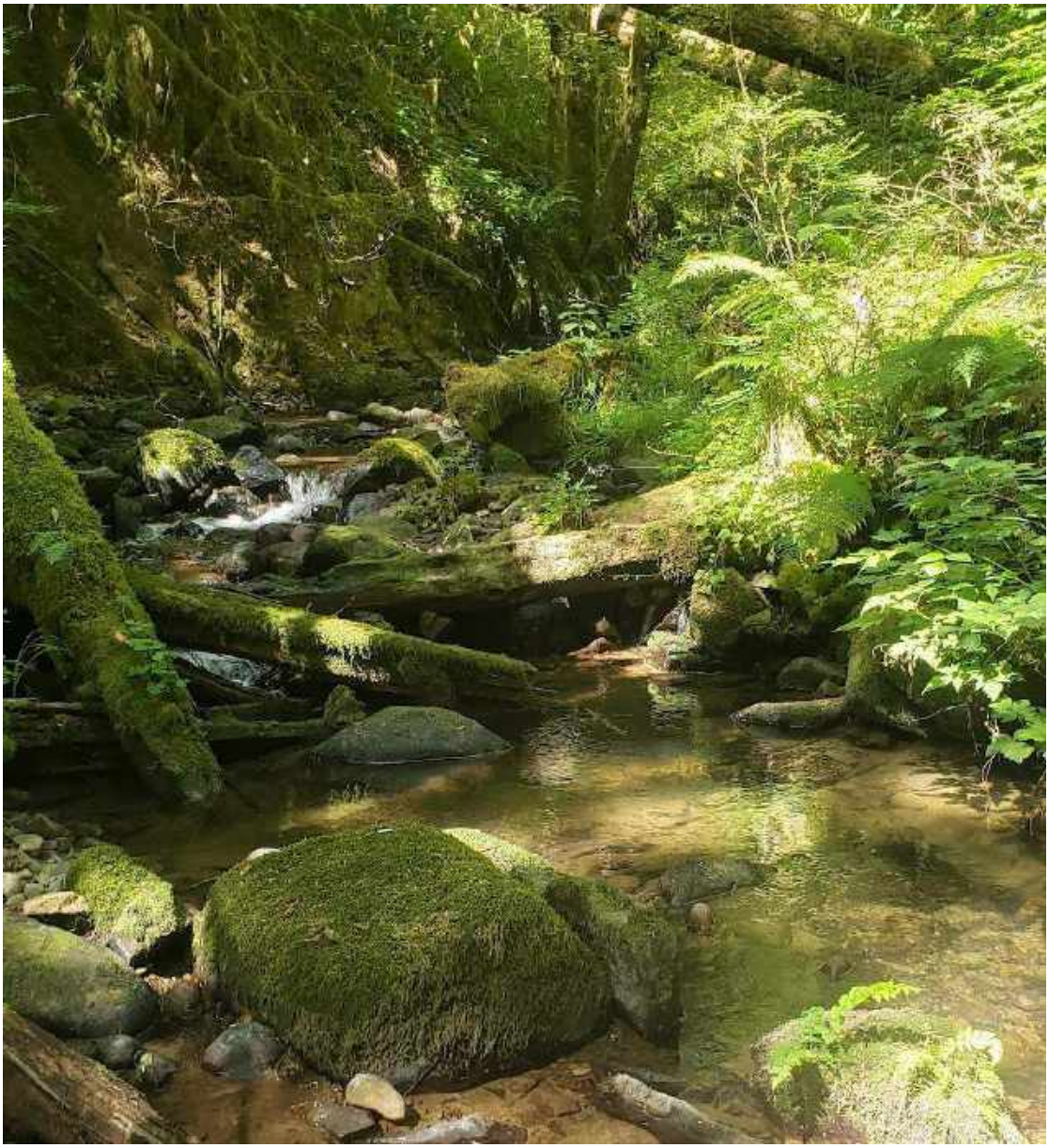


Photo 31: Campbell Creek

Coho

Coho abundance was low in both inventoried years with coho distribution (2013, 2022). In 2022, an average pool density of 0.6 fish/m² (745 fish/mile) was documented with a density peak of 1.23 fish/m² observed at RM 0.77. 2022. In 2013, an average pool density of 0.75 fish/m² was documented with a peak coho density of 2.4 fish/sqm observed 545 ft above the culvert above the EF Dairy confluence.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, estimated adult coho escapement (combined male and female) to Campbell Creek was 6 coho in 2021 and 2 coho in 2012. Estimated adult coho capacity based on spawning gravel availability was 0 — 2 coho. In 2021, access to high quality spawning gravel appeared to be functioning as a limiting factor for coho production.

Steelhead

Steelhead were not observed. Stream habitats in the inventory were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was similarly low in all inventoried years with an average density of 0.19 fish/m² (150 fish/mile) in 2013, 0.15 fish/m² (143 fish/mile) in 2014, and 0.24 fish/m² (140 fish/mile) in 2022.

0+ Trout

0+ trout abundance exhibited a 78.1% reduction from 2013 to 2022. Average densities in 2013 were 0.76 fish/m² compared to 0.24 fish/m² in 2014 and 0.48 fish/m² in 2022. The significantly higher abundances observed in 2013 may have been the result of a steelhead spawning event occurring in 2012, though no steelhead progeny were observed in 2014.

Table 29: Campbell Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat
2013	372	0.75	1,280	0	280
2014	0	0	415	0	225
2022	708	0.61	280	0	155

Denny Creek

Denny Creek enters EF Dairy Creek at RM 18.3 (just below the Dairy Creek bridge at the start of Fern Flat Rd). The survey extended 2.16 miles where a legacy old growth log jam is functioning as an ephemeral adult barrier to passage. Upstream of the barrier increased gradient (avg. 5.6%) and boulder dominated substrates limit further anadromous potential. Anadromous distribution extended to RM 0.9 in 2013, RM 1 in 2014, and RM 2.03 in 2022. The upper mile of stream habitat exhibited high wood complexity with legacy wood throughout the active channel creating ephemeral log jams that functioned as barriers to passage lower in the system in 2013 and 2014.

Stream habitats were characterized by moderate gradient (avg. 3%); increased wood complexity above RM 1 with large coniferous logs noted in the active stream channel; boulder and cobble dominated substate with gravel sorting associated with instream wood complexity; and channel meander largely confined by hillslope but with four anchor sites accounting for 29.6% of the inventoried habitat.

Denny Creek had high summer flows with low temperature profiles. A 1°C temperature differential was measured at the time of the inventory (Denny 14.5°C, EF 13.5°C). It's unusual for a tributary to exhibit higher temperature profiles than a larger mainstem. This is consistent with temperature data collected in 2014.Temperatures in 2014 and 2022 were both taken late in the season, in early September. Interestingly, two Denny Creek tributaries (at RM 1.1 and RM1.8) exhibited warmer temperature profiles than Denny Creek. Both tributaries exhibited substantial flows with temperature differentials of 3.9°C (Trib 18.4°C, Denny 14.5°C) and 3.1°C (Trib 16.4°C, Denny 13.3°C). Flow from one of the tributaries was surface spill from a nearby pond. Further investigation of these warm water contributions should be a high priority.

Anchor Sites:

Three anchor sites were observed.

Anchor Site #1 (RM 0.0 – 0.36) was moderately functional with limited spawning gravel and inadequate large wood complexity. Anchor Site #1 was contiguous with EF Dairy Anchor #4 covering a broad low floodplain.

Anchor Site #2 (RM 0.49 — 0.66) was low functioning with shallow pools, limited spawning gravel, and inadequate large wood complexity.

Anchor site #3 (RM 1.66 – 1.8) was high functioning with low terrace heights, high wood complexity, and mature coniferous riparian. This intact anchor along with the upper 0.6 miles of the survey was one of the only inventoried reaches of the Tualatin basin exhibiting unadulterated stream habitat function.

Photo 32: Denny Creek Anchor Site #3

Coho

In 2022, coho abundance was the highest of the inventoried years and extended twice as far upstream but remained moderate with an average pool density of 1.08 fish/m² expanding to 771 fish/mile. The dominant density peak of 2.94 fish/m² was observed at RM 0.31.

Average densities for the other inventoried years were 0.68 fish/m² (447 fish/mile) in 2013 and 1.34 fish/m² (78 fish/mile) in 2014. Density peaks for 2013 (2.69 fish/m²) and 2014 (6.2 fish/m²) were both observed in the lower 0.3 miles of habitat. These density profiles suggest the occurrence of upstream juvenile migration from EF Dairy. This is interesting given that Denny Creek exhibited a higher temperature profile at the time of the inventory, ruling out temperature dependent migration. It's possible that juveniles are utilizing Denny Creek for velocity refuge during high flows and remaining there for the summer.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, adult coho escapement (combined male and female) to Denny Creek was 4 coho in 2013, 8 coho in 2014, and 14 coho in 2022. Estimated adult coho capacity based on spawning

gravel availability was 12 — 36 coho. In all inventoried years, Denny Creek was functioning below its current spawning habitat capacity and limited by inadequate adult escapement.

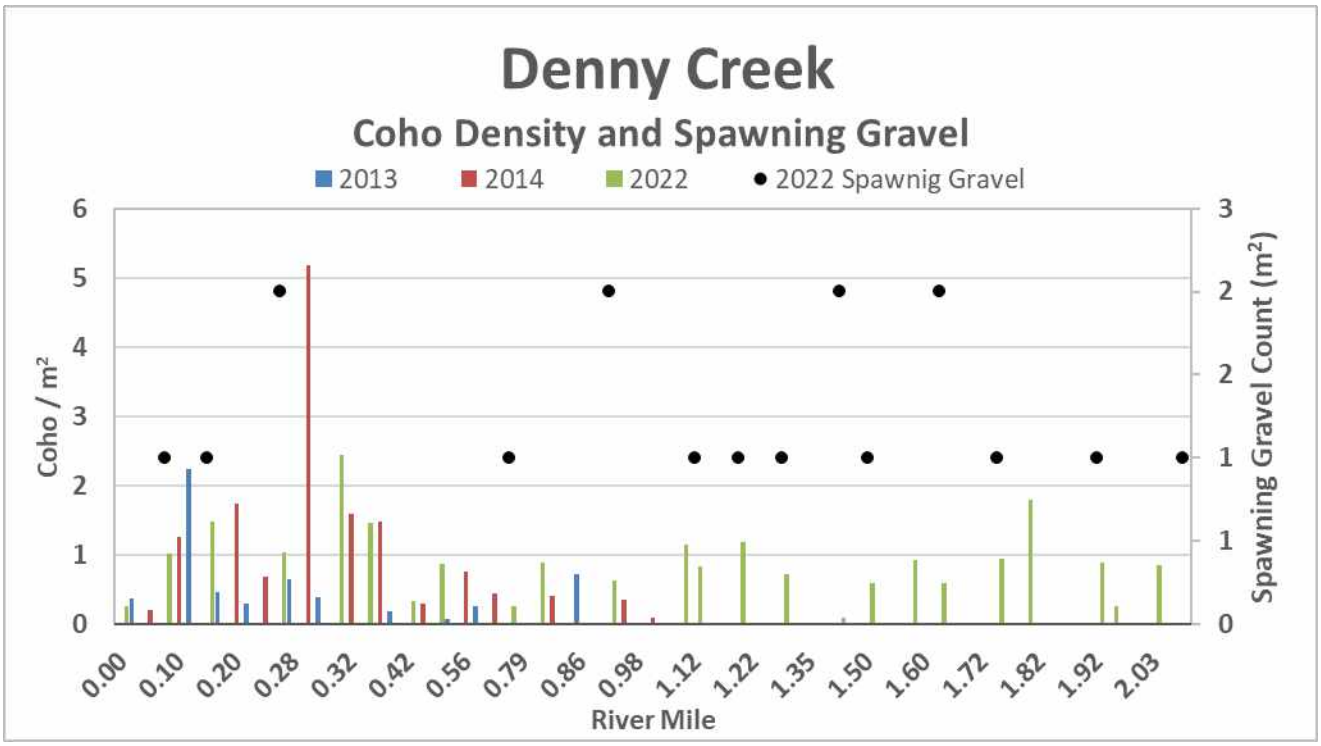


Figure 36: Denny Creek Densities 2013, 2014, 2022

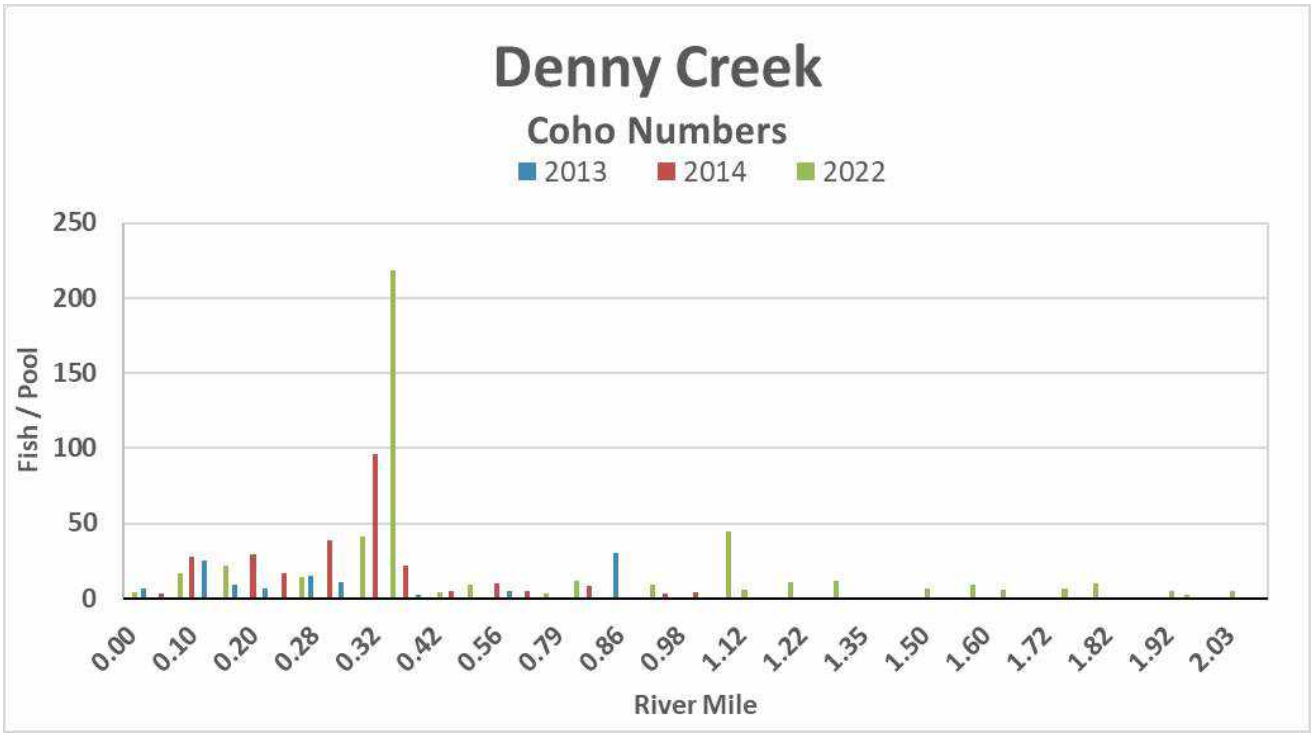


Figure 37: Denny Creek Numbers 2013, 2014, 2022

Steelhead

Steelhead abundance was low in all inventoried years with sporadic pool presence throughout the lower mile of inventoried habitat.

Cutthroat

Though cutthroat abundances remained low for all inventoried years, Denny Creek was one of the few inventoried reaches in 2022 that exhibited significant increases in cutthroat production. Average densities were 0.25 fish/m² (145 fish/mile) in 2013, 0.2 fish/m² (101 fish/mile) in 2014, and of 0.31 fish/m² (206 fish/mile) in 2022.

Cutthroat exhibited two separate density peaks representing differences in abundance related to proximity to EF dairy mainstem near the confluence and limited interspecies competition along with increased habitat quality in the upper reaches of anadromous access. The first spikes of 0.6 fish/m² in 2013, 0.3 fish/m² in 2014, and 0.4 fish/m² in 2022 around RM 0.25 is representative of upstream migration out of EF Dairy mainstem. The second spikes of 0.6 fish/m² in 2013, 0.7 fish/m², and 1.1 fish/m² in 2022 around RM 1.65 probably represents nearly full seeded habitats for more isolated components of the cutthroat population.

0+ Trout

0+ trout abundance was more than three times higher in 2013 than in 2014 and 2022. Density spikes of 1.55 fish/m² in 2013, 0.7 fish/m² in 2014, and 0.67 fish/m² in 2022 were all documented above the end of anadromy. Increased abundances observed in 2013 may have been the result of a winter steelhead spawning event occurring in the lower 1.2 miles of habitat, where the peak production was observed.

Table 30: Denny Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat
2013	402	0.68	1,205	5	285
2014	780	1.34	340		200
2022	1,566	1.08	390	25	445

Meadowbrook Creek

Meadowbrook Creek enters EF Dairy Creek at RM 15.8. The survey extended 0.87 miles upstream where divided flows, gradient increase, and lack of spawning gravel limited further anadromous spawning and rearing potential. Anadromous distribution extended to just below the survey endpoint. A small tributary at RM 0.83 provided a short reach of habitat with coho observed in one sample pool.

Stream habitat in the lower 0.25 miles of the survey was ditched, deeply incised, and brushed over with blackberry with high solar exposure. Upstream of RM 0.25 stream habitats were characterized by low gradient (avg.2%); well forested canopy of mature Doug fir and western red cedar; sinuous channel meander; high wood complexity; and bedrock, cobble, and gravel dominated substrates. Abundant well sorted spawning gravel was documented throughout lower 0.8 miles of the inventory. Meadowbrook Creek had low summer flows with a 1.6°C warmer temperature profile than EF Dairy mainstem at the time of the inventory (Meadowbrook 17.8°C, EF 16.2°C).

Meadowbrook Creek was not inventoried in 2013 or 2014 due to landowner access denials.

Anchor Sites:

No anchor sites were observed. Though sinuous channel meander was noted throughout the upper 0.5 miles of habitat terrace heights were 3ft or higher.

Photo 33: Meadowbrook Creek

Coho

Coho abundance was moderate with an average pool density of 1.91 fish/m² expanding to 1352 fish/mile. The dominant density peak of 3.4 fish/m² was observed at 0.52.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 10 adults (combined male and female) coho escaped to Neahkahnie Creek to spawn. Estimated adult coho capacity based on spawning gravel availability was 30 — 88 coho. In 2022 Meadowbrook Creek was functioning far below its current adult spawning capacity and limited by inadequate adult escapement.

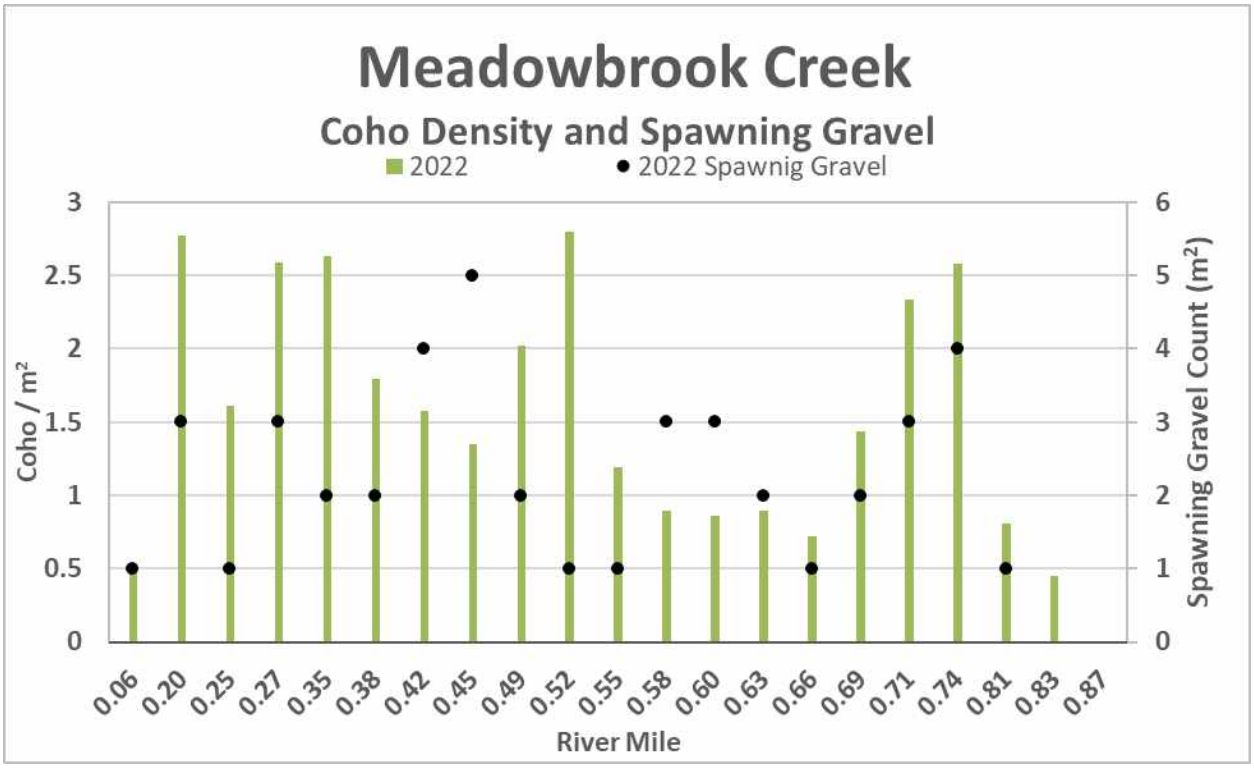


Figure 38: Meadowbrook Creek Densities 2022

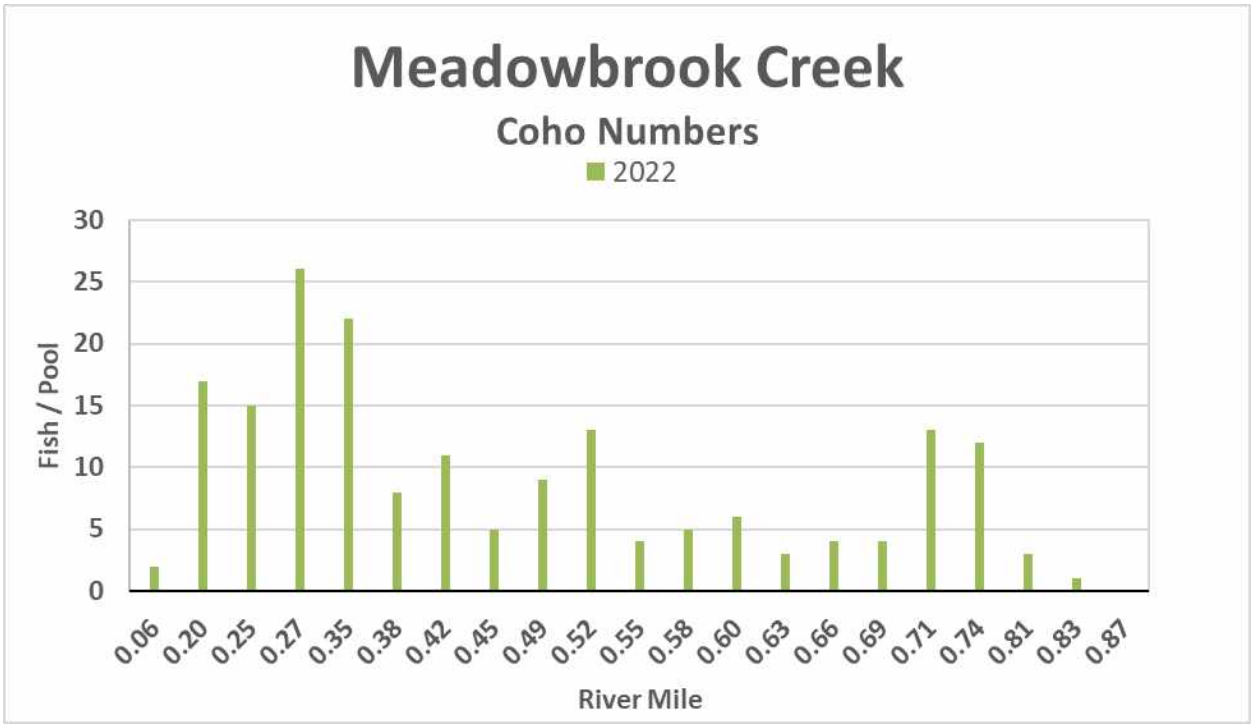


Figure 39: Meadowbrook Creek Numbers 2022

Steelhead

Steelhead were not observed. Stream habitats were more suited for coho occupation.

Cutthroat

Cutthroat abundance was low expanding to 81 fish/mile.

0+ Trout

0+ trout abundance was very low with pool presence observed only above the end of anadromy.

Table 31: Meadowbrook Creek – 2022 Expanded fish counts for all salmonid species

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat
2022	1,122	1.91	40		70

Plentywater Creek

Plentywater Creek enters EF Dairy Creek at RM 17. 34. The survey extended 0.56 miles to the end of anadromous distribution where gradient increase over boulder and cobble, a lack of sorted gravel, and shallow pools limited further anadromous potential (spawning and rearing).

Stream habitats were characterized by high gradient (avg.6.7%), cobble and boulder dominated substrate with limited gravel sorting, small shallow pools, moderate wood complexity, and well forested riparian canopy. Plentywater Creek had high summer flows with a slightly warmer temperature profile than EF Dairy (Plentywater 17.5 °C, EF Dairy 17.1 °C).

The construction of two alcoves in lower Plentywater Creek was part of an EF Dairy mainstem restoration project completed in 2019 The upper alcove, located about 350ft above the EF Dairy confluence, provided high quality summer rearing habitat with a pool surface area greater than any other pools observed throughout the inventoried reach. The highest pool count (132 coho) and second coho highest density (3.17 fish/m²) were documented in this alcove pool. This alcove pool alone accounted for 29% of the total coho population estimate for Plentywater Creek. The lower alcove pool was shallower with more sedimentation but still provided summer rearing habitat for juvenile coho. Both alcoves likely provide high quality winter velocity refuge for juvenile salmonids.

Anchor Sites:

No anchor sites were observed. Inventoried reach was hillslope confined.

Photo 34: Plentywater Creek alcove pool

Coho

Coho abundance estimates for 2013 and 2014 were low with sporadic pool presence. Coho abundance in 2022 was moderate with an average pool density of 1.4 fish/m² expanding to 894 fish/mile. The dominant density peak in 2022 of 3.7 fish/m² and in 2013 of 0.97 fish/m² was observed in the first sampled pool just upstream of the EF Dairy confluence. This elevated density just upstream from the EF Dairy confluence is evidence of upstream juvenile migration into Plentywater Creek. This behavior is interesting given that Plentywater Creek exhibited a higher temperature profile than EF Dairy, ruling out temperature dependent migration. It is possible that these coho entered Plentywater Creek earlier in the season in search of velocity refuge from the mainstem and remained through the summer. Other density peaks were observed below the juvenile barrier at the culvert (3 fish/m²) and in the upper alcove pond discussed above (3.17 fish/m²).

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 4 (combined male and female) coho escaped to Plentywater Creek to spawn in 2021. Estimated adult coho capacity based on spawning gravel availability was 2 — 6 coho. In 2021,

Plentywater Creek was functioning near its current habitat capacity and limited by inadequate adult escapement.

Steelhead

Steelhead were not observed. Stream habitats were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was similarly low for all three inventoried years with 2022 abundance expanding to 63 fish/mile.

0+ Trout

0+ trout abundance were low in all inventoried years but exhibited a 37% reduction from 2013 to 2022. Average densities in 2013 were 0.6 fish/m² compared to 0.3 fish/m² in 2014 and 0.36 fish/m² in 2022.

Table 32: Plentywater Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat
2013	6	0.45	135		40
2014	84	0.55	70		35
2022	456	1.4	85		35

Rock Creek

Rock Creek enters EF Dairy Creek at RM 19.2 (just above the Greener Rd crossing). The survey extended 0.94 miles. Anadromous distribution extended to RM 0.24 in 2013, 0.06 in 2014, and 0.47 in 2022.

Stream habitat was characterized by high gradient (avg. 9.5%), bedrock/boulder dominated substrate with unsorted gravel, and well forested riparian. 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, interactive floodplain, and increased gravel sorting.

Rock Creek had high volume summer flows and was an important cold-water contribution with a 1.6°C temperature differential measured at the time of the inventory (Rock 13.7°C, EF 15.3°C). We recommend investigating potential conservation measures that would protect and or enhance riparian buffers within Rock Creek for the maintenance of mainstem EF Dairy water quality parameters.

Anchor Sites:

No anchor sites were observed. Stream habitats were hillslope confined throughout inventoried reach.

Photo 35: Rock Creek sill log

Coho

Coho abundance was low in all three inventoried years. The dominant density peaks for 2013 of 2 fish/m² and for 2014 of 0.65 fish/m² were observed in the first sample pool. The 2022 density peak of 0.92 fish/m was documented at ² RM 0.21.

Spawning Gravel and Adult Escapement:

It appears that coho abundances documented in all inventoried years were the result of upstream temperature dependent migration from EF Dairy mainstem. It is unlikely that adult coho spawned in Rock Creek in 2012, 2013, or 2021.No adequate spawning gravel was observed within the range of anadromous distribution.

Steelhead

Steelhead were not observed. Stream habitats lacked suitable spawning gravel but were otherwise suitable for steelhead rearing.

Cutthroat

Cutthroat abundance was moderate in 2013 and 2022 and low in 2014 with average densities of 0.35 fish/m² (170 fish/mile) in 2013, 0.17 fish/m² (122 fish/mile) in 2014, and 0.42 fish/m² (223 fish/mile) in 2022. Density peaks for all three years were observed above the end of anadromous distribution. Similar to trends observed in Denny Creek, Rock Creek exhibited the highest cutthroat and lowest 0+ trout production in 2022, while 2013 exhibited the highest 0+ trout production. This trend was also observed in the upper tributaries of the Gales Creek subbasin.

0+ Trout

0+ trout abundance varied from varied from moderately high in 2013 to low in 2022 with average densities of 0.98 fish/m² (558 fish/mile) in 2013, 0.43 fish/m² (340 fish/mile) in 2014, and 0.48 fish/m² (207) fish/mile in 2022.

Table 33: Rock Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Steelhead	Cutthroat
2013	210	1.19	525	0	160
2014	18	0.39	320	0	110
2022	198	0.59	195	0	210

West Fork Dairy Creek Subbasin

The WF Dairy Subbasin contained 24 miles (mainstem and tributaries combined) of stream habitat with significant anadromous potential that was inventoried in 2022. The WF Dairy subbasin was previously surveyed in 2013. No steelhead parr were observed in either of the inventoried years.

Within this palmate drainage eight tributaries of WF Dairy were sampled in 2022. The lower 4.1 miles of WF Dairy mainstem (Garrigus - Mendenhall) and several additional tributaries sampled in 2013 were not included in 2022 due to low salmonid usage and limited anadromous potential (spawning and rearing).

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 its tributaries displayed evidence of heavy impacts to riparian corridors, water quality, and stream habitat function as a result of the human footprint. 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 lateral channel migration; silt deposition burying spawning gravels; infestation of invasive species; and refuse commonly deposited in the active stream channel.

Table 34: West Fork Dairy Creek Subbasin 2013 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Cut	%
WF Dairy	2,430	18.9	1,205	25.7	375	25.1
Burgholzer	306	2.4	470	10.0	115	7.7
Paisley	546	4.2	200	4.3	75	5.0
Cummings	150	1.2	390	8.3	50	3.3
Garrigus	2,682	20.8	240	5.1	150	10.0
Mendenhall	2,802	21.7	995	21.2	395	26.4
Buxton	24		115	2.4	60	4.0
Sadd						
Trib A WF	388	3.0	295	6.3	60	4.0
Trib A1 WF						
Whitcher	2,038	15.8	525	11.2	125	8.4
Williams	1,519	11.8	260	5.5	90	6.0
Subbasin Total	**12,885**		**4,695**		**1,495**	

Table 35: West Fork Dairy Creek Subbasin 2022 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Cut	%
WF Dairy	2,616	28.6	46	6.5	142	15.0
Burgholzer	1,148	12.6	55	7.8	115	12.2
Cummings	24		80	11.3	55	5.8
Garrigus	1,534	16.8	115	16.2	80	8.5
Mendenhall	941	10.5	235	33.2	307	32.5
Buxton	20					
Paisley (Burgholzer)	510	5.6	5		55	5.8
Sadd (Cedar Canyon)			17	2.4	5	
Trib A	1,074	11.8	40	5.6	90	9.5
Trib A1	90	1	50	7.1	30	3.2
Whitcher	486	5.3	40	5.6	35	3.7
Williams	696	7.6	25	3.5	32	3.4
Subbasin Total	**9,139**		**708**		**946**	

West Fork Dairy Creek

The WF Dairy inventory began at RM 18.4 (confluence of Mendenhall Creek). Downstream of the 2022 start point limited spawning and rearing potential exists due to low gradient (0.3% average); silty alluvial deposits lacking spawning gravel; and high summer temperature profiles. These habitat conditions, along with high tannins limiting visibility, rendered inventory efforts further downstream impertinent. Anadromous distribution ended in both years around RM 24.6 (just below Stub Stewart State Park) where divided flows, step hillslope confinement, and increased gradient limit anadromous spawning and rearing potential further upstream.

From Mendanhall Creek (RM 18.4) to Burgholzer Creek (RM 19.2) habitat conditions that support salmonid production begin to improve. 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 can support the life history needs of salmonids from incubation to summer and winter rearing habitat. This transition is accompanied by a gradient increase (avg.1.25%), gravel sorting in pool tailouts, higher pool to riffle ratio, and further upstream, a land use transition from cropland/pastureland to predominantly forest land.

Photo 36: WF Dairy Creek upstream of Mendenhall

The dominant salmonid production zone was observed from RM 20.6 – RM 24.6. This 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 highest priority reach and the most likely zone to experience a response from restoration actions extended from RM 21.1 (confluence of Williams Cr) to RM 24.5 (upstream end of Anchor Site #1). This stream segment exhibited the highest mainstem rearing densities for coho and cutthroat, overlapped the only inventoried anchor site, and likely contained the bulk of the spawning events. Low wood complexity was noted throughout the WF Dairy inventory.

Landowner access denials prevented a contiguous inventory and complete assay of the upper mainstem which resulted in the underestimation of abundance in some of the habitat exhibiting the highest potential. In particular, the section of stream habitat from the confluence of Williams Creek (RM 21.1) to Trib A (RM 23.9) exhibited high potential. Field notes for this reach described high quality steam habitat with well sorted gravel, wide floodplain with low terrace, sinuous channel meander, and an average gradient of 1.25%.

10 beaver dams were documented in 2013 and five beaver dams were documented in 2022. In 2022, beaver augmented pools provided an estimated 3.7% of total surface area while constituting 2.1% of the total pool count. This is not a substantial increase in rearing capacity

compared to other inventoried systems with beaver occupation. Field notes indicated that dams were small with minimal recent maintenance. In 2013, surveyors noted fresh beaver activity with more substantial dams.

Anchor Sites:

One moderately functioning anchor site was documented extending from RM 23.3 – 23.6. Field notes indicated that inadequate large wood complexity was reducing function. Additional anchor site habitats were likely located in the reach between Williams Creek (RM 21.1) and Trib A (RM 23.9). As noted above, landowner access denial restricted full inventory of this reach.

Coho

Coho abundance was moderate in both inventoried years with average pool densities in 2013 of 0.45 fish/m² and in 2022 of 0.49 fish/m². In both inventoried years, overlapping bimodal distribution profiles exhibited density peaks around RM 23.25 of 1.58 fish/m² (2013) and 1.51 fish/m² (2022); and at RM 24 with 1.7 fish/m² (2013) and 1.35 fish/m² (2022). Due to the lack of contiguous data, fish/mile expansions would inaccurately portray production.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to WF Dairy Creek for the two inventoried years was estimated at 24 coho for 2012 and 26 coho for 2021. Estimated adult coho capacity based on spawning gravel availability was 27 – 82 coho. In both inventoried years, WF Dairy Creek was functioning below its current spawning habitat capacity and limited by inadequate adult escapement.

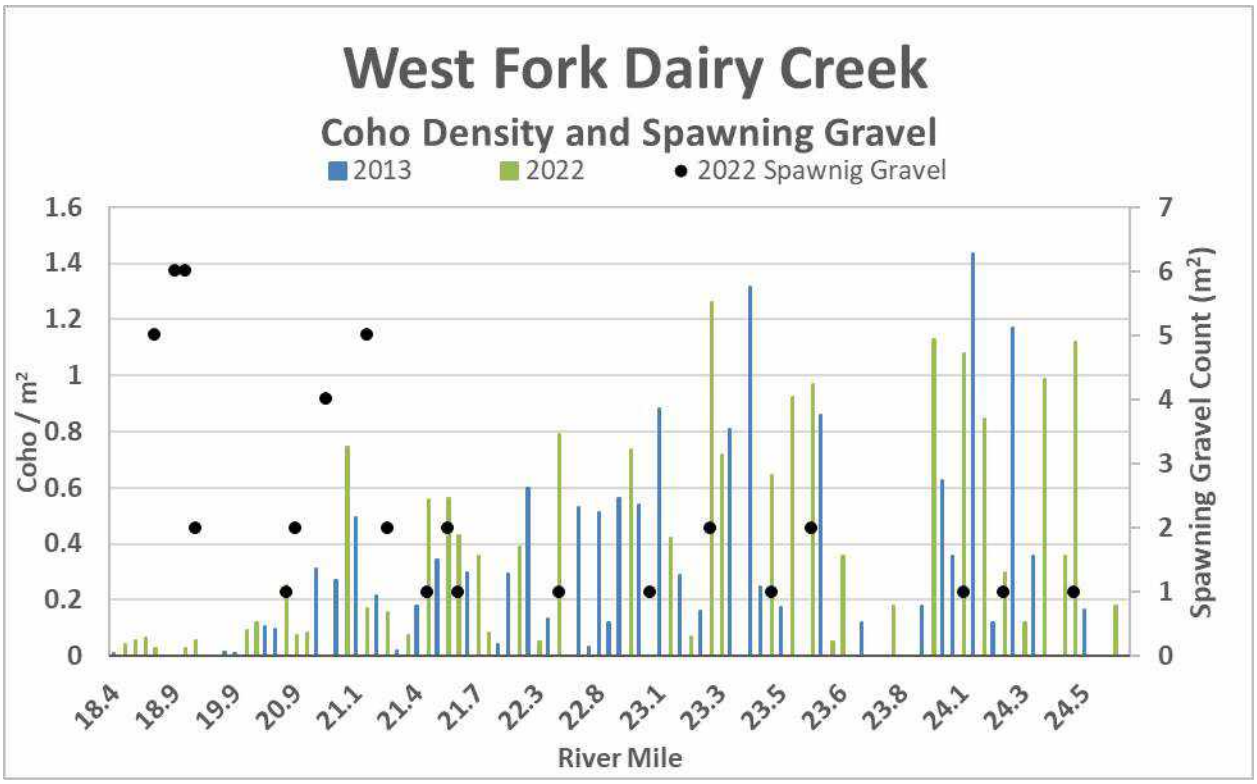


Figure 40: WF Dairy Creek Coho Densities 2013, 2022

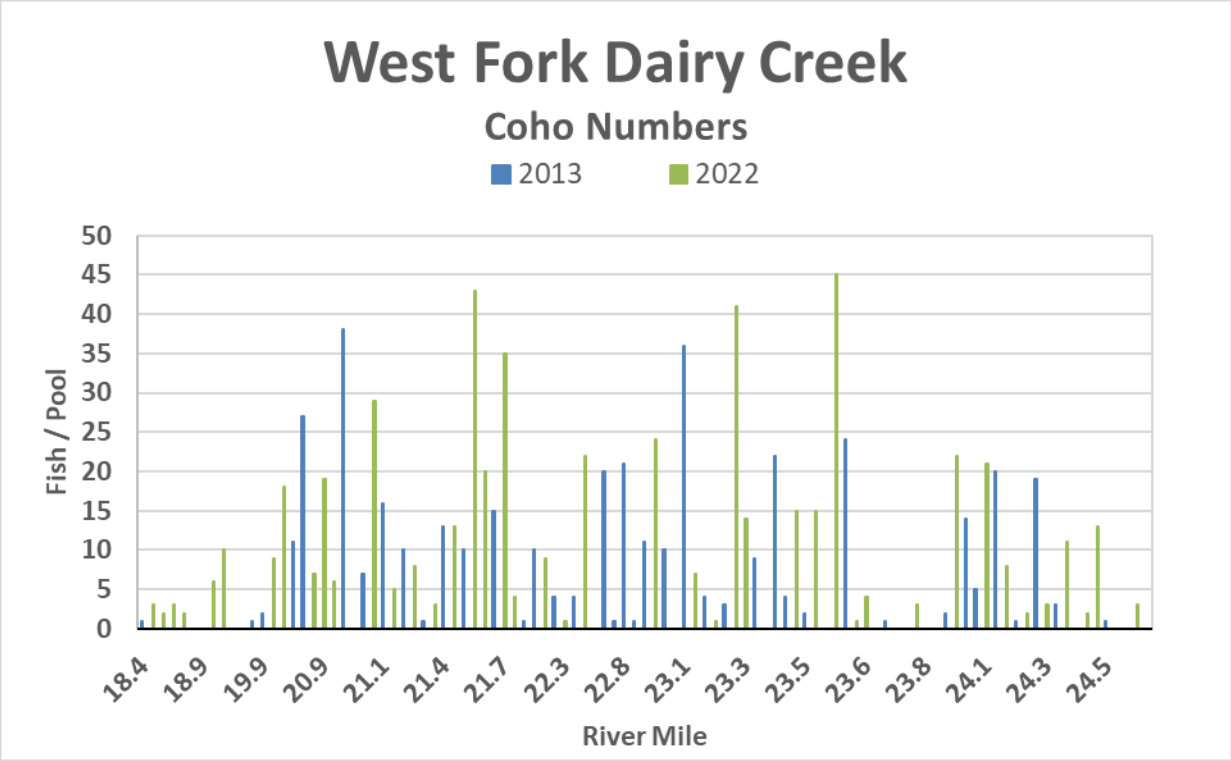


Figure 41: WF Dairy Creek Numbers 2013, 2022

Steelhead

Steelhead were not observed. Stream habitats in the upper half of the inventory were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance exhibited a 62.1% reduction in abundance from 2013 to 2022. There was no obvious reason for this reduction. Similar reductions in abundance were observed in some WF tributaries, EF Dairy mainstem, and lower Gales Creek tributaries.

0+ Trout

0+ trout abundance was low in 2013 and extremely low in 2022 with sporadic pool presence. The absence of the 0+-age class trout in 2022 suggests a substantial reduction in spawning potential for cutthroat in the lower mainstem. This also suggests that tributary habitats play an important role for native cutthroat for both spawning and rearing.

Table 36: WF Dairy Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	2,430	0.45	1,205	375
2022	2,616	0.49	46	142

Minor Tributaries of West Fork Dairy Creek

Sadd Creek

Sadd Creek is a tributary to Cedar Canyon Creek. Cedar Canyon Creek enters WF Dairy mainstem several miles below the start point of WF Dairy Creek outside the town of Banks.

Anadromous fish distribution was not observed in Sadd Creek in 2013 or 2022. Sadd Creek exhibited viable anadromous habitat throughout the first mile of the inventory with stream gradients averaging 2% and abundant beaver activity in 2013 (13 dams) observed in the first ½ mile (no beaver dams in 2022). Cutthroat and 0+ trout abundance was low in both inventoried years.

No adult barriers to passage were observed in the lower mile of stream habitat. 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. Above RM 1.0 stream gradients increase over scoured bedrock limiting further anadromous potential. This suggests that replacement of the perched culverts is a low priority until a comprehensive strategy can be formulated for restoring the degraded stream habitat.

Burgholzer Creek

Burgholzer Creek enters WF Dairy Creek at RM 19.24 (at the Highway 26 crossing west of the Vernonia Highway). The survey extended 3.02 miles where channel confinement, gradient increase (6.75%), and boulder/cobble dominated substrate with a lack of sorted gravel limited additional anadromous potential upstream. Anadromous distribution extended to RM 2.76 miles with no definitive adult barriers to passage observed. The inventory included Paisley Creek, the only tributary of Burgholzer Creek exhibiting anadromous potential.

Stream habitats were characterized by low gradient (avg. 0.4% transitioning to avg. 2.4%); sinuous cannel meander; gravel and silt dominated substrate transitioning to cobble and gravel; wide floodplain with deeply incised banks in the lower 0.75 miles transitioning to low terraces; and high solar exposure with thin riparian canopy. 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.

Burlgholzer Creek had medium summer flows and was a cool water contribution with a 1.9°C temperature differential measured at the time of the inventory (Burlgholzer 16°C, WF 17.9°C).

Landowner access denial in 2013 restricted inventory of the most productive habitat (morphologically) which resulted in a very limited assay of fish distribution and abundance. In 2022, access was granted, and a full inventory was conducted. Due to this inconsistency, year to year comparisons of fish abundance would be of little value.

One beaver dam was documented in both 2013 and 2022. In 2022, the beaver pool was not providing any additional surface area of rearing habitat compared to non-beaver pools in the reach.

Anchor Sites:

2 anchor sites were observed.

Anchor Site #1, extending from RM 1.01 — 1.15 was moderately functioning due to inadequate large wood complexity.

Anchor Site 2, extending from RM 1.40 — 2.15 was low functioning due to lack of spawning gravel and inadequate large wood complexity.

Photo 37: Upper Burgholzer Creek

Coho

Coho abundance was low with an average pool density of 0.33 fish/m² expanding to 465 fish/mile. The dominant peak density of 0.93 fish/m² was observed at RM 1.53 in Anchor Site #2.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho mode, 12 adult (combined male and female) coho escaped to Burlgholzer Creek to spawn. Estimated adult coho capacity based on spawning gravel availability was 38 — 116 coho. In 2022 Burgholzer Creek was functioning far below its current spawning habitat capacity and limited by inadequate adult escapement.

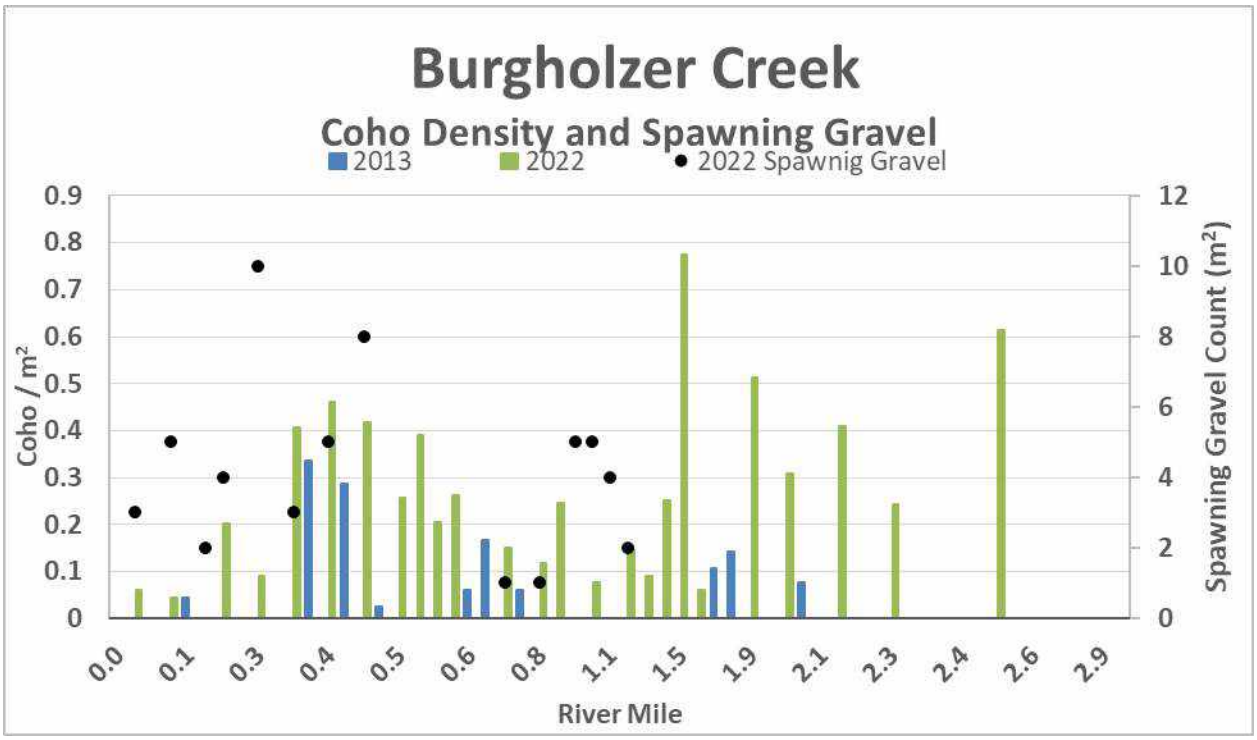


Figure 42: Burgholzer Creek Densities 2013, 2022

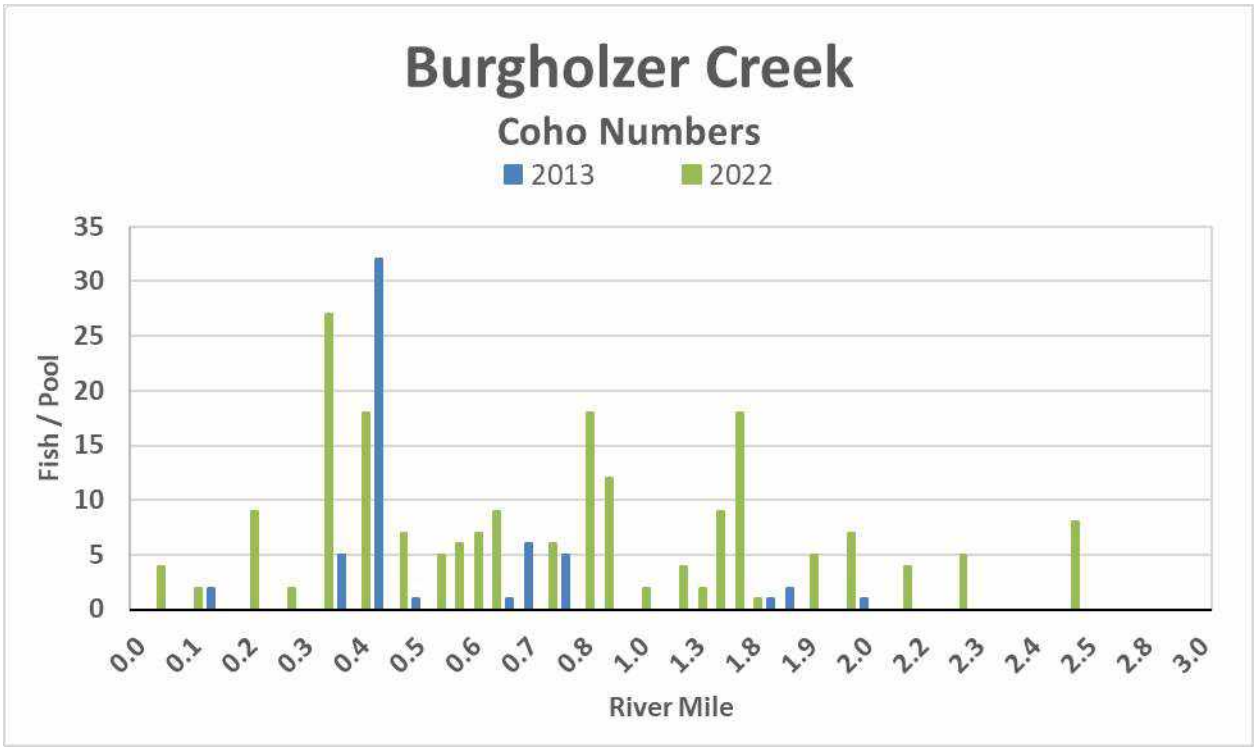


Figure 43: Burgholzer Creek Numbers 2013, 2022

Steelhead

Steelhead were not observed. Stream habitats in the upper end of the inventoried reach were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was low with intermittent pool presence at an average density of 0.07 fish/m². Abundance expanded to 38 fish/mile.

0+ Trout

0+ trout abundance was extremely low with an average density of 0.16 fish/m². Abundance expanded to 55 fish/mile throughout the range of significant distribution (RM 2.03 – 3.02).

Table 37: Burgholzer Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	306	0.16	470	115
2022	1,140	0.33	55	115

Paisley Creek (Tributary to Burlgholzer Creek)

Paisley Creek enters Burgholzer Creek at RM 0.5. The inventory extended 1.17 miles where increased gradient and lack of spawning gravel limits further anadromous potential upstream. Anadromous distribution extended to a failed culvert at RM 0.89. A series of three failed culverts were documented in this upper reach.

Stream habitats were characterized by low gradient (avg. 2.3%); cobble and gravel dominated substrates; wide floodplain with 2 – 3 ft terraces; and high solar exposure with thick Himalayan blackberry and reed canary grass in the lower 0.25 miles transitioning to a forested canopy.

Paisley Creek had low summer flows and was a cool water contribution with a 0.9°C temperature differential measured at the time of the inventory (Paisley 15.9°C, Burlgholzer 16.8°C).

Anchor Sites

3 anchor sites were observed.

Anchor Site #1, extending from RM 0.26 — 0.38 was moderately functioning due to inadequate large wood complexity.

Anchor Site #2, extending from RM 0.53 — 0.59 was low functioning due to lack of spawning gravel and inadequate large wood complexity.

Anchor Site #3, extending from RM 0.81 — 0.87 was low functioning due to lack of spawning gravel and inadequate large wood complexity.

Photo: 38 Paisley Creek

Coho

Coho abundance in both inventoried years was similarly moderate with an average pool densities of 0.68 fish/m² expanding to 563 fish/mile (2013) and 0.6 fish/m² expanding to 510 fish/mile (2022).

Coho density spikes in both years were observed just upstream of the confluence with Burgholzer Creek suggesting an upstream temperature dependent migration. The highest gravel estimates were also in that zone. The dominant density peaks were 2.26 fish/m² at RM 0.06 (2013) and 1.6 fish/m² at RM 0.05 (2022).

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 4 adult (combined male and female) coho escaped to Paisley Creek to spawn in both 2013 and 2022. Estimated adult coho capacity based on spawning gravel availability was 14 — 44 coho. In 2022 Paisley Creek was functioning far below its current spawning habitat capacity and limited by inadequate adult escapement.

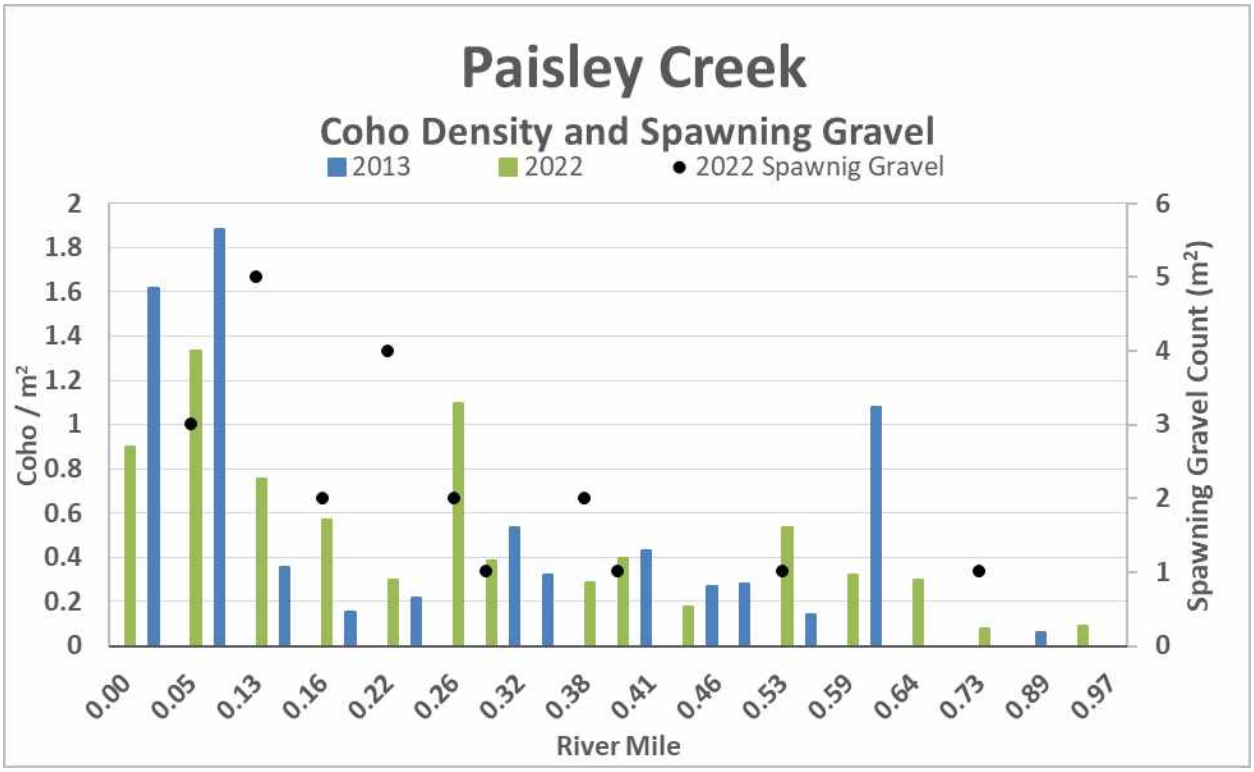


Figure 44: Paisley Creek Coho Densities 2013, 2022

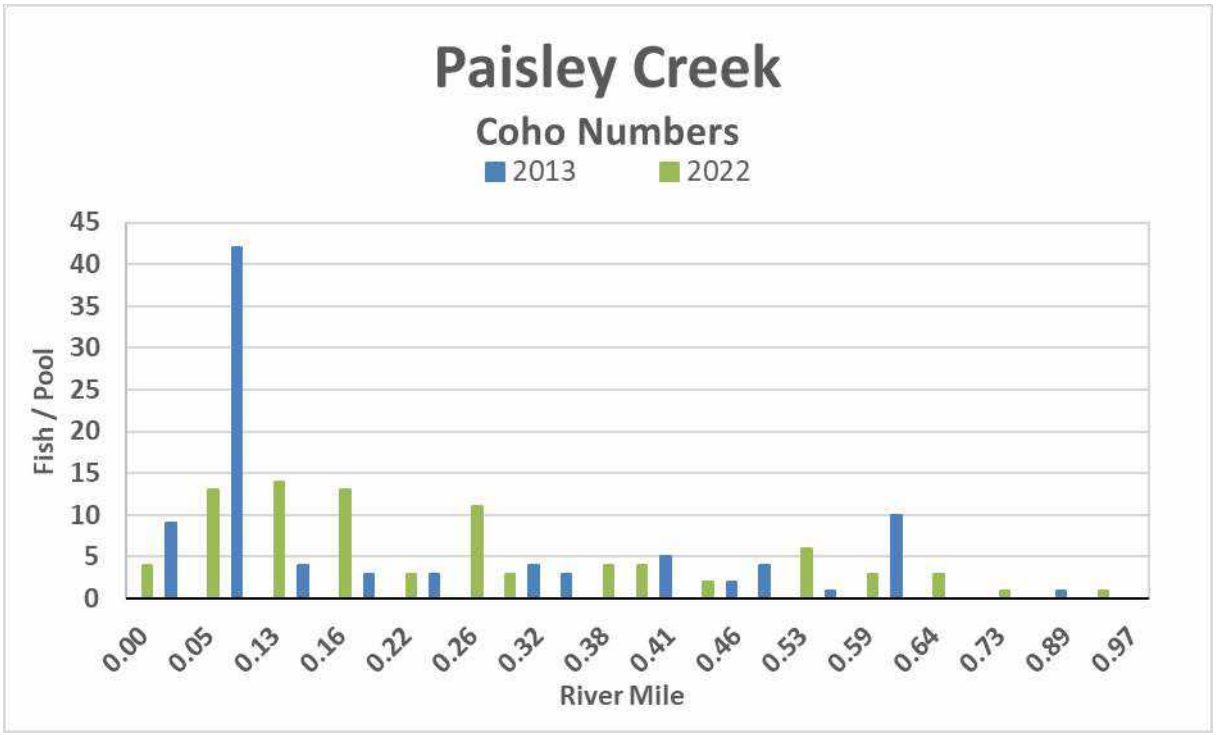


Figure 45: Paisley Creek Coho Numbers 2013, 2022

Steelhead

Steelhead were not observed. Stream habitats were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was low in both inventoried years with intermittent pool presence. Abundance expanded to 73 fish/mile in 2013 and 47.0 fish/mile in 2022.

0+ Trout

0+ trout abundance was low in 2013 expanding to 194 fish/mile. 0+ trout estimates in 2022 exhibited a 97.5% decrease in abundance. This is consistent with trends observed throughout the Tualatin basin in many tributaries as well as larger mainstem habitats.

Table 38: Paisley Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	546	0.68	200	75
2022	510	0.60	5	55

Cummings Creek

Cummings Creek enters WF Dairy Creek at RM 22.2. The inventory extended 0.7 miles where gradient increase, confined canyon, subsurface flows, and lack of spawning gravel limited further anadromous potential upstream. Anadromous distribution extended 0.6 miles.

Stream habitats were characterized by high gradient, channel incision, shallow pools, and cobble and mudstone dominated substrate.

Cummings Creek had medium flows exhibiting a cool water contribution with a 1.4°C temperature differential measured at the time of the inventory (Cummings 16.2°C, WF 17.6°C). Subsurface confluence through rootward likely complicates upstream juvenile migration from WF Dairy in Cummings Creek during low summer flows.

Anchor Sites:

No anchor sites were observed. Stream habitats were incised, or hillslope confined throughout the inventoried reach.

Coho

Coho abundance was low in 2013 with an average pool density of 0.78 fish/m² expanding to 467 fish/mile. The 2013 dominant density peak of 2.69 fish/m² was observed at RM 0.23. Coho abundance in 2022 was 86.3% lower than 2013 with sporadic pool presence. Coho distribution in 2022 was likely the result of upstream juvenile migration from WF Dairy or one spawning event with poor egg to fry survival.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 2 adult (combined male and female) coho escaped to Cummings Creek to spawn in 2012. No spawning events likely occurred in 2022. No spawning gravel was documented in Cummings Creek. In both 2013 and 2021, lack of high-quality spawning gravel was functioning as the primary limiting factor to coho production in Cummings Creek.

Steelhead

Steelhead were not observed. Stream habitats were not suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was similarly low in both inventoried years with intermittent pool presence expanding to 74 fish/mile in 2013 and 72 fish/mile in 2022.

0+ Trout

0+ trout abundance was high in 2013 with an average density of 1.05 fish/m² expanding to 582 fish/mile. The peak density of 2.91 0.24 fish/m was observed below a juvenile barrier at RM 0.61, in a reach where subsurface flows were concentrating abundance into pool habitats.

0+ trout estimates in 2022 exhibited a 79.5% decrease in abundance with intermittent pool presence at 0.24 fish/m². This is consistent with trends observed throughout the Tualatin basin in many tributaries as well as larger mainstem habitats.

Table 39: Cummings Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	150	0.78	390	50
2022	24	0.17	80	55

Garrigus Creek

Garrigus Creek enters WF Dairy Creek at RM (about four miles below the 2022 mainstem start point). The survey extended 2.38 miles with anadromous distribution extending to RM1.72 in 2013 and RM 2.22. In 2013, coho distribution terminated in a series of back-to-back 3ft – 4ft beaver dams. No barrier to passage was noted in 2022.

Stream habitats were characterized by low gradient (avg. 2.8%); mixed substrates of bedrock, small boulder, cobble, and gravel; deeply incised banks in lower 0.5 miles transitioning to low terraces with wide floodplain; high solar exposure in lower 0.5 miles transitioning to well forested riparian; and moderate channel complexity.

Garrigus Creek had medium summer flows exhibiting a cool water contribution with a 2°C temperature differential measured at the time of the inventory (Garrigus 17.6°C, WF 19.6°C). A 3ft Beaver dam just upstream from the WF Dairy confluence terminated temperature dependent migrations from WF Dairy.

A strong and vibrant beaver presence was note in 2013 with 22 active beaver dams. Most of the dams observed were 3 – 4ft tall and freshly maintained. Beaver occupation was observed in two locations, the lower 0.5 miles and a 0.3-mile reach from RM 1.55 – RM 1.85. In the upper reach beaver were colonizing legacy flats with 14 active dams. Beaver occupation extended above the end of the inventory.

In 2022, only four dams were documented, all in the lower 0.4 miles of the inventory. Field notes indicated that the upper legacy flats were drained with 3ft channel incision and devoid of beaver sign. The dams were 1ft – 3ft in height with three of the four dams being freshly maintained. The four beaver dams impounded large pools responsible for an estimated 19.8% of the surface area of pool habitats within the inventoried reach while representing only 2.9% of the total number of pools.

Photo 39: Garrigus Creek 2022, unmaintained beaver dam just above confluence with WF Dairy

Anchor Sites:

Four anchor sites were observed.

Anchor Site #1, extending from RM 0.88 – 0.94 was moderately functioning due to inadequate large wood complexity.

Anchor Site #2, extending from 0.99 – 1.1 and Anchor Site #3, extending from RM 1.45 — 1.54 were moderately functioning due to lack of sorted gravel.

Anchor Site #4 extending from RM 1.93 — 2 was low functioning due to lack of sorted gravel with terrace heights and floodplain width on borderline of qualification.

Photo: 40 Garrigus Creek

Coho

Coho abundance was high in 2013 and moderate in 2022 with average pool densities of 0.58 fish/m² (1,532 fish/mile) in 2013 and 0.63 fish/m² (691 fish/mile). The 2022 dominant density peak of 1.67 fish/m² was observed at RM 0.6 correlating with a reach containing high abundance of spawning gravel. In 2013, two density peaks of 1.2 fish/m² were observed, one in the same reach as 2022 at RM 0.7 and the other in a beaver pool at RM 1.72. The higher densities paired with lower abundances observed in 2022 are likely the result of the reduction in pool surface area due to the loss of beaver pool habitats.

Garrigus Creek was a top coho producer when compared to other streams of the WF Dairy subbasin. It contained 21% of all coho documented in the WF Dairy Cr subbasin in 2013 and 16.8% in 2022 while accounting for 9.2% of the inventoried linear miles.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female adult coho escapement to Garrigus Creek for the two inventoried years was estimated at 25 coho for 2013 and 14 coho for 2022. Estimated adult

coho capacity based on spawning gravel availability was 25 — 76 coho. In both 2013 and 2022, Garrigus Creek was functioning below its current spawning habitat capacity and limited by inadequate adult escapement.

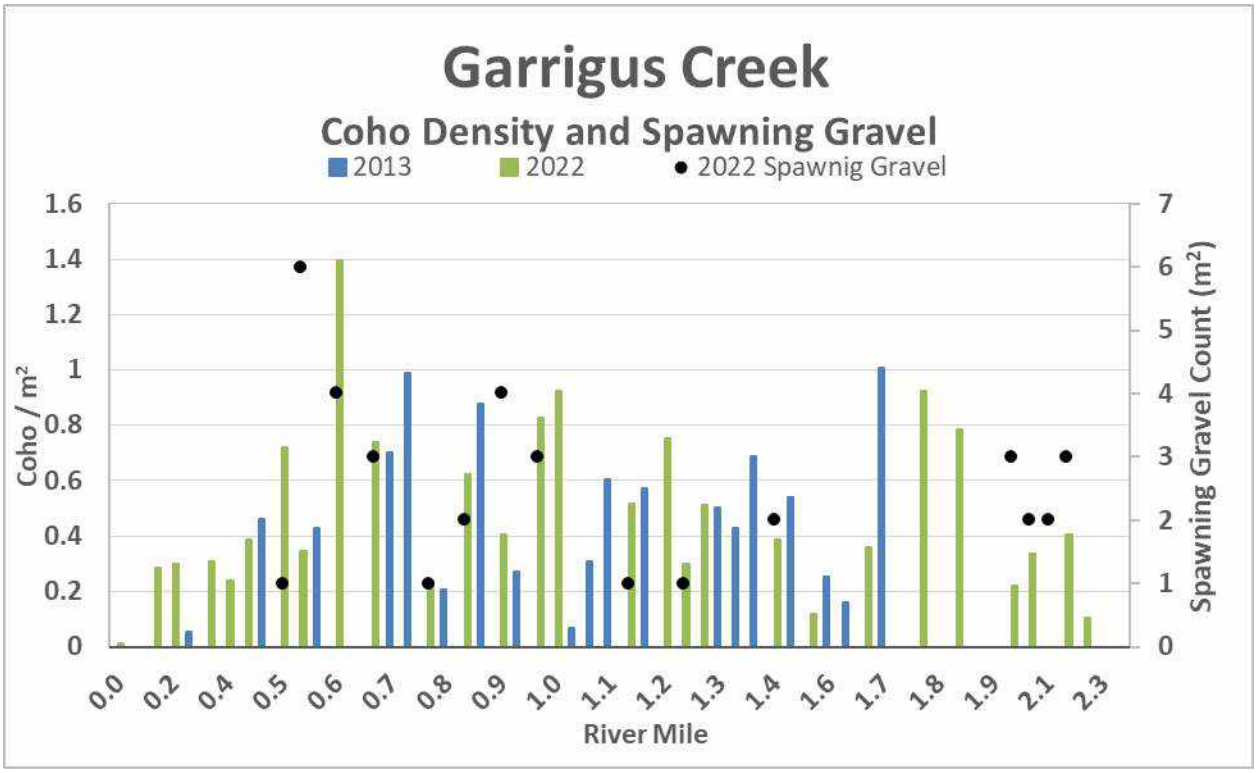


Figure 46: Garrigus Creek Coho Densities 2013, 2022

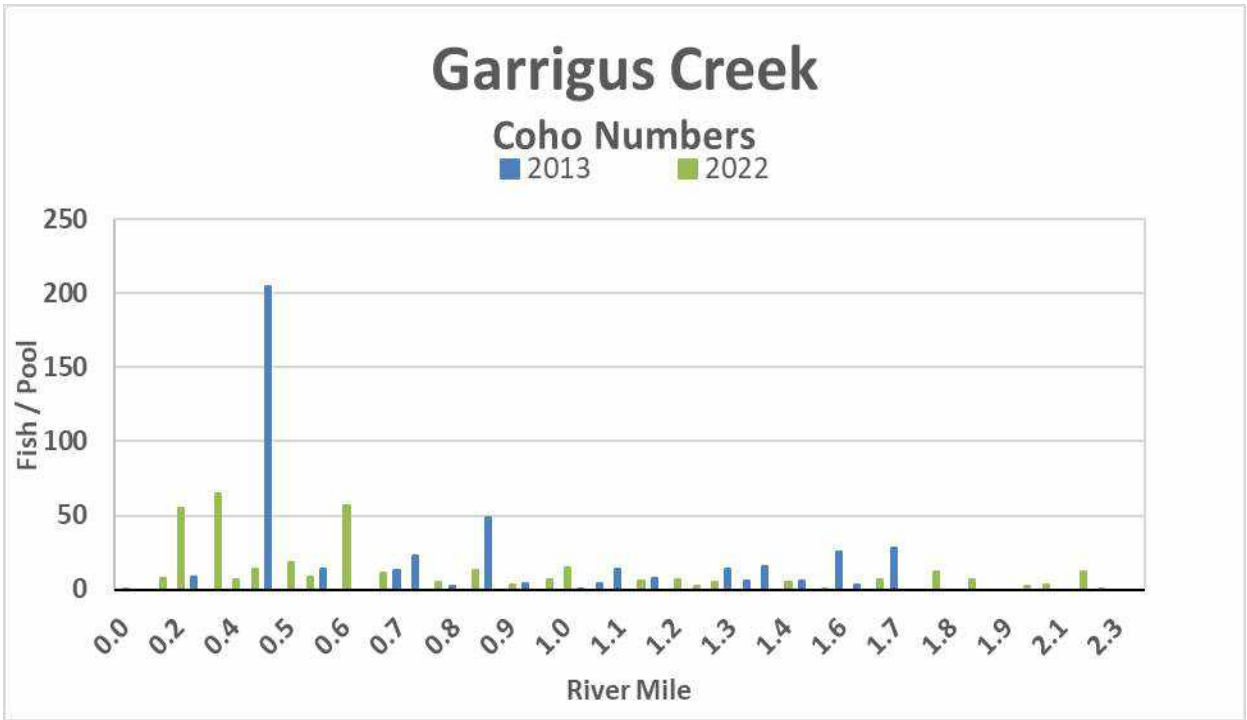


Figure 47: Garrigus Creek Coho Numbers 2013, 2022

Steelhead

Steelhead were not observed. Stream habitats in the upper half of the inventory were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was low in both years expanding to 81 fish/mile in 2013 and 34 fish/mile in 2022. Abundance in 2022 exhibited a 46.7% decline from 2013 estimates.

0+ Trout

0+ trout abundance was low in both years expanding to 133 fish/mile in 2013 and 48 fish/mile in 2022. Abundance in 2022 exhibited a 52.1% decline from 2013 estimates.

Table 40: Garrigus Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	2,682	0.58	240	150
2022	1,534	0.63	115	80

Mendenhall Creek

Mendenhall Creek enters WF Dairy Ck at RM 18.4. The inventory extended 3.76 miles where increased gradient over exposed bedrock with cobble and small boulder dominated substates limited further anadromous potential (spawning and rearing) upstream of this point. Coho distribution extended 2.8 miles in 2013 and 3.2 miles in 2022 with no barriers to passage observed.

Mendenhall Cr was the top producer of coho in the WF Dairy subbasin in 2013 rearing 22% of the total estimated population while accounting for 13% of the inventoried linear miles. It was also a top producer of cutthroat (25%) and 0+ trout (21%). In 2022, Mendenhall Creek was only rearing an estimated 10.5% of coho but remained a top cutthroat (32.5%) and 0+ trout (33.2%) producer.

Stream habitats were characterized by low gradient (avg. 2.2%); small boulder, cobble, and gravel dominated substrate; channel meander across wide floodplains; low wood complexity; and high solar exposure in the lower 1.8 miles due to thin riparian transitioning to well forested riparian of mature cedar, doug fir, alder, and maple.

Mendenhall Creek had strong summer flows exhibiting a cool water contribution with a 1.2°C temperature differential measured at the time of the inventory (Mendenhall 16.9°C, WF 18.1°C). The failed culvert functioning as a juvenile barrier to upstream temperature dependent migration located just upstream of the WF Dairy confluence was being replaced in summer 2022.

In 2013, 15 beaver dams were present. Nine dams were spread across the lower 1.25 miles of the inventory with the remaining six dams clustered together in the upper end of Anchor Site #3.

In 2022, Five beaver dams were present. Four of the dams were almost back-to-back extending from RM 0.3 – 0.4. This cluster of dams substantially increased the rearing capacity of this reach providing an estimated 13.1% of total surface area of pool habitat while accounting for 2.1% of the total number of pools within the inventoried reach. Visibility was restricted due to heavy tannins and beaver activity, reducing confidence in estimated coho abundance within these pools.

Anchor Sites:

Three anchor sites were observed. Anchor habitats accounted for 50% of the inventoried reach.

Anchor Site #1, extending from 0.41 — 1.37 was low functioning due to inadequate large wood complexity and limited spawning gravel.

Anchor Site #2, extending from RM 1.9 — 2.38 was low functioning due to terrace heights on borderline of qualification, inadequate large wood complexity, limited spawning gravel.

Anchor Site #3, extending from RM 2.7 — 3.1, was moderately functioning due to limited spawning gravel.

Photo 41: Mendenhall Creek Anchor Site #2

Photo 42: Upper Mendenhall Creek

Coho

Coho abundance was moderate in 2013 and low in 2022 with average pool densities of 0.82 fish/m² (966 fish/mile) in 2013 and 0.33 fish/m² (279 fish/mile) in 2022. The dominant density peak for 2013 was 2.6 fish/m² (observed at RM 0.73 within Anchor Site #1) and for 2022 was 1.55 fish/m² (observed at RM 2.93).

Distribution profiles suggest that peak spawning in 2013 occurred over a 1.66-mile reach extending from just above the Pongratz Rd bridge (RM 0.6) to RM 2.26 (0.22 miles below Buxton Creek). The gradient increases to about 1.5% in this section from the 0.6% average leading up from the confluence. The highest pool counts in 2013 were also documented in this reach. In 2022, Peak production was confined to 1 mile reach from RM 2.1 -3.1.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 10 combined male and female adult coho escapement to Mendenhall Creek for the two inventoried years was 26 coho in 2013 and 10 coho in 2022. Estimated adult coho capacity based on spawning gravel availability was 16 — 46 coho. In 2013 and 2022, Mendenhall Creek

was functioning below its current spawning habitat capacity and limited by inadequate adult escapement.

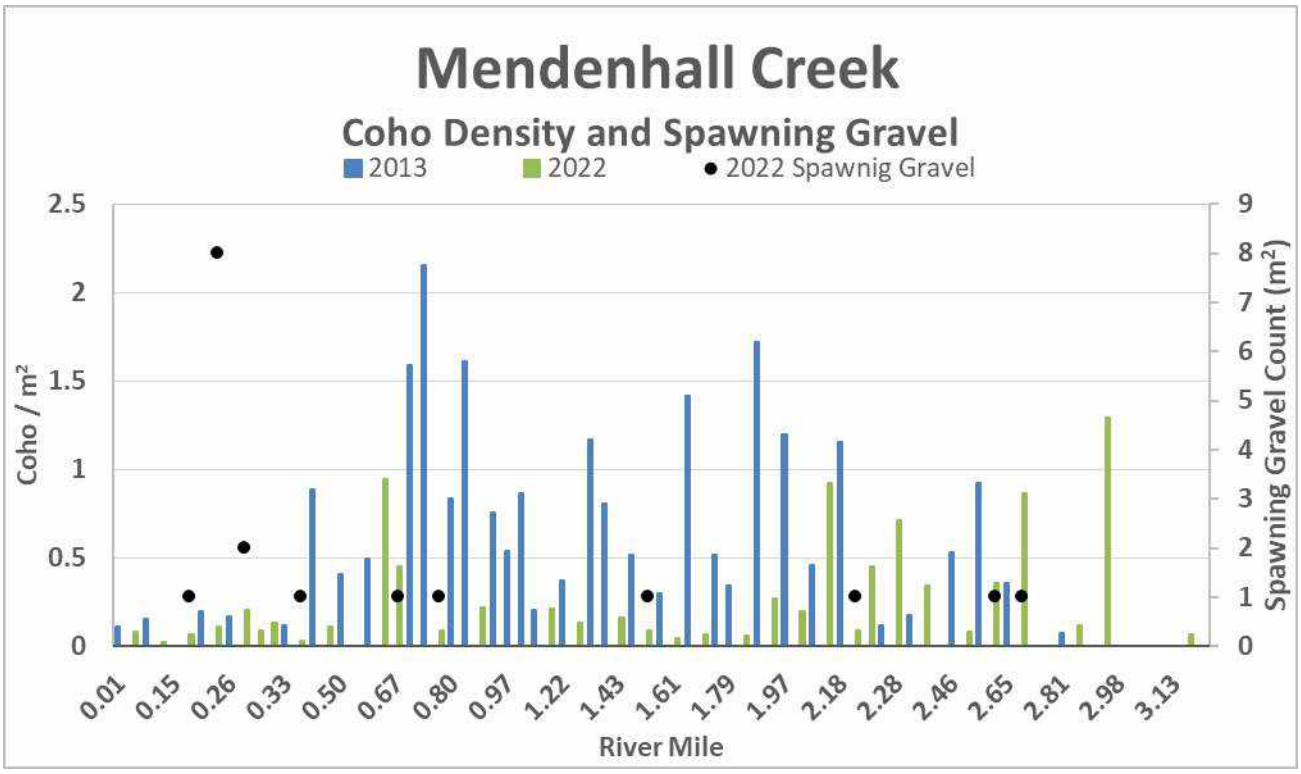


Figure 48: Mendenhall Creek Densities 2013, 2022

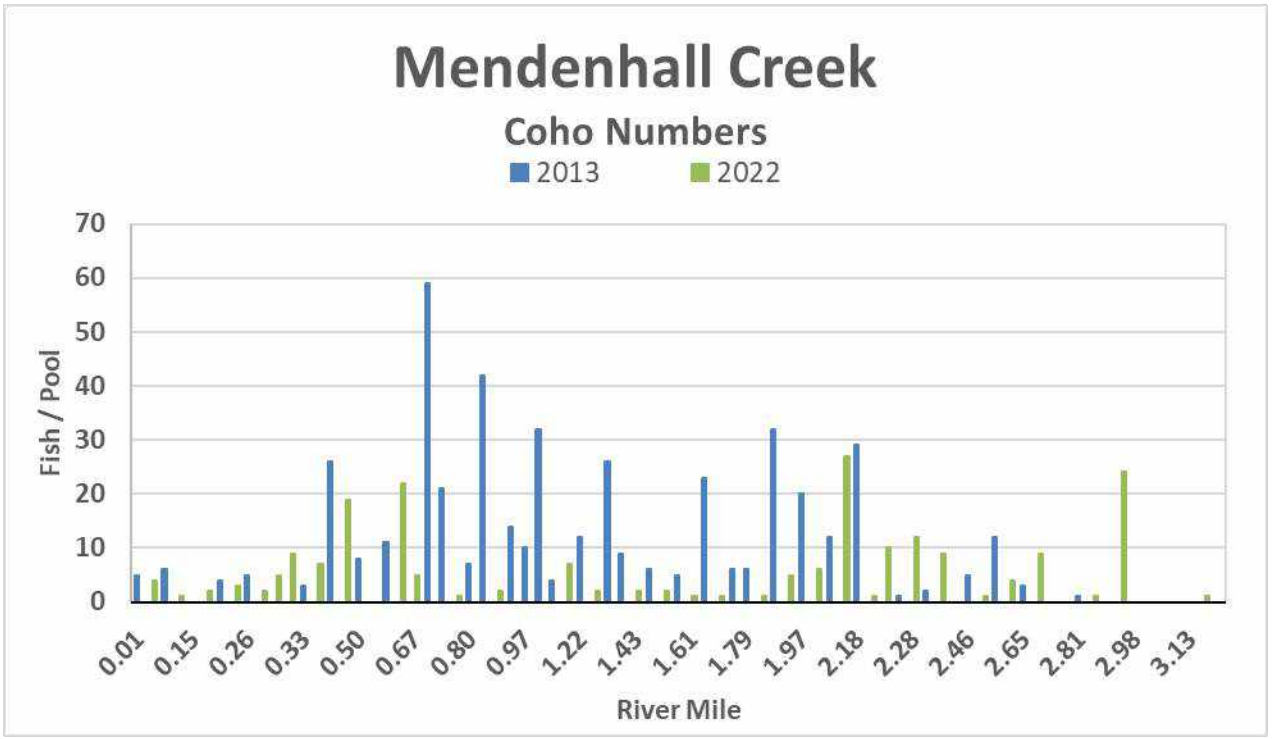


Figure 49: Mendenhall Creek Numbers 2013, 2022

Steelhead

Steelhead were not observed. Stream habitats in Mendenhall Creek exhibited the highest potential for steelhead occupation in the WF Dairy subbasin.

Cutthroat

Cutthroat abundance was similarly low in both inventoried years expanding to 107 fish/mile in 2013 and 82 fish/mile in 2022. Abundance estimates exhibited a 22.3% decline in 2022.

0+ Trout

0+ trout abundance was low in both inventoried years expanding to 333 fish/mile in 2013 (from RM 0.73 – 2.7) and 104 fish/mile in 2022 throughout the range of distribution (RM 1.5 – 2.76). 0+ trout estimates in 2022 exhibited a 76.4% decrease in abundance. This reduction in abundance combined with a reduction in range of distribution is consistent with trends observed throughout the Tualatin basin in many tributaries as well as larger mainstem habitats.

Table 41: Mendenhall Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	2,802	0.82	995	395
2022	961	0.33	235	307

West Fork Dairy Creek Trib A & A1

West Fork Dairy Creek Trib A enters WF Dairy Creek at RM 23.08. The survey extended 1.01 miles. The end of anadromous distribution was not reached due to landowner access restrictions. Based on increased gradient profiles (avg. 6.6%) and tributary junctions dividing flows upstream of the survey endpoint, anadromous potential likely extended an additional 0.15 miles. In 2013, inventories extended only 0.3 miles due to landowner access restrictions. 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.

Stream habitats were characterized by moderate gradient (avg. 3.7%); moderate wood complexity; cobble and gravel dominated substrates; well forested riparian canopy. Trib A was a primary headwater tributary of WF Dairy providing an estimated 30% - 40% of summer flows and contributing cool water. Trib A and WF Dairy exhibited similar temperature profiles at the time of the inventory (Trib A 15.4°C, WF Dairy 15.7°C).

The Trib A inventory included one tributary. Trib A1 entered Trib A at RM 0.5. Anadromous potential extended 0.33 miles to a large log jam functioning as an ephemeral adult barrier to passage. Coho were observed in two sample pools. Coho abundance was likely the result of upstream juvenile migration from Trib A.

Anchor Sites:

No anchor sites were observed. The inventoried reach was hillslope confined.

Photo: 43 West Fork Dairy Creek Trib A

Coho

Coho abundance in both inventoried years was moderately high with average pool densities of 1.61 fish/m² (1240 fish/mile) in 2013 and 1.27 fish/m² (1063 fish/mile) in 2022. The 2022 dominant density peak of 2.07 fish/m² was observed in the first sampled pool upstream from the WF Dairy confluence. The 2013 peak coho density of 2.84 was observed 0.25 miles above the confluence below a 1ft sill log. Both distribution profiles are indicative of upstream migratory behavior. No data further upstream for 2013

Spawning Gravel and Adult Escapement

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 12 adult (combined male and female) coho escaped to WF Dairy Tribs A and A1 to spawn in 2021. Estimated adult coho capacity based on spawning gravel availability was 4 — 10 coho. In 2022, Trib A was functioning above its estimated spawning habitat capacity with access to high quality spawning gravel functioning as a limiting factor to coho production.

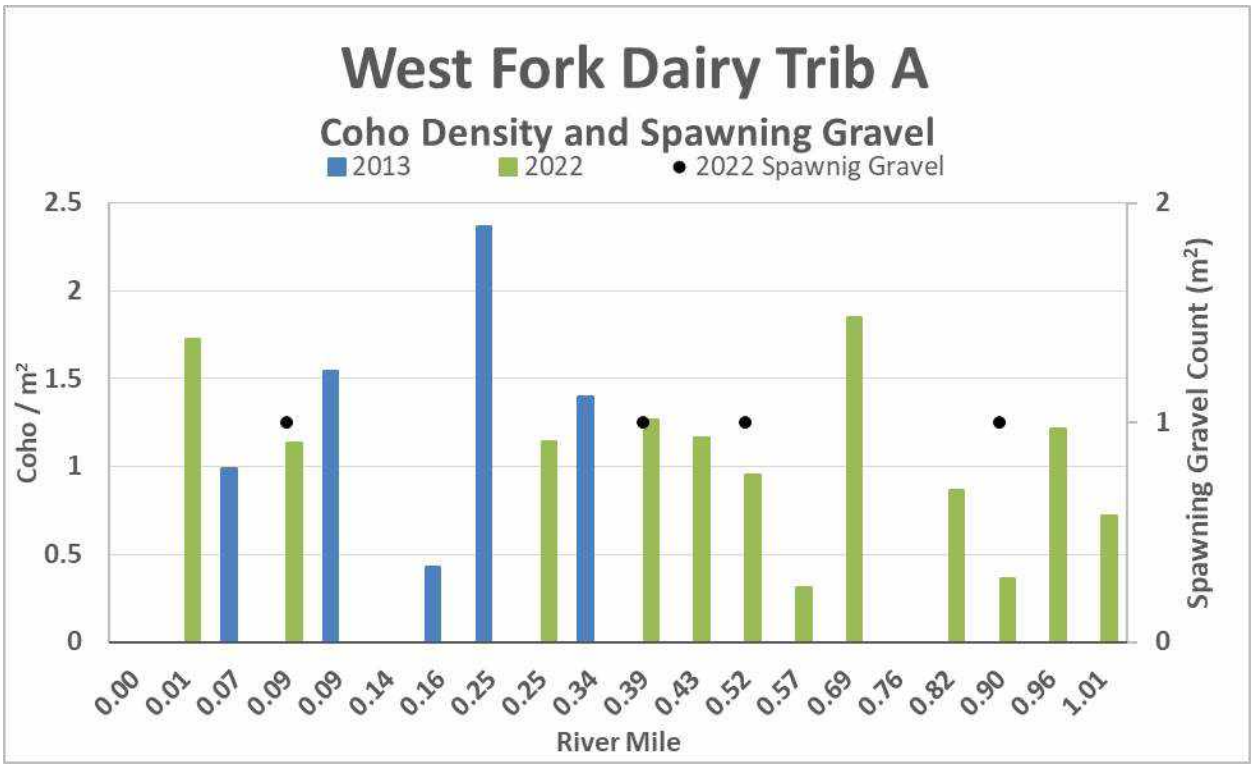


Figure 50: West Fork Dairy Creek Trib A Densities 2013, 2022

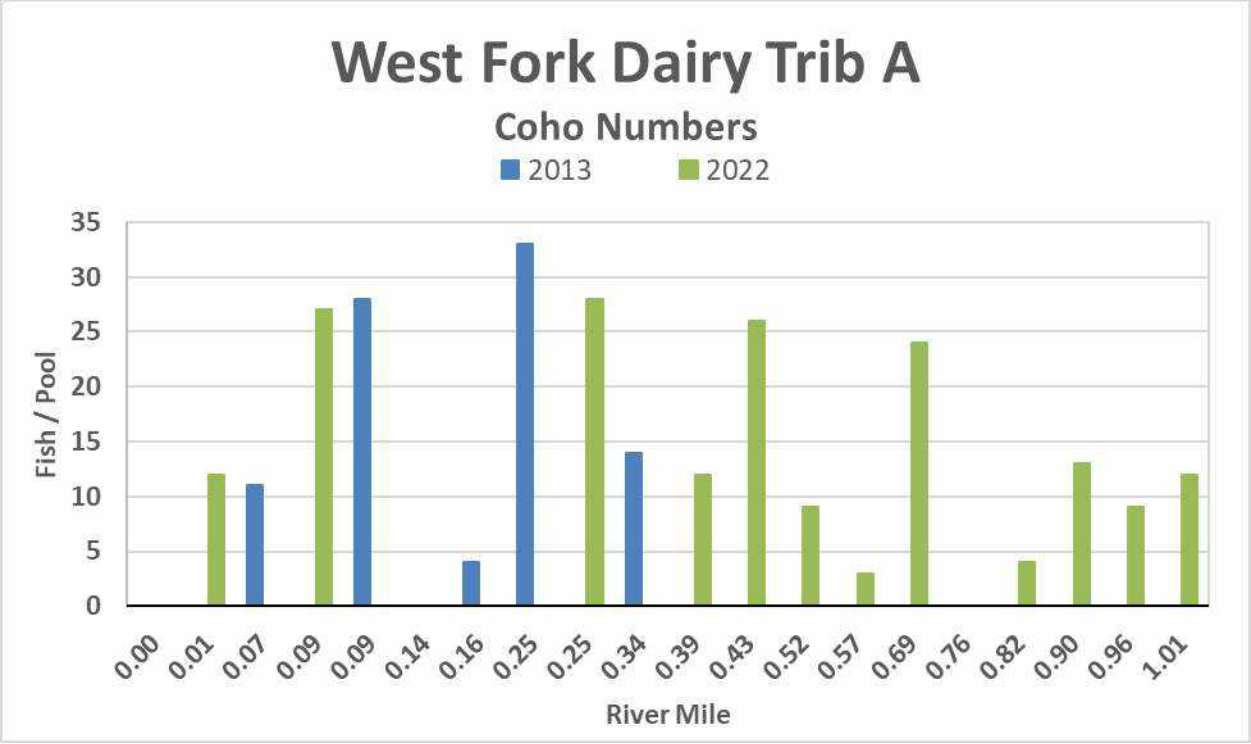


Figure 51: West Fork Dairy Creek Trib A Numbers 2013,2022

Steelhead

Steelhead were not observed. Stream habitats were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was moderate in 2013 with an average density of 0.3 fish/m² (200 fish/mile). Distribution in 2022 exhibited sporadic pool presence averaging 0.39 fish/m² (90 fish/mile).

0+ Trout

In 2013, 0+ trout abundance was high in the short inventoried reach with an average density of 1 fish/m² (983 fish/mile). 0+ trout abundance in 2022 was low with an average density of 0.18 fish/m² (40 fish/mile).

Table 42: West Fork Dairy Creek Trib A & A1 - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	372	1.61	295	60
2022	1,164	1.27	90	120

Whitcher Creek

Whitcher Creek enters WF Dairy Creek at RM 16.5. The survey extended 2.65 miles where increased gradient (avg.7%), channel confinement, and lack of spawning gravel limited further anadromous potential upstream. Coho distribution extended to RM 2.56.

Channel conditions for the first 0.7miles were described as exhibiting extensive solar exposure, thin riparian buffer, and deeply entrenched terraces. Upstream of RM 0.7 stream habitats were characterized by low gradient (avg. 2.7%); sinuous channel meander; moderate wood complexity; small boulder, cobble, and gravel dominated substrates; and well shaded riparian canopy.

Whitcher creek had medium summer flows and was a cool water contribution with a 2.3°C temperature differential measured at the time of the inventory (Whitcher 14.2°C, WF 16.5°C).

Two active beaver dams were documented in 2013 with evidence of older dams. No beaver activity was observed in 2022.

Anchor Sites:

2 anchor sites were observed. Anchor Site #1, extending from RM 0.51 — 0.79 and Anchor Site #2, extending from RM 1.32 — 1.74 were moderately functioning due to inadequate large wood complexity.

Photo 44: Whitcher Creek

Coho

Coho abundance was moderate in 2013 and 76.1% lower in 2022. Average pool densities were 0.68 fish/m² (764 fish/mile) in 2013 and 0.34 fish/m² (190 fish/mile) in 2022. The dominant density peaks for both years (2.58 fish/m² in 2013 and 0.85 fish/m² in 2022) were observed in the upper end of Anchor Site #2 (RM 1.6 — 1.7).

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to Whitcher Creek was 18 in 2012 and 6 in 2021. Estimated adult coho capacity based on spawning gravel availability was 40 — 118 coho. In both inventoried years Whitcher Creek was functioning far below its current habitat capacity and limited by inadequate adult escapement.

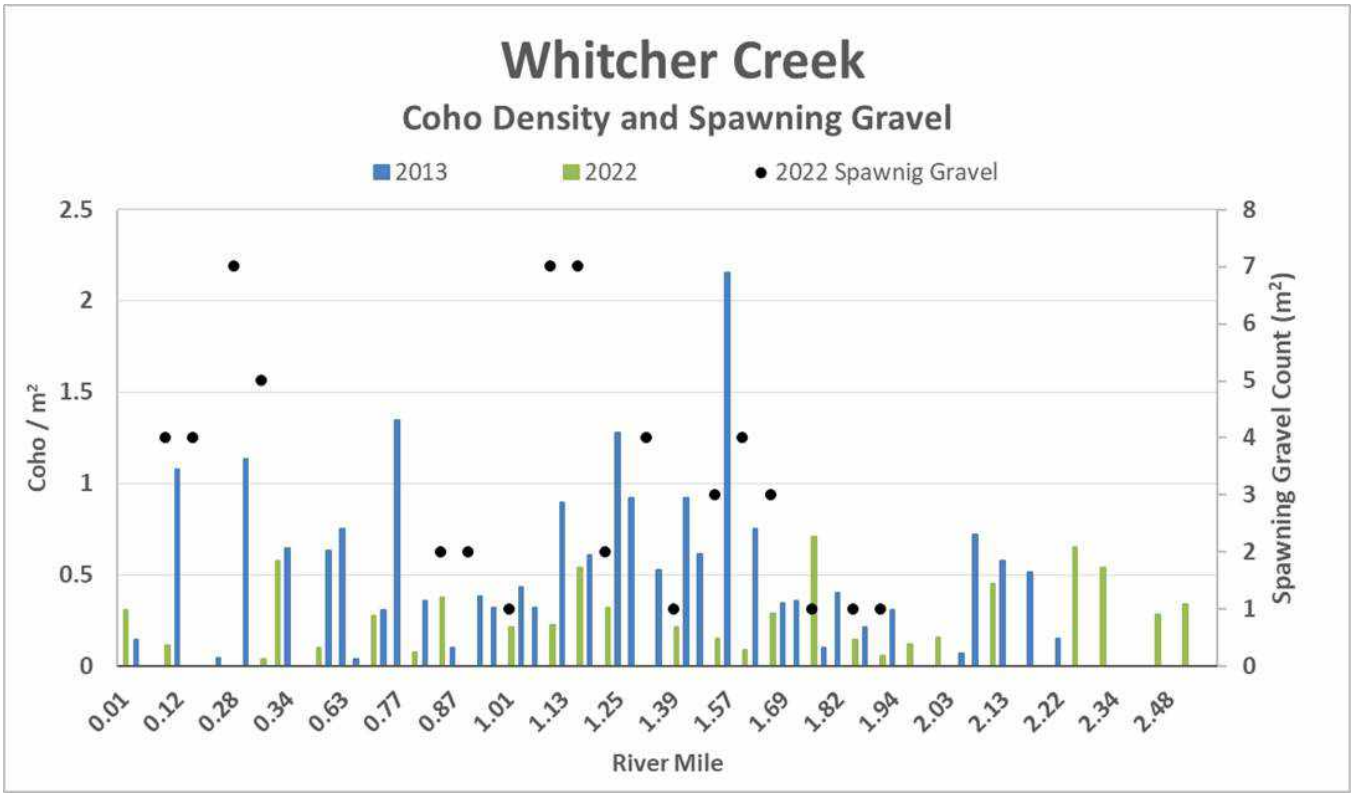


Figure 52: Whitcher Creek Densities 2013, 2022

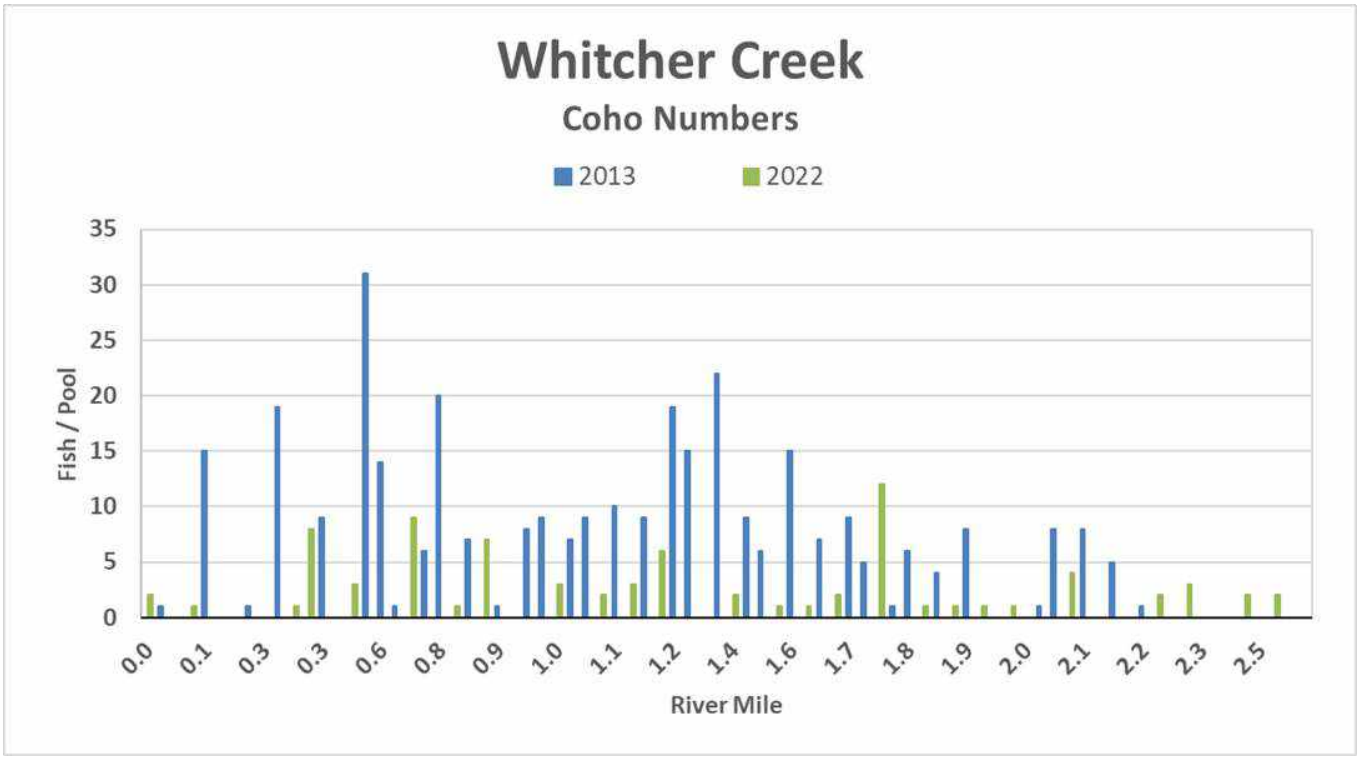


Figure 53: Whitcher Creek Numbers 2013, 2022

Steelhead

Steelhead were not observed. Stream habitats in the upper half of the inventory were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was low in both inventoried years with sporadic pool presence. In 2022 a 72% decline in cutthroat abundance was observed.

0+ Trout

In 2013, 0+ trout densities peaked at 1 fish/m² at RM 1.4, well below full seeding with an average density of 0.3 fish/m² (218 fish/mile). In 2022, a 93.28% decline in 0+ trout abundance was observed.

Table 43: Whitcher Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	1,956	0.68	525	125
2022	486	0.34	40	35

Williams Creek

Williams Creek enters WF Dairy Creek at RM 6.5. The survey extended 2.14 miles where reduced summer flows limit further anadromous rearing potential upstream. Coho distribution extended to RM 1.7 in 2013 and RM 2.05 in 2022 with no adult barriers to passage observed.

Stream habitats were characterized by low gradient (avg. 2%); cobble, gravel, and silt dominated substates; sinuous channel meander across wide floodplain; forested riparian canopy; and beaver augmentation. Williams Creek had low summer flows with a slightly cooler temperature profile than WF Dairy mainstem (Williams 17.5°C, WF Dairy 18.1°C).

Nine beaver dams were observed in 2013. Three active dams were documented in 2022 between RM 0.75 —0.91. These three dams substantially increased the rearing capacity of this reach providing an estimated 13% of total surface area of pool habitat while accounting for 2.26% of the total number of pools. Visibility was restricted due to turbidity caused by beaver activity, reducing confidence in estimated coho abundance within these pools.

Anchor Sites

2 anchor sites were observed. Anchor Site #1, extending from RM 0.33 — 1.20 and Anchor Site #2, extending from RM 1.93 — 2.05 were moderately functional due to inadequate large wood complexity and limited spawning gravel.

Photo 45 Williams Creek beaver dam

Coho

Coho abundance was moderate in 2013 and substantially lower in 2022 exhibiting a 52.3% decline. Average pool densities were 0.53 fish/m² (828 fish/mile) in 2013 and 0.47 fish/m² (327 fish/mile) in 2022.

The dominant density peak in 2013 of 1.83 fish/m² was observed at RM 0.78. This peak was within Anchor Site #1 and overlapped a stream reach with high beaver activity and high spawning gravel estimates. Coho abundance quickly declined above this reach in 2013. In 2022, peak production was higher in the basin with a density spike of 2.37 fish/m² documented at RM 1.7.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to Williams Creek was 14 coho in 2013 and 6 coho in 2022. Estimated adult coho capacity based on spawning gravel availability was 10 — 28 coho. In both inventoried years, Williams Creek was likely functioning below its current spawning habitat capacity and limited by inadequate adult escapement.

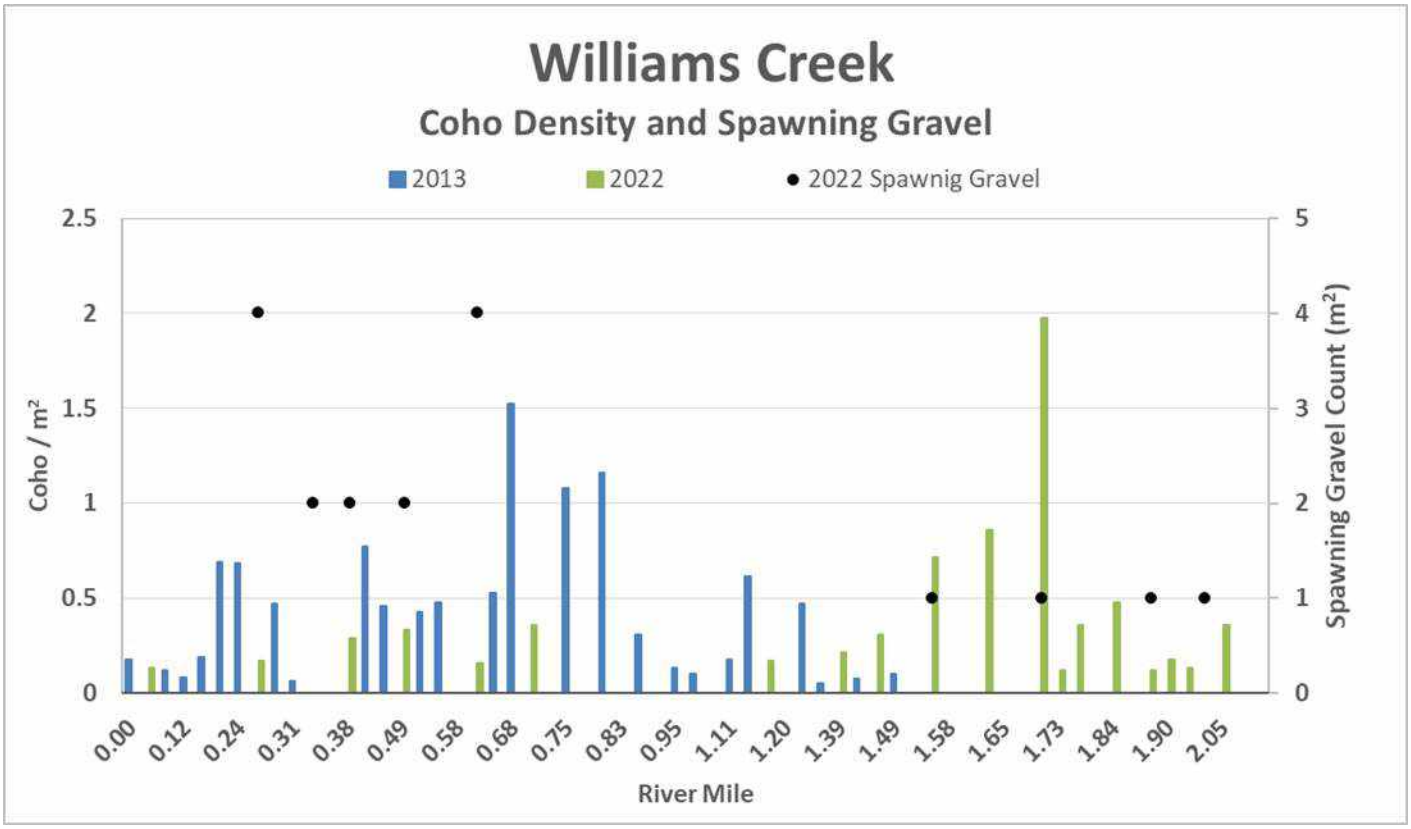


Figure 54: Williams Creek Densities 2013, 2022

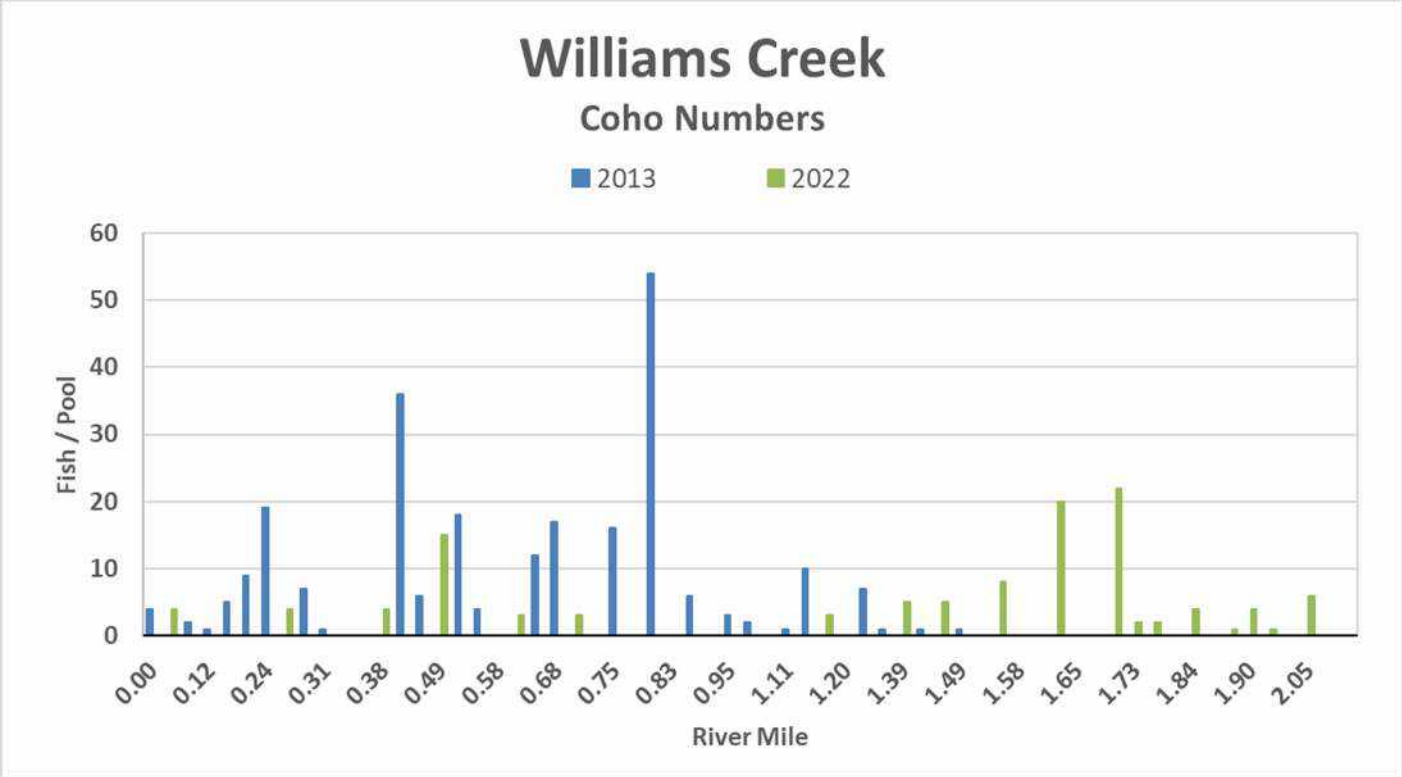


Figure 55: Williams Creek Numbers 2013, 2022

Steelhead

Steelhead were not observed. Marginal steelhead habitat was present in the inventoried reach.

Cutthroat

Cutthroat abundance was low in both inventoried years with sporadic pool presence. In 2022 a 64.44% decline in cutthroat abundance was observed.

0+ Trout

0+ trout abundance was low in both inventoried years with sporadic pool presence. In 2022 a 90.4% decline in 0+ trout abundance was observed.

Table 44: Williams Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	1,458	0.53	260	90
2022	696	0.47	25	32

McKay Creek Subbasin

McKay Creek, a tributary to Dairy Creek, was the smallest of the five inventoried Tualatin subbasins (McKay, EF Dairy, WF Dairy, Upper Tualatin, Gales). In 2022, a total of 8.35 miles was inventoried in the combined mainstem of McKay and its tributaries. Two tributaries and two side channels were included in the inventory. Of the two tributaries, only EF McKay exhibited significant spawning potential for anadromous salmonids. No steelhead were observed rearing in the McKay Creek subbasin in either inventoried year. The McKay Creek subbasin was previously inventoried in 2013. Inventory of three tributaries (Jackson, Neil, and Trib B) and 6.3 miles of mainstem habitat was not replicated in 2022 due to limited salmonid spawning and rearing potential.

Table 45: McKay Dairy Creek Subbasin 2013 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Subbasin	Coho	%	0+	%	Cut	%
McKay	4,482		1,390	57.2	975	49.9
Side Channel A	167		4		4	
Side Channel B	19		3			
Brunswick	90		30	1.2	35	1.8
EF McKay	3684		1,005	41.3	940	48.1
Subbasin Total	**8,442**		**2,432**		**1,954**	

Table 46: McKay Dairy Creek Subbasin 2022 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Cut	%
McKay	8,730		390		1085	
Side Channel A	210		7		2	
Side Channel C	238		3		4	
Side Channel D	124		3		4	
Brunswick Canyon	646		5		27	
EF McKay	5,862		195		525	
Subbasin Total	**15,810**		**603**		**1647**	

McKay Creek

The McKay Creek mainstem inventory began at RM 15.8 (Collins Rd bridge) and extended 5.2 miles to a 10ft basalt falls that terminated anadromous potential. Coho distribution extended to 5ft falls at RM 19.9, not observed to be a definitive adult barrier to passage. Water temperature taken at the time of the inventory was 17.7° C.

Downstream of the 2022 start point, limited spawning and rearing potential exists due to low gradient (0.12% average); silty alluvial deposits with lack of spawning gravel; and high summer temperature profiles. These habitat conditions, along with high tannins limiting visibility, rendered inventory efforts further downstream impertinent.

These stream habitat conditions extended upstream to the inventory start point (RM15.8) where channel morphology changes. Increased gradient (avg.0.8%), gravel dominated substrates, and lower terrace heights with higher frequency of floodplain interaction were noted in the transition reach to RM 16.

Photo 46 McKay Creek anchor Site #1

Upstream of RM 16 extending to RM 17.5 the highest quality habitat was observed. This reach exhibited sinuous channel meander and braiding across a wide floodplain; low terrace heights;

moderate wood complexity; cobble and gravel dominated substrate; coniferous riparian canopy; and average gradient of 1.6%. The entirety of this section met anchor site qualifications. Beaver occupation was documented here in 2013. 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. The EF McKay and Brunswick Canyon confluences along with Side Channels A and B were in this section.

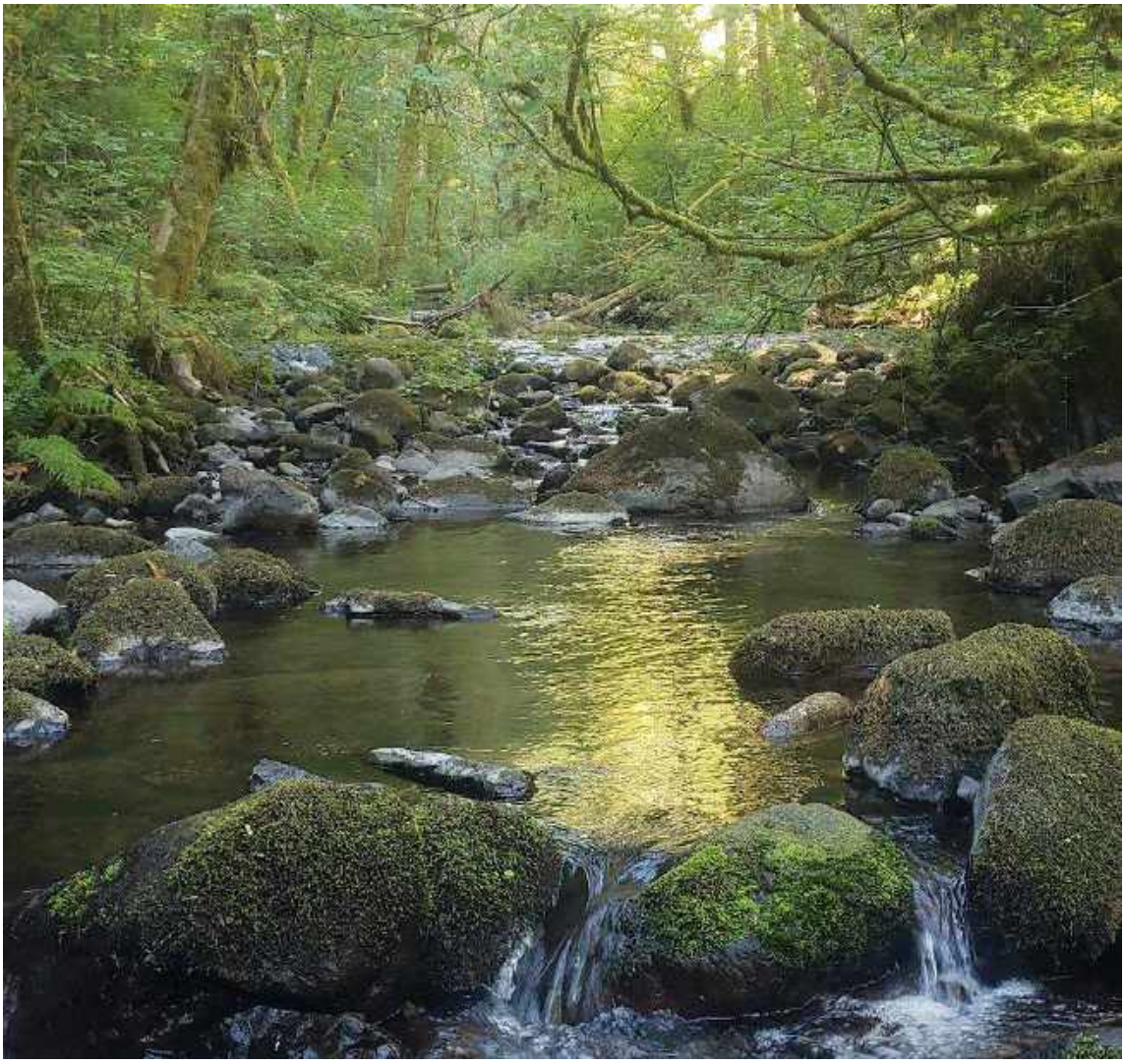


Photo 47: Upper McKay Creek

Upstream of RM 17.5 extending to RM18.8 a stream habitat transition is observed characterized by an increase in gradient (avg. 3.07); lateral channel migration largely constrained by a more confined canyon; boulder and cobble dominated substrates with limited gravel sorting; low wood complexity; and mixed coniferous and deciduous riparian canopy. Three short anchor sites totaling 0.4 miles along with two short side channels exhibiting full seeded coho densities were documented in this reach.

Stream habitat in the remaining 2.2 miles of the inventory extending to the barrier falls exhibited moderately high gradient (avg. 3.8%); bedrock, boulder, and cobble dominated substrates with very limited gravel sorting; narrow canyon; and continued well forested riparian.

Photo 48: McKay Creek Falls

Anchor Sites:

Four anchor sites were observed. Anchor Site #1, extending from RM 16 — 17.4, Anchor Site #2, extending from RM 18 — 18.12, Anchor Site #3, extending from RM 18.38 — 18.6, and Anchor Site #4, extending from RM 18.72 — 18.78 were all moderately functional due to inadequate large wood complexity and limited spawning gravel.

Photo 49: McKay Creek high complexity Side Channel C

Coho

Coho abundance was nearly twice as high in 2022 as it was in 2013. Average pool densities were 0.64 fish/m² (1,139 fish/mile) in 2013 and 1.13 fish/m² (2,269 fish/mile) in 2022. The dominant density peaks for both years were documented in similar locations near the upper end of Anchor Site #4. In 2013, 1.75 fish/m² was observed at RM 18.7 and in 2022, 7.85 fish/m² was observed at RM 18.78 below a log jam functioning as a juvenile barrier to upstream migration.

In 2013, coho abundance peaked from RM 16.8 — 17.8. The highest pool count of 110 coho was observed in a beaver pool at RM 17. This reach contained the braided confluences of Brunswick Canyon Cr, EF McKay, and Side Channels A and B. With the side channels included (186 coho), this one-mile reach, approximately 19.6% of the usable stream habitat, was rearing 52% of the coho parr in mainstem McKay Creek. Landowner access denials restricted a full inventory of this reach in 2022.The peak production zone in 2022 was from RM 16.15 — 17 which was producing 38.24% of the coho population while accounting for 20.73% of the usable stream habitat. This high production zone would have likely contributed a higher percentage and extended further upstream in 2022 if landowner access was granted.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to McKay Creek was 44 coho in 2012 and 88 coho in 2021. Estimated adult coho capacity based on spawning gravel availability was 38 — 112 coho. In 2022, McKay Creek was functioning within its current spawning habitat capacity.

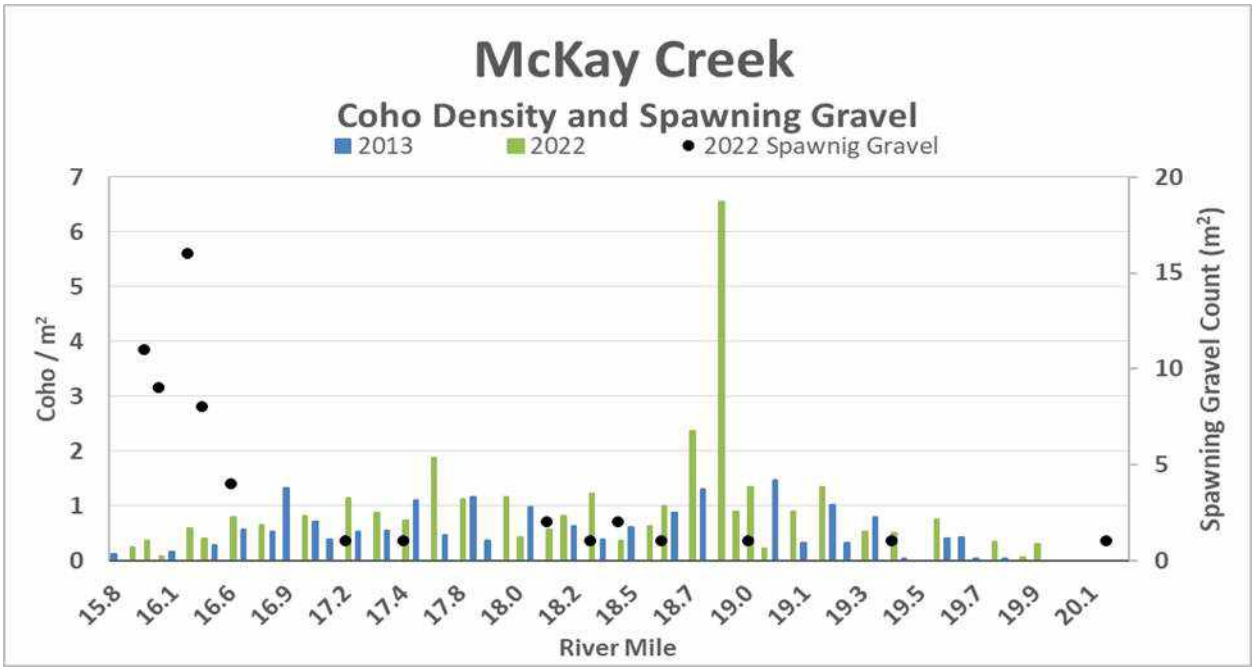


Figure 56: McKay Creek Coho Densities 2013, 2022

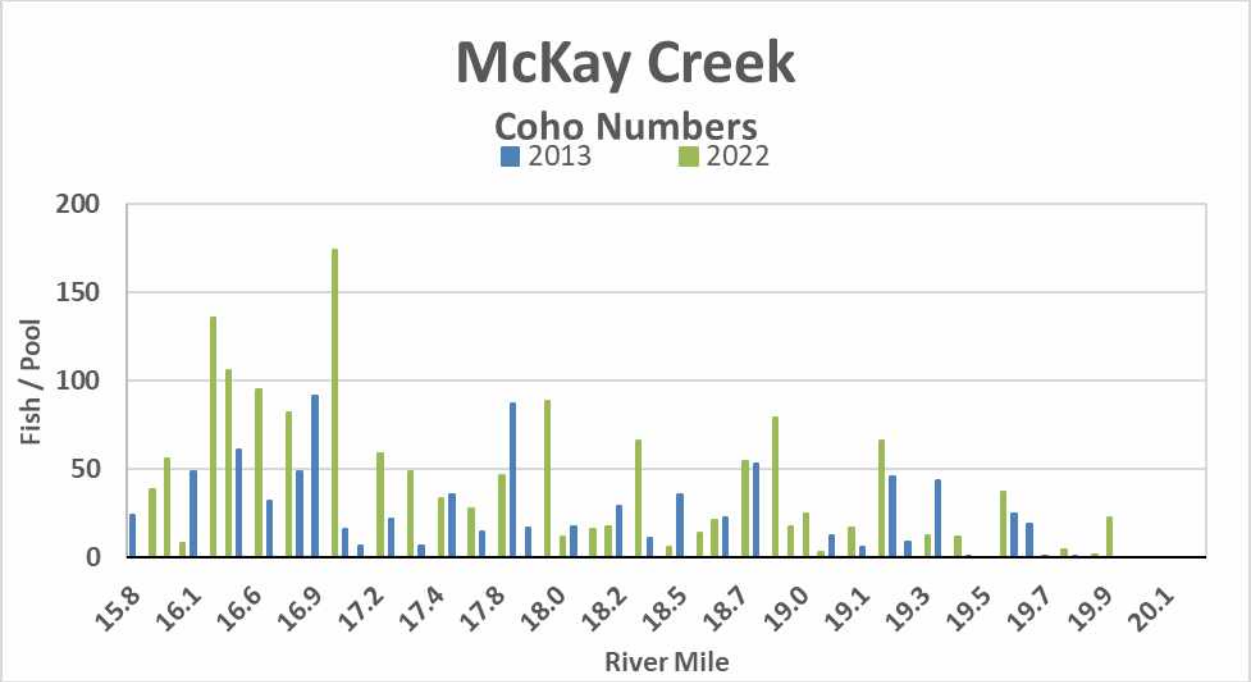


Figure 57: McKay Creek Coho Numbers 2013, 2022

Steelhead

Steelhead were not observed. Stream habitats were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was similar in both inventoried years, remaining well below full seeding capacity with average densities of 0.16 fish/m² (179 fish/mile) in 2013 and of 0.13 fish/m² (211 fish/mile) in 2022. Peak densities for both years (0.74 fish/m² in 2013 and 0.59 fish/m² in 2022) were observed in the pool below the barrier falls (RM 21).

0+ Trout

0+ trout estimates in 2022 exhibited a 71.9% decrease in abundance from 2013. 0+ trout abundance throughout the range of significant distribution expanded to 267 fish/mile in 2013 and 105 fish/mile in 2022. Abundance estimates for both inventoried years remained well below full seeding capacity.

0+trout distribution in 2013 was documented extending downstream to RM 15.1. In 2022, distribution was reduced by 2.2 miles. This reduction in range of distribution combined with reduction in abundance is consistent with trends observed throughout the Tualatin basin in many tributaries as well as larger mainstem habitats.

Table 47: McKay Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	4,668	0.64	1,390	975
2022	9,302	1.13	390	1085

Brunswick Canyon Creek

Brunswick Canyon Creek enters McKay Creek at RM 17. Coho distribution extended for 0.5 miles in 2013. Landowner access restrictions in 2022 terminated the inventory at RM 0.5 where coho were still present. 2013 field notes indicate that gradient quickly increases above that point, limiting any additional anadromous potential. Coho abundance in 2022 was substantially higher than 2013, suggesting that a short reach of additional distribution may have been excluded from the inventory.

Brunswick Canyon had a strong beaver presence with five dams in 2013 and three dams in 2022. 32.6% of pool habitat was provided by beaver augmentation in 2022. Additional beaver activity was observed in an extensive side channel legacy beaver swamp. High wood complexity, deep silt deposition, and reduced visibility restricted comprehensive inventory of this complex. Coho usage was not observed above a 2.5ft grassed over dam with subsurface flows restricting connectivity at the downstream confluence.

Anchor Sites:

Nearly the entirety of the inventoried reach exhibited anchor site characteristics with sinuous channel meander across a broad legacy beaver flat thick with reed canary grass. Though abundant cover was provided by reed canary grass, cool temperature profiles (16.1°C) were observed, and active beaver dams were providing channel lift to maintain low terrace heights, functionality was limited by inadequate large wood complexity and limited spawning gravel.

Photo 50 Brunswick Canyon Creek legacy beaver flat

Coho

Coho abundance was seven times higher in 2022 than 2013 with an average pool densities of 0.26 fish/m² (176 fish/mile) in 2013 and 1.81 fish/m² (1318 fish/mile) in 2022.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to Brunswick Canyon Creek was 2 coho in 2012 and 6 coho in 2021. Estimated adult coho capacity based on spawning gravel availability was 2 — 8 coho. In 2022, Brunswick Canyon Creek was functioning within its current spawning habitat capacity. In 2022, spawning gravel estimates were only conducted on the lower 0.5 miles. Additional gravel sites may have been present further upstream.

Steelhead

Steelhead were not observed. Inventoried stream habitats were not suitable for steelhead occupation.

Cutthroat

Cutthroat abundance in both inventoried years was low with intermittent pool presence.

0+ Trout

0+ trout abundance in both inventoried years was low with sporadic pool presence.

Table 48: Brunswick Canyon Creek - Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	90	0.26	30	35
2022	646	1.81	5	27

EF McKay Creek

EF McKay Creek enters McKay Creek at RM 17 in McKay Anchor Site #1 within a broad interactive floodplain. EF McKay is the primary tributary to McKay Creek. The 2013 survey extended 3.28 miles where a 7ft bedrock falls with shallow jump pool terminated further anadromous distribution. Access to the McKay Creek confluence up to RM 0.2 and the upper 0.57 miles below the barrier falls was denied by landowners in 2022 resulting in an incomplete assay of stream habitats.

Stream habitats were characterized by low gradient (avg. 2.6%); bedrock small boulder, and cobble dominated substrates with limited gravel sorting; channel braiding across wide floodplains; and forested riparian canopy.

In 2013, six beaver dams ranging from 1ft — 4ft tall were observed with evidence of recent occupation clustered together in a legacy flat from RM 0.74 —0.91. No beaver activity was observed in 2022.

Anchor Sites:

Four anchor sites were observed accounting for 33.9% of the inventoried stream habitat within the anadromous range. Anchor Site #1, extending from RM 0 — 0.48; Anchor Site #2, extending from RM 0.80 — 0.90; Anchor Site #3, extending from RM 1.09 — 1.31; and Anchor Site #4, extending from RM 1.57 — 2.04 all exhibited reduced functionality due to inadequate wood complexity and limited gravel sorting.

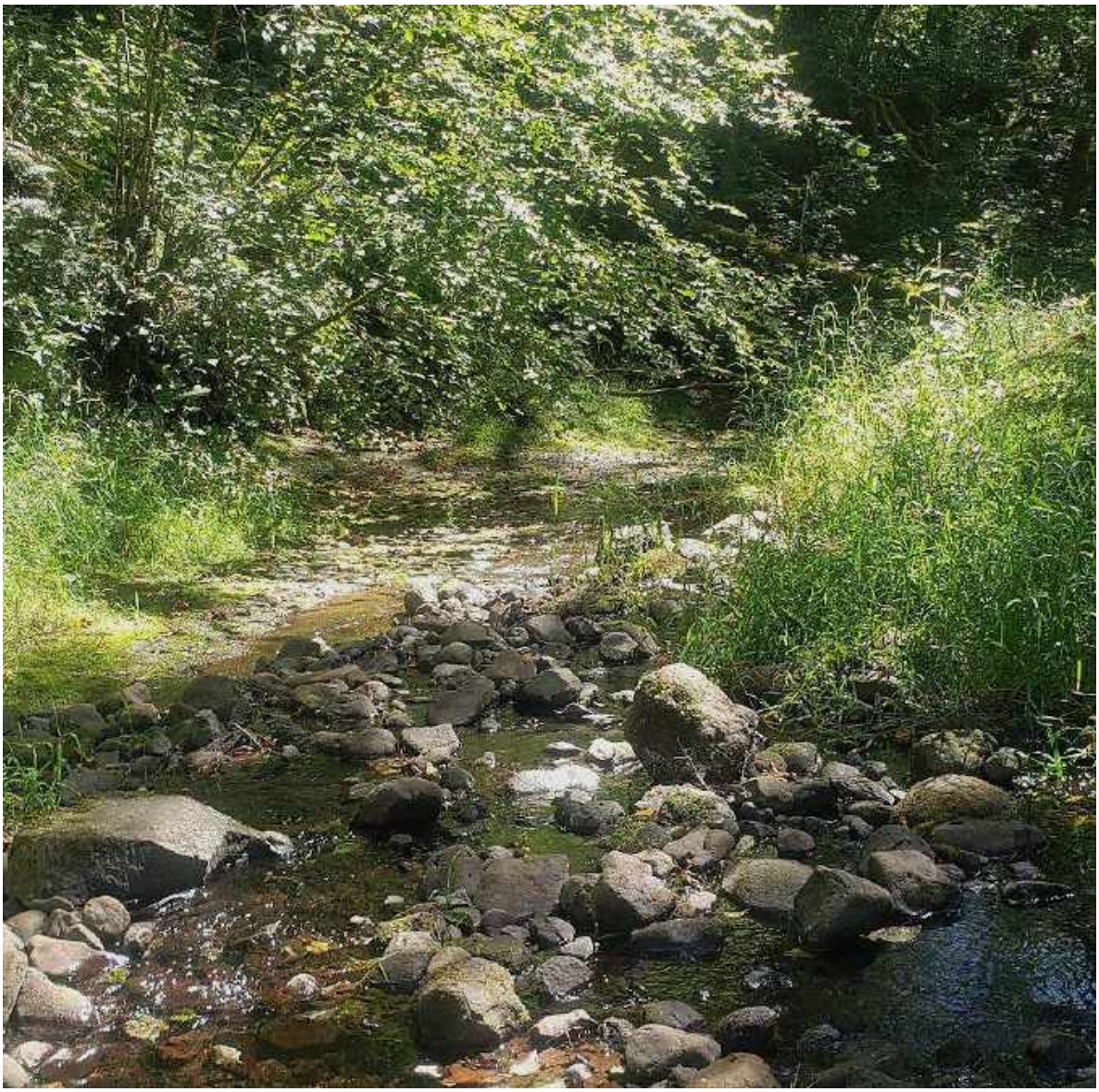


Photo 51: EF McKay Creek

Coho

Coho abundance was high in both inventoried years with a 59.1% increase from 2013 to 2022. This increase in abundance was likely substantially higher given that 23.4% of stream habitats were not inventoried in 2022 due to landowner access denial.

Average pool densities were 1.05 fish/m² (1,123 fish/mile) in 2013 and 2.17 fish/m² (2,393 fish/mile) in 2022. In both inventoried years, coho abundance exhibited a bimodal distribution pattern with increased abundance in the lower 0.4 miles (Anchor Site #1), likely resultant from upstream juvenile migration out of McKay Creek, followed by dominant spawning peak higher in the basin. In 2013, Neil Creek, a small tributary, exhibited a similar upstream temperature

dependent juvenile migration for the first 0.25 miles. Neil Creek was not sampled in 2022 due to landowner access denial.

In 2013, the dominant coho spawning peak extended from RM 1.96 – 3.28 with a peak pool density of 4.7 fish/m² at RM 2.82. This 1.32-mile reach constituted 40% of the steam miles and was rearing 62% of the coho parr.

In 2022, the peak production reach started at RM 1.31 extending to the end of the inventory with a peak pool density of 6.72 fish/m² at RM 2.3. This 1.35-mile reach (encompassing Anchor Site #4) constituted 50% of the steam miles and was rearing 66.4% of the coho parr. Increased production levels likely extended upstream to the barrier falls as it did in 2013.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, combined male and female coho escapement to EF McKay Creek was 34 coho in 2013 and 56 coho in 2022. Spawning gravel estimates were not conducted in 2022. Field notes indicated a limited abundance of sorted gravel with bedrock, boulder and cobble dominated substrates.

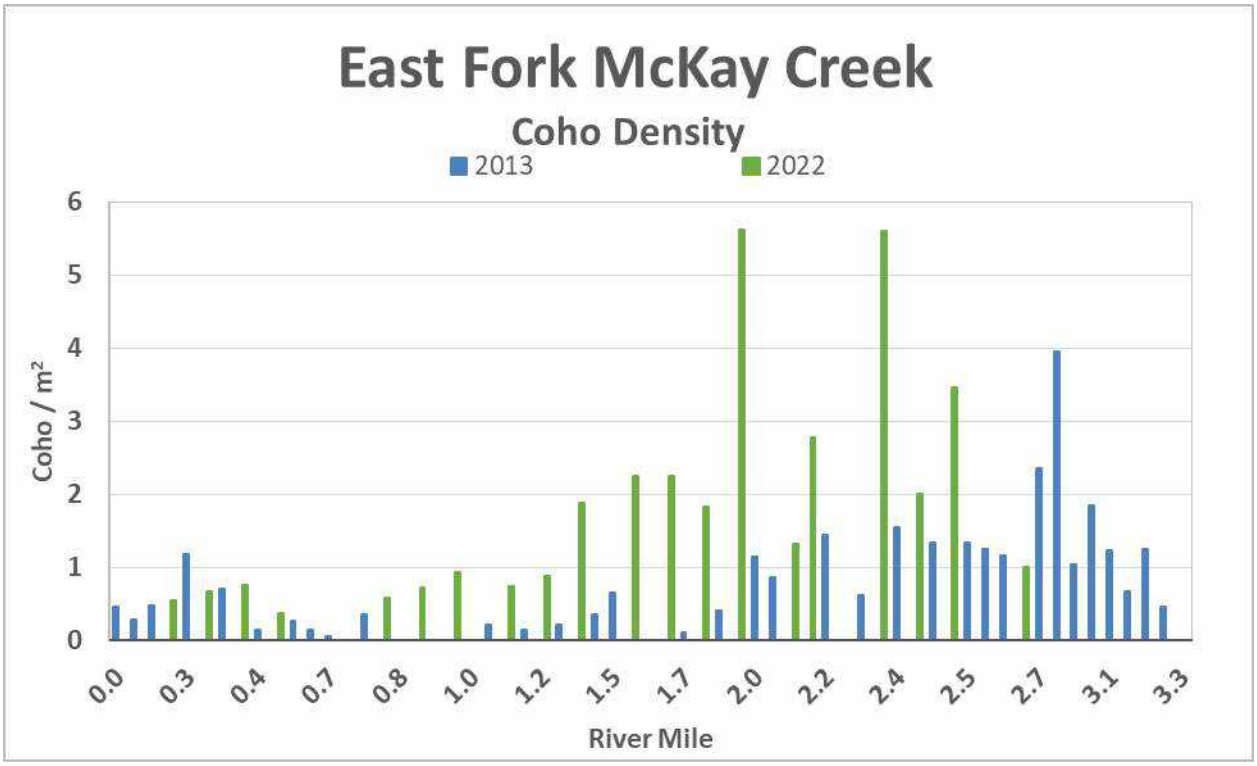


Figure 58: EF McKay Creek Coho Densities 2022

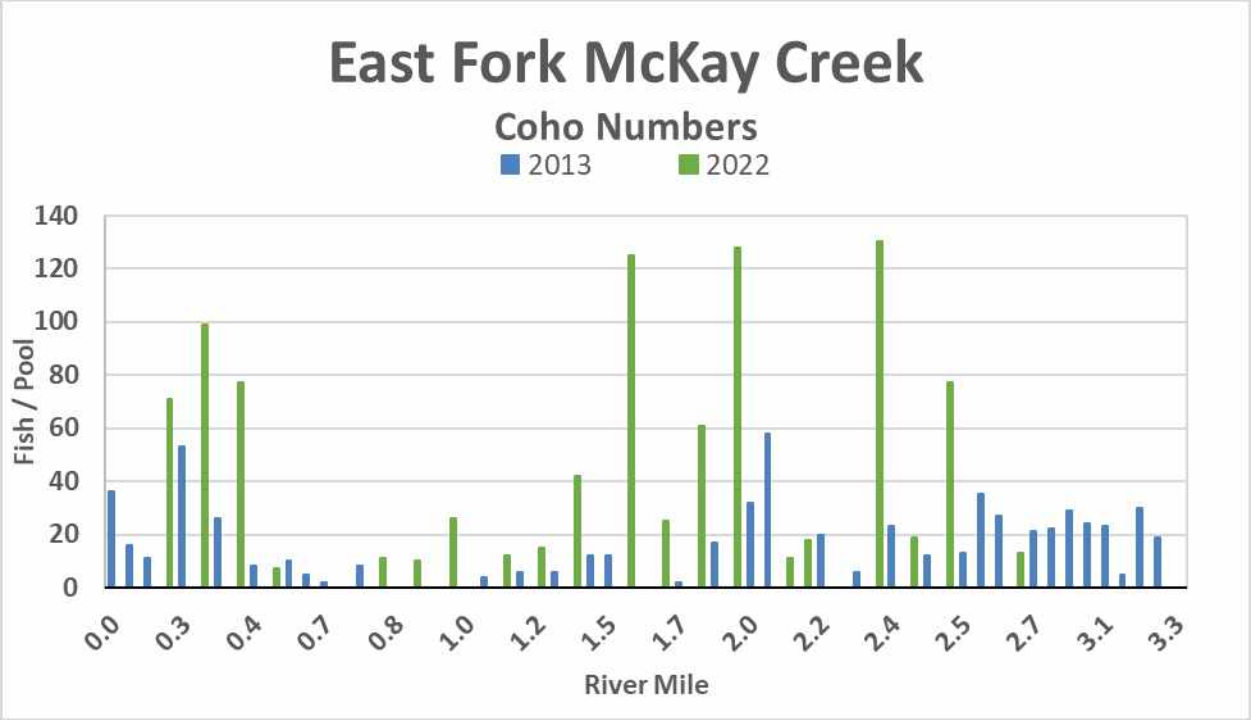


Figure 59: EF McKay Creek Coho Numbers 2022

Steelhead

Steelhead were not observed. Stream habitats were suitable for steelhead occupation.

Cutthroat

In 2013, cutthroat abundance was moderately high with an average density of 0.23 fish/m². expanded to 272 fish/mile. A peak density of 0.86 fish/sqm was observed at RM 1.34.

In 2022, cutthroat abundance in the replicated reach exhibited a 25.5% decrease from 2013 estimates. An average density of 0.31 fish/m² expanded to 214 fish/mile with a peak density of 0.99 fish/m² at RM 2.3. Cutthroat abundance was low in the lower 0.8 miles of the inventory mirroring that of 0+ trout distribution.

0+ Trout

In 2022, 0+ trout abundance in the replicated reach exhibited a 76.8% reduction from 2013. Abundance for both years remained low with average densities of 0.25 fish/m² (342 fish/mile) and 0.18 fish/m² (80 fish/mile) in 2022. No 0+ trout were observed below RM 0.9 in 2022. Substantial decreases in 0+ trout abundance and reductions in range of distribution, compared to 2013 & 2014 inventories, is consistent with patterns observed in other systems throughout the Tualatin basin in 2022.

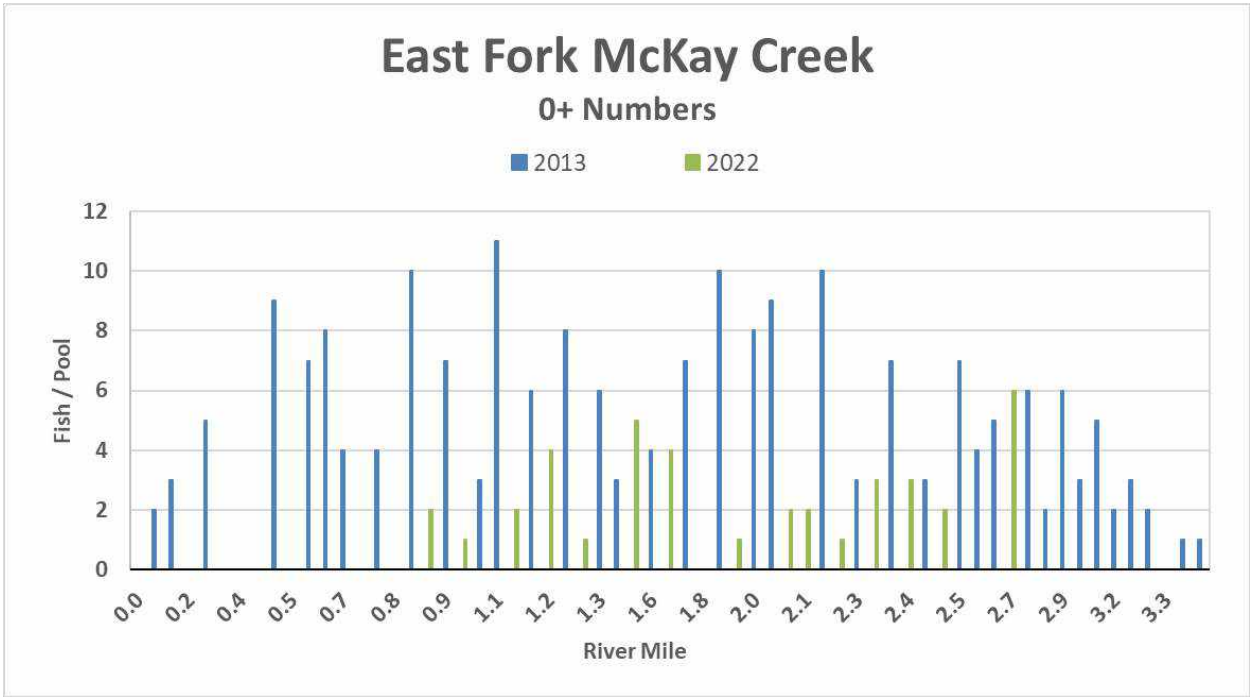


Table 49: EF McKay Creek – Expanded fish counts for all salmonid species by year

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2013	3,684	1.05	1,005	940
2022	5,862	2.17	195	525

Chehalem Mt Tributaries

The headwaters of McFee Creek originate in the Chehalem Mountains, a series of isolated remnants from Columbia River Basalt flows. This low elevation range rises steeply out of the deep unconsolidated sediments burying the Willamette Valley as a result of numerous inundations of catastrophic floods towards the end of the last ice age. This abrupt interface of geologic units, where low gradient silt dominated valley bottoms meet higher gradient scoured basalt uplands, is providing a limited range for the collection and sorting of mobile gravel and cobble substrates necessary for successful salmonid spawning within the stream reaches exhibiting adequate gradient and flow. Most of the drainages palmate once gradient increases, quickly diminishing flow and reducing the quality of habitat necessary for the summer rearing of salmonids. The lower reaches of these drainages predominantly support agricultural, livestock, and residential interests exhibiting a legacy of heavy impact on water quality and stream habitats.

17.45 miles of stream habitat in two primary subbasins (Chicken and McFee) was inventoried in 2014. The Mcfee subbasin exhibited the highest spawning and rearing potential of the 2014 inventoried Chehalem Mountain systems. A three-mile segment of Mcfee Creek and its primary tributary Heaton Creek was selected for a 2022 replicate inventory.

Stream	Coho	%	0+	%	Cut	%
McFee	1,181	60.0	10	10	150	40.5
Heaton	786	40.0	90	90	220	59.5
Subbasin Total	**1,967**		**100**		**370**	

Table 50: Chehalem Mtn Tributaries Subbasin 2022 Expanded Fish Counts for all Salmonid Species. Percentages are of total within the subbasin.

Stream	Coho	%	0+	%	Cut	%
McFee			48	87.3	74	98.7
Heaton			7	12.7	1	1.3
Subbasin Total			**55**		**75**	

McFee Creek

McFee Creek enters the Tualatin River at USGS RM 28.2. In 2022, the inventory started at RM 5 (0.4 miles upstream of Vanderschuers Rd crossing) extending 1.14 miles to an 8ft bedrock falls with shallow jump pool below, functioning as a permanent barrier to adult passage. A full replicate of the 2014 inventory was not completed due to landowner access denial in the lower 0.6 miles of stream habitat exhibiting significant anadromous spawning and rearing potential. The highest quality habitat was included in the 2022 replicate inventory. Additionally, a 1.8-mile reach of McFee Creek's primary tributary, Heaton Creek, was selected for the 2022 inventories.

Downstream of the 2013 start point limited spawning and rearing potential exists due to low gradient (0.18% average); silty alluvial deposits lacking spawning gravel; and increased summer temperature profiles. These habitat conditions, along with high tannins and turbidity limiting visibility, rendered inventory efforts further downstream impertinent.

Stream habitat was characterized by low gradient (avg. 0.4% increasing to 1.5% above RM 5.6 (McCormick Hill Rd); sinuous channel meander; dominant substrates of cobble, gravel, and silt; high solar exposure with thin riparian zone transitioning to mature coniferous canopy above RM 5.6; and cool summer temperature profiles (15.4°C) at the time of the inventory.

Six beaver dams were present in 2013, seven in 2022.Dam sizes ranged from 3in — 2ft. Beaver augmentation increased the rearing capacity of the inventoried reach providing an estimated 28% of total surface area of pool habitat while accounting for 12.28% of the total number of pools.

Speckled dace and abundant Western pearlshell mussel beds were observed throughout the inventory.

Anchor Sites:

No anchor sites were observed. Wide floodplains with deep channel incision was observed throughout the inventoried reach.

Photo 52 McFee Creek beaver dam above McCormick Hill Rd

Photo 53: McFee Creek Western pearlshell mussels

Coho

In 2013, Coho abundance was moderate with an average pool density of 0.62 fish/m² expanding to 733 fish/mile. The dominant density peak of 1.7 fish/m² was observed at RM 5.2.

No coho were observed in 2022.

Spawning Gravel and Adult Escapement:

Utilizing season to season survival rates developed for coho by the Nickelson / Lawson Coho model, 10 adult (combined male and female) coho escaped to McFee Creek to spawn in 2012. Estimated adult coho capacity based on spawning gravel availability was 14 — 40 coho. In 2012, McFee Creek was functioning far below its current spawning habitat capacity and limited by inadequate adult escapement.

Steelhead

Steelhead were not observed. Stream habitats in the upper half of the inventory were suitable for steelhead occupation.

Cutthroat

Cutthroat abundance was low in both inventoried years with an average densities 0.18 fish/m² (155 fish/mile) in 2013 and 0.04 fish/m² (65 fish/mile) in 2022. In 2013, a cutthroat density spike of 0.7 fish/m² was observed in the pool below the barrier falls.

0+ Trout

0+ trout abundance was extremely low in both inventoried years with sporadic pool presence at an average densities of 0.05 fish/m² (42.1 fish/mile) in 2022. 0+ trout were observed in only two sample pools in 2013.

Table 51: McFee Creek - Expanded fish counts for all salmonid species by year.

Year	Coho	Avg Coho/m^2	0+ Trout	Cutthroat
2014	1,181	0.5	10	150
2022	0	0	48	74

Minor Tributaries of McFee Creek

Heaton

Heaton Creek enters McFee Creek at RM 0.34. The 2022 inventory started at RM 1.4 (Rd crossing) extending 1.8 miles.

Stream habitat was characterized by low gradient (avg. 0.2%), high solar exposure, entrenched brushy banks, silt dominated substrate with limited gravel sorting, cool summer temperature profile (16.5°C), and high beaver activity. Visibility was very low throughout the entirety of the inventory reducing confidence in abundance estimates.

In 2013, coho were present in low abundances throughout a 2.6-mile reach (RM 1.24 — 3.64). No coho were observed in 2022. Cutthroat and 0+ trout abundance was very low with pool presence observed in only a few sampled pools.

13 beaver dams were present within the inventoried reach in both 2014 and 2022. Even in this extremely low gradient system beaver augmentation increased rearing capacity, providing an estimated 41.5% of the total pool habitats while accounting for 34.2% of total pool count.

Recommendations

- Address known manmade barriers to upstream migration in the forms of perched/failing culverts and reservoir dams lacking fish passage and impeding temperature dependent migration. Below Table 51 lists sites in order of priority.

Table 52: Tualatin Manmade Barriers to Fish Passage

Stream	River Mile	Priority Level	Details
Beaver Trib C	0.02	Med	Rusted out culvert perched 4in. All flow passing through rusted holes. Top of culvert caged in steel. Juvenile barrier
Beaver Trib C	0.23	Med	1.5 ft perched culvert, undercut and rusted out. Juvenile barrier.
Beaver Trib C	0.67	Low	Double barreled, steel 3 ft culvert set in creek. Top side of culverts getting packed with debris
Beaver Trib D	0.04	Low	4 ft culvert perched 2ft over boulders, Bad for adults and juveniles.
Beaver Trib E	0.01	Med	6 ft culvert perched 1.5ft over deep pool. Bad for juveniles but OK for adults. Water running under culvert.
Beaver Trib E	0.32	Med	2 new 5ft diameter side by side culverts perched about 3 inches with the stream running underneath culverts.
Burgholzer	0.78	Med	Rusted culvert perched about 15 inches with partial flow underneath. Juvenile barrier.
Buxton	0.05	Low	Culvert 3 ft diameter; rusted out.
Campbell	0.02	High	Campbell Creek enters EF Dairy through rusted out culvert perched 2.5 ft .
Coffee	0.01	High	Undersized culvert perched above steep boulders. Juvenile barrier and partial adult barrier.
Coffee	0.99	Med	Culvert undersized, flush in channel.
Finger	0.02	Low	Culvert bottom is heavily rusted and damaged rusted. Not perched yet.
Garrigus	0.22	med	5 ft rusted out culvert plugged with 2 ft beaver dam at top.

Stream	River Mile	Priority Level	Details
Heaton	0.00	Low	3 passage concrete culvert with fish ladder; partially blocked by wood. A potential juvenile barrier.
Iler	0.25	High	Concrete steps. Juvenile barrier
Low Divide	0.07	Low	8 ft culvert, slanted and perched 2 inches
Mendenhall	2.12	Med	6ft culvert undercut but set in creek. Top of culvert packed with debris and wood
Meadowbrook	0.27	Med	Culvert 3ft diameter, perched 3in
Meadowbrook	0.35	Med	Culvert 3ft plastic, set in creek
Paisley	0.89	Low	Culvert 5x6. rusted out 4" perch log jam with old legacy wood.
Paisley	1.00	Low	Culvert rusted out, flush in creek.
Plentywater	0.16	Low	Culvert 5ft tall and 4ft wide with concrete base. Juvenile barrier, OK for adults.
Prickett	0.26	Med	Seasonal irrigation dam made with two 2x10 boards pools water 2ft above concrete slab. Juvenile barrier.
WF Dairy Trib A	0.09	High	8-inch concrete sill on top side of culvert. Culvert perched about 6 inches. Probable juvenile barrier.
White 2013	0.02	High	Square concrete culvert ~5X5 ft, perched 1 ft. Juvenile barrier.

- LWD treatments in mainstem and tributary reaches that displayed the potential for significant fish production first and lesser reaches second. Prioritization focuses on protecting and enhancing those remnant habitats that currently exhibit the highest function and morphological potential (Anchor Sites). This stabilizes populations in their current anchors so that expansion from these high priority reaches can be achieved. These efforts would be designed to: dissipate hydraulic potential during winter flows; increase the frequency and size of pools; provide complex cover; aggrade mobile gravels to boost spawning and incubation habitat; and for smaller tributaries with less potential for fish production, build deep accumulations of bedload that are capable of developing a hyporheic lens of summer flow to mitigate for elevated mainstem

temperatures. Below Table 53 lists all documented anchor sites with prioritizations for restoration based on highest coho production.

Table 53: 2022 Anchor Sites Identified in Tualatin Basin

Stream	*Anchor Site #	Function Level	*Priority for Restoration
Tualatin Subbasin			
Tualatin	1	Low	
Gales Subbasin			
Gales	1	Low	X
Gales	2	Low	X
Gales	3	Moderate	
Gales	4	Moderate	X
Gales	5	Moderate	PT
Gales	6	Moderate	PT
Gales	7	High	PT
Gales	8	Moderate	PT
Gales	9	Moderate	
Coffee	1	Moderate	X
Coffee	2	High	
Iler	1	Moderate	X
Iler	2	Moderate	X
Iler	3	Moderate	
NF Gales	1	Moderate	PT
NF Gales	2	Moderate	PT
NF Gales	3	Moderate	
EF Dairy Subbasin			
EF Dairy	1	Moderate	
EF Dairy	2	Moderate	X
EF Dairy	3	Moderate	PT
EF Dairy	4	Low	PT
EF Dairy	5	Moderate	PT
EF Dairy	6	Moderate	X
EF Dairy	7	Moderate	X
Denny	1	Moderate	X
Denny	2	Low	X
Denny	3	High	
WF Dairy Subbasin			
WF Dairy	1	Moderate	X
Burgholzer	1	Moderate	
Burgholzer	2	Low	

Stream	*Anchor Site #	Function Level	*Priority for Restoration
Paisley	1	Moderate	
Paisley	2	Low	
Paisley	3	Low	
Garrigus	1	Moderate	X
Garrigus	2	Moderate	X
Garrigus	3	Moderate	X
Garrigus	4	Low	X
Mendenhall	1	Low	X
Mendenhall	2	Low	X
Mendenhall	3	Moderate	
Whitcher	1	Moderate	
Whitcher	2	Moderate	X
Williams	1	Moderate	X
Williams	2	Moderate	
McKay Subbasin			
Mckay	1	Moderate	X
McKay	2	Moderate	X
McKay	3	Moderate	X
McKay	4	Moderate	
Brunswick Canyon	1	Moderate	
EF McKay	1	Moderate	X
EF McKay	2	Moderate	X
EF McKay	3	Moderate	X
EF McKay	4	Moderate	X

*Anchor Sites #'s are assigned from the confluence, upstream. Thus, Anchor Site 1 is always downstream of Anchor Site 2.

*PT references previously treated reaches within anchor sites. These sites would otherwise be high priorities for restoration.

- Expand complexity and the refuge surface area of pool habitats in tributaries, at tributary confluences, and in backwaters where fish populations are concentrating to seek thermal refugia during peak summer temperatures. These dependable sources of cool water are critically valuable to all salmonid species and can accommodate multiple age classes for use as refugia during high temperature periods. Preemptive treatments should be considered in locations that haven't yet exhibited fish density increases but have potential to offer thermal refugia in the future given the likelihood of temperature profiles increasing due to climate change. Increasing the complexity and rearing capacity of these identified habitats is a high priority. This strategy may include anchoring of root wads that remain oriented in the confluence plume for cover; full spanning log structures with rootwads intact; and boulder structures. These strategies should be designed to provide refuge in the form of cover; increase scour and size of pool habitats; and lower velocity to reduce mixing of cool water contributions with mainstem flows. Below is a list of prioritized sites.

- Gales Creek Mainstem backwater at RM 11.6 (Anchor Site #1): Large backwater collecting cold hyporheic flows from floodplain
- Iler Creek confluence: both in Gales mainstem and in lower 0.25 miles of Iller Creek (treatments could extend further if concrete steps are removed)
- White Creek confluence: both in Gales mainstem and lower 0.2 miles of White Creek (provided perched culvert is replaced)
- Bateman Creek confluence: Gales mainstem at confluence and lower 0.1 miles of Bateman Creek
- Campbell Creek confluence: EF Dairy mainstem and lower 0.2 miles of Campbell Creek (provided culvert is replaced)
- Cummings Creek confluence: WF Dairy mainstem and lower 0.1 miles of Cummings Creek
- Mendenhall Creek confluence: WF Dairy mainstem and lower 0.25 miles of Mendenhall Creek
- Williams Creek confluence: WF Dairy mainstem and lower 0.2 miles of Williams Creek
- Panther Creek, Roundy Creek, Rock Creek and Big Canyon Creek: EF Dairy mainstem at these tributary confluences that provide high volumes of cold water.as preemptive measure

- The RBA has provided temperature data and fish distribution trends that suggest summer temperature limitations are increasing in several mainstem reaches. Consider the future deployment of thermistors to validate relationships documented in this inventory between lethal mainstem temperature profiles and key thermal refugia as well as tracking year to year increases in mainstem temperatures. Additional temperature data will be critical in crafting a basin scale restoration plan that addresses actual seasonal habitat limitations and will establish a baseline for recovery monitoring. To record the full seasonal temperature range, data loggers should be deployed early in the season by June 1rst. A paired deployment of data loggers (one in tributary and one in mainstem above tributary confluence) would be the most effective in capturing temperature differentials. The highest priority confluences and mainstem locations are listed below.
    - Clear Creek (Gales)
    - Iler Creek (Gales)
    - White Creek (Gales)
    - Bateman Creek (gales)
    - EF Dairy mainstem RM 9.24 (Dairy Creek Rd)
    - Big Canyon Creek (EF Dairy)
    - Murtaugh Creek (EF Dairy)
    - Denny Creek (EF Dairy)

    - Mendenhall (WF Dairy)
    - Williams (WF Dairy)
    - EF McKay Creek (McKay)

- Consider the importance of the tributaries identified in this document as critical cold-water contributions and thermal refugia, as well as warm-water contributions, an important upslope management objective. Develop a strategy to encompass these streams (no matter their size) and their headwaters in a conservation easement for protecting and enhancing high value thermal refugia for resident and anadromous salmonids. Tactics should include: Focused riparian planting in areas of weak riparian; conservation easements to expand the riparian buffer on type N stream channels in the headwaters to protect water quality and quantity; removing impoundments that surface spill and elevate stream temps; and establish instream water rights for stream segments with excessive water withdrawals. A complete inventory of tributary flow contributions (volume / temperature) would be required to prioritize all high value targets.
- Establish an annual snorkel inventory in a subset of the highest quality reaches of aquatic habitat to monitor trends in salmonid abundance over time. Conduct these surveys at an identical time each year.

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