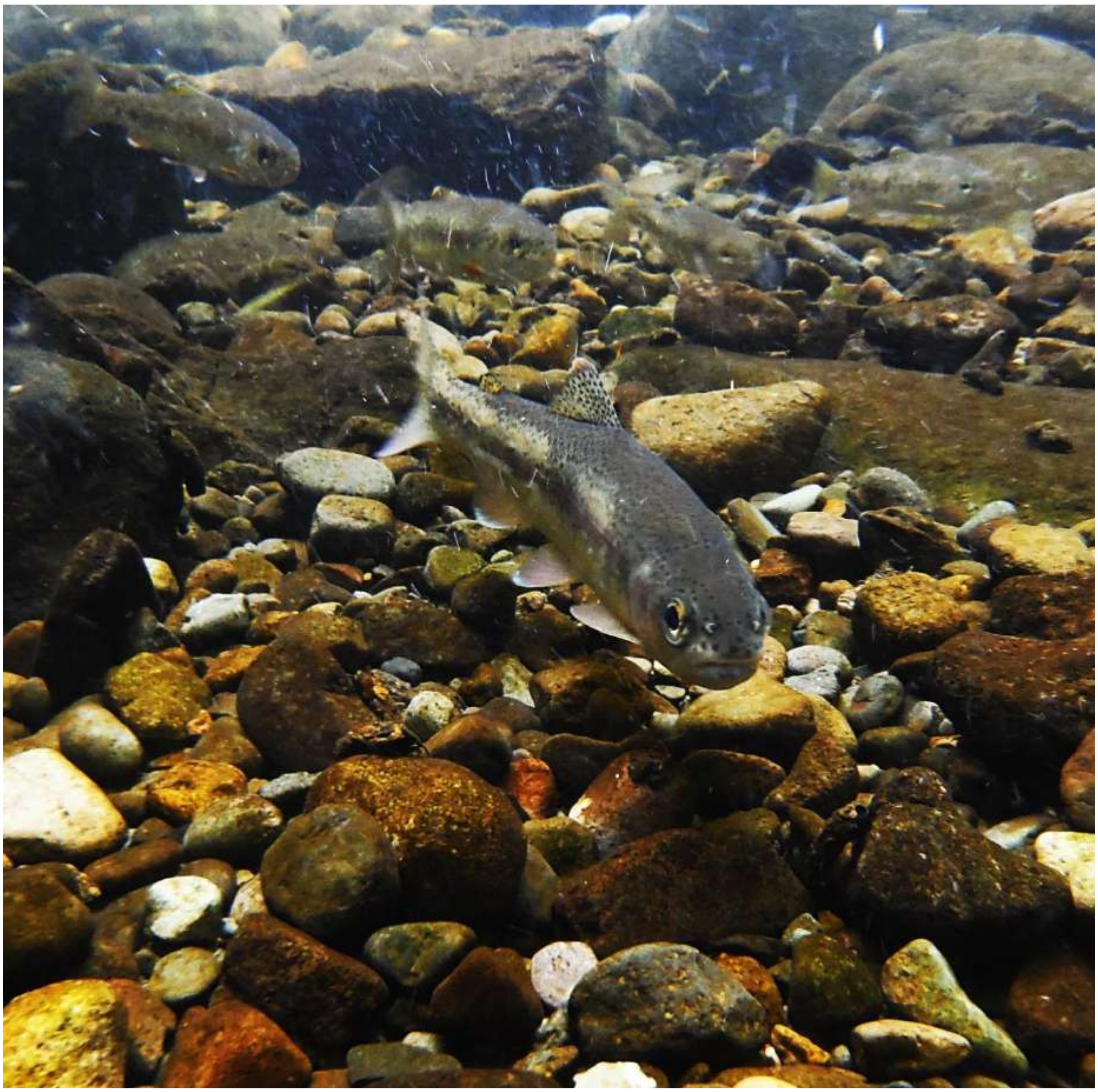
2015

Calapooia RBA



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Introduction

The 2015 Rapid Bio-Assessment inventory of the Calapooia basin covered 37.2 miles of stream habitat. The effort encompassed all of the mainstem and tributary habitats, upstream of the Holley Bridge (USGS RM45.5). Tributary inventories extended to the end of significant rearing potential for anadromous salmonids. In addition, a spring chinook resting count inventory encompassing the same mainstem reach and an additional 9.5 miles downstream to the deconstructed Brownsville Dam site (USGS RM36) was conducted in an attempt to quantify the abundance of adult Spring Chinook returning to the basin to spawn. An inventory of spawning gravel abundance was also conducted in the 30 miles of mainstem and tributary stream habitats exhibiting any anadromous potential (only spawning gravel sites appropriate for steelhead were quantified).

The Calapooia River enters the Willamette River at USGS RM 119.5. Historically the Calapooia marked the upper end of winter steelhead distribution in the Willamette Basin. The WLC-TRT identified four historical demographically independent populations for UWR (above Willamette falls) winter steelhead: the Molalla, North Santiam, South Santiam, and Calapooia (Myers et al. 2006). These population delineations were based on geography, migration rates, genetic attributes, life history patterns, phenotypic characteristics, population dynamics, and environmental and habitat characteristics (McElhany et al. 2000). Estimated contributions of the Calapooia to the total Upper Willamette basin winter run steelhead population vary among sources with current modeled abundances between 4.5% and 6%, and historical abundance at 8% (Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. NOAA, Seattle. ODFW. 2005. 2005 Oregon native fish status report. ODFW, Salem, OR.). The Calapooia is the only one of the four independent populations with winter run steelhead that has had no direct hatchery supplementation (stray potential from other basins is thought to be less than 5%).

Historically the Calapooia floodplain covered a far broader area with winter flow events filling numerous side channels and wide winter wetlands across the valley floor. So dynamic and wide was the floodplain that early settlers to the valley chose to build in the foothills (Calapooia River Watershed assessment 2004). Early loggers "improved" the river for log drives. This practice "eliminated sloughs and minor courses, removed trees and debris, tore out drifts...." (Boag 1992). The manipulation of the river forced the river into a narrower channel, separating it from the floodplain, which 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, over the years, numerous dams, ditches, and flow diversions have further modified stream habitats and blocked or complicated salmonid access to thermal refugia and spawning grounds. This ultimately led to the extirpation of native spring chinook from the basin. The legacy of these modifications has permanently reduced the spawning and rearing capacities of the basin with salmonid life history diversity and over all abundance greatly suffering.

Water quality issues within the Calapooia basin may also be limiting anadromous salmonid abundance and/or adversely affecting resident fish and aquatic food web relationships. The DEQ conducts assessments of water quality in Oregon to meet the federal Clean Water Act Sections 305(b) and 303(d) requirements and report on conditions in Oregon's surface waters. Water bodies where standards are not met are identified as water quality limited in their Integrated Annual Report and are assigned a status of either Category 4 or Category 5. The

Calapooia mainstem was sited with several water quality limitations including three Category 5 303(d) listings for: biological criteria (year-round, RM 0-69.2); dissolved oxygen (1/1-5/15, RM 0-31.2); and iron (year-round, RM 0-78). In addition, recent delisting's for three Category 4A listings made for temperature: year-round, RM 0-35.7; 9/1-6/15, RM 35.7-72.4; and year-round core cold water habitat, RM 35.7-78 show current improvements but the legacy of their impacts likely continue to influence system function. These conditions are known to affect resident fish, aquatic life, anadromous fish passage, salmonid spawning, and juvenile salmonid rearing and migration (DEQ Water Quality Oregon's 2012 Integrated Report). The listing of "Biological Criteria" is not a measurement of any pollutant but quantifies numerical values or narrative expressions that describe the biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use (Oregon DEQ, TMDL: Appendix H (Biological Criteria). The criteria are: 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 intent of this project was to quantify the distribution and relative abundance of all juvenile salmonid species during pinch period summer low flow regimes that are known to truncate their distribution as a function of elevated stream temperature. The inventory consisted of snorkel surveys that began in the mainstem at USGS RM 45.5 and at the mouth of each tributary. Surveys continued to at least the end of the current distribution of steelhead and therefore describe the full extent of distribution for steelhead in 2015. The surveys did not extend to the end of cutthroat distribution. The surveys are intended to establish base-line distribution and abundance metrics, provide a foundation for long term trend analysis, identify anchor habitats and guide future restoration and management actions.

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

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

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

1) The abundance of anadromous fish fell substantially short of full seeding capacities in both mainstem and tributary habitats.

2) The only evidence of spring chinook (adult or juvenile) presence within the inventoried portion of the basin was a single jaw bone observed in a mainstem pool. This verified the presence of at least 1 returning adult spring chinook.

3) O.mykiss are by far the most abundant salmonid species.

4) Broad and shallow active channels, high solar exposure, and inadequate riparian buffers were consistently documented in lower mainstem reaches

5) 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 its tributaries.

6) Mainstem summer temperature limitations and the lack of access to thermal refugia is severely limiting summer rearing potential in a majority of the mainstem Calapooia. The presence of these durable elevated temperature profiles during pinch period summer flows is driving large scale temperature dependent fish migrations.

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

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

It’s important to clarify that two different metrics for location are utilized in this assessment for describing specific fish distributions. This was necessary because the mainstem inventory began above the actual river mouth. For management actions and for all of 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 data base and the Excel Pivot table that archive all of the recorded data have been described in lineal feet above the survey start point. The use of USGS RM estimates was not required to georefference any of the tributary inventories because all the tributary surveys began at RM 0.0.

Methods

Snorkel survey crews conducted RBA surveys between July 20 and August 10 of 2015. Land owner contacts were made for all of the small private, industrial and public ownerships that existed on both sides of every stream reach surveyed.

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

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

In sub-basins with low rearing densities, there were situations where steelhead 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 very minor, isolated populations of juvenile steelhead could be overlooked in head water reaches of small 2nd order tributaries.

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

Distances reported in the Access database are from the beginning of one sampled unit to the beginning of the next sampled unit. The length of the sampled pool is an independent quantity, which was also measured and not estimated. Total distances represented in the database are consistently greater than distances generated utilizing a GIS measuring tool on a GIS stream layer (regardless of projection). This is related to the level of sinuosity within the floodplain that is not projected in GIS base map layers. If you are attempting to overlay this database on existing stream layer information there would be a need to justify lineal distances with known tributary junctions (these can be found in the comments column of the Access database). Comparisons of lineal distance have not been made between the RBA field data and a LIDAR base layer. We would expect the differences to be less significant between these two platforms.

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

The snorkeler entered the pool from the downstream end and proceeded to the transition from pool to riffle at the head of the pool. In pools with large numbers of juveniles of different species, multiple passes were completed to enumerate by species. (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.

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

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

The following criteria were utilized:

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

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

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

<u>Visibility</u>

1	excellent
2	moderate
3	poor

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

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

There was also commentary recorded within each of the surveyed reaches that included information on temperature, tributary junctions, culvert function, the abundance of other species and adjacent land use. This commentary is included in only the raw Access database under the "comments" field.

Distribution profiles

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

Average Pool Densities and Seeding Levels

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

To understand how any particular stream reach is functioning in relation to its potential, it is desirable to compare the observed densities of salmonid species to some known standard. The term full seeding is utilized to represent a density of juvenile salmonids that are rearing near the habitats capacity. The carrying capacity of habitats varies seasonally in relation to food abundance, adjacent pool / riffle ratios, flow, temperature and the species tolerance to interspecific competition. The interaction of this multitude of values is highly complex and unquantifiable at the level of this RBA inventory. Therefore, we can only comment on seeding levels as they relate to standards observed from a combination of many other stream systems in many geographically unique locations. This renders all discussions of carrying capacity in this document subjective. Any discussion of carrying capacity in the following text is an attempt to highlight the lows and highs within a range of observed values and to use a modicum of professional judgment to help steer comparative analyses in a direction that facilitates the decision making and prioritization necessary to guide restoration.

Within the Calapooia basin cutthroat densities between the range of 0.8 and 1.91 fish / sqm were documented as the top end of the observed range. This high range was observed only in a few tributary pools and with only one exception, existed above anadromous fish distribution (no interspecific competition). Observations within this density range represented 14.1% of all cutthroat observed. Two very unique and high value pools were responsible for 70% of the cutthroat observed in this range and thus did not represent the average pool (quality). A more representative upper end of the density range would rest between 0.2 and 0.6 fish / sqm which accounted for 29.9% of all cutthroat observed. This range, with the exception of one pool, was exclusively distributed in tributary and side channel habitats only. This range fits within the normal observation of full seeding where interspecific competition for rearing habitat exists. Steelhead densities were similar with a top end range between 0.2 and 0.4 fish / sqm (aggregated densities of both steelhead and cutthroat exhibiting full seeding characteristics in the 0.8 -1.0 fish/ sqm range). The steelhead in the 0.2 - 0.4 fish / sqm range represented 19.8% of all steelhead observed and existed in a mix of the highest value mainstem, side channel, and tributary reaches. Density profiles were not calculated for the resident rainbow population, due to their relative low values. Because the habitats ability to rear older age class salmonids is heavily influenced by fish size, available pool surface area and food availability, we assume that in zones of cohabitation by steelhead/rainbow and cutthroat that the combined densities of these similar sized species would not exceed the 0.8 -1.0 fish /sqm observed in the highest quality habitats of the system. Observations in many thousands of miles of both Willamette and coastal streams suggest that densities above 0.7 fish / sqm for older age class steelhead or cutthroat without competition from the other are rare.

For the 0+ age class, there were 243 pools in 2015 within the inventory that contained young of the year fry (combined steelhead / cutthroat). 17 of these pools exhibited the highest observed densities in the inventory between 1 and 1.58 fish / sqm. 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 / sqm. The similar habitat characteristics observed in the Calapooia basin to many other watersheds suggests that the 3 fish / sqm 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 Location

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

Spawning gravel abundance

Spawning gravel was quantified throughout 30 miles of combined mainstem and tributary habitats. This inventory was conducted for 2 reasons, to test the hypothesis that wild winter steelhead in the Calapooia basin could be limited by the abundance of spawning gravel and to map the distribution of functional spawning gravel. The effort targeted only gravels appropriate for steelhead and did not include the larger diameter gravels utilized by spring 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 utilized;

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 1sq 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 were quantified.

The criteria utilized by ODFW's OASIS program documented in their Coastal Steelhead Spawning Survey Procedure Manual, 2011 describes the typical steelhead redd as 2-3.5 sqm in area and any redd less that 2 sqm as atypical. Some of this variation exists because steelhead, unlike coho are known to spawn in both large and small stream orders. Because the intent of the spawning gravel inventory in the 2012 RBA survey 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 1sqm of gravel as the minimum area for all tributary habitats and 2 sqm for the mainstem.

Adult and Juvenile Barriers

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

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

Temperature Dependent Migrations

Potential temperature dependent migrations can be observed in the database by looking for densities that decrease significantly as the lineal distance increases from the mouth of the stream or tributary. This is more likely to be observed in low abundance years where tributary habitats that are seeded to capacity are the exception. During years of high abundance there is a more significant potential for density dependent upstream migrations that would be indistinguishable from the distribution pattern mentioned above. The recognition of this migration pattern allows us, during years of low escapement, to identify important sources of high water quality within the basin that may be traditionally overlooked because of some other morphological condition that suggests to us that there is no significant potential for rearing salmonids (i.e. lack of spawning gravel). These reaches typically exhibit declining densities with increased distance from the mouth and no indication of a spawning peak (a point near the upper distribution of the population with significantly higher rearing densities of the 0+ age class). These tributaries may be functioning as important summer refugia for salmonid juveniles threatened by increasing temperatures in the mainstems. Several significant temperature dependent juvenile migrations were observed in the Calapooia system in 2015. These migrations will be discussed within the document in each stream where the behavior is occurring.

Precautions

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

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

(Table 1): ODFW Lobster Creek Survey

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

General Observations

Calapooia River System

During the summer of 2015 the combined age classes of juvenile O. mykiss (0+, 1+, and 2+) were the most abundant salmonid species rearing in pool habitats throughout the Calapooia River basin. In addition, O. mykiss distribution was widespread with a strong presence even in lower mainstem habitats extending as low as the Holley Bridge (USGS RM45.5).

Resident rainbow adults are also present in low abundance. An expanded population estimate of 325 older age class adults was generated from the 20% census that occurred in the surveyed portion of the basin (Holley Bridge to the anadromous barrier at RM 72.9). Because these are larger, older age class fish (3+ or older), we are assuming that limited riffle / rapid habitats are utilized for summer rearing. This suggests that the 20% sample of all pool habitats is a valid sampling strata for estimating the abundance of resident O. mykiss adults.

Because younger age class rainbow are indistinguishable from juvenile steelhead no formal estimate of juvenile resident rainbow could be produced. In addition, it would be safe to assume that some of the juvenile steelhead quantified within this inventory would eventually display a resident rainbow life history and consequently not all the O. mykiss classified in this document as steelhead will exhibit anadromy.

Table (1)

Stream	0+	%	Sthd	%	Cut	%	Rainbow	%
Calapooia	**14,295**	**79.7**	**4,865**	**96.2**	**1,715**	**55**	**325**	**100**
Side Channels A-C	356	2	39		51	1.6		
Trib A	15				10			
Trib B	255	1.4	5		90	2.9		
Trib C	135				10			
Trib D	85				60	1.9		
Biggs	315	1.8	25		195	6.2		
Blue	180	1	5		60	1.9		
Hands	315	1.8			75	2.4		
McKinley	100		10		20			
NF Calapooia	**905**	**5**	**45**		200	6.4		
Trib A	140				65	2.1		
Potts	**745**	**4.2**	**65**	**1.3**	**525**	**16.8**		
Trib A	95				25			
Treadwell	5				30			
United States	100				15			
Total	**17,946**		**5,059**		**3,121**		**325**	

Spawning Gravel abundance and distribution

The 2015 RBA inventories noted a pervasive lack of high quality spawning gravel in headwater tributaries of the mainstem Calapooia. A supplemental sampling effort covering 30 miles of mainstem and tributary habitats was conducted in an attempt to quantify the abundance of spawning gravel appropriate for spawning steelhead. Survey on the mainstem began at RM 50.9 and extended 22 miles 22.8 stream miles to the anadromous barrier at RM 72.9. The remaining 8 miles 7.2 miles of inventory where distributed within the tributaries exhibiting the greatest potential (see table 2). This effort was testing the hypothesis that the abundance of the appropriate sized gravels for spawning and incubation could potentially limit steelhead production. Many reviews of habitat variables in the contemporary literature refer to the abundance of spawning gravel as seldom the primary habitat limitation for adult salmonids. Quantitative measurements of this key habitat variable however are rarely included in these analyses and an invalid assumption is possible.

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 gravels are not randomly distributed. Their distribution is driven primarily by gradient, channel form (sinuosity and entrenchment), dominant bed form (sandstone / basalt) and watershed area. Large watershed areas develop greater hydraulic potential during winter flow regimes and are capable of transporting large volumes of alluvium to lower gradient stream reaches. This in general describes the Calapooia and its primary headwater tributaries (NF Calapooia / Potts Cr).

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 appropriate sized gravels for spawning is the reason 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 over estimate adult spawner abundance. This has been commonly done historically in other basins to estimate the run size of winter steelhead.

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 conifer would have historically existed in the tributary network of the Calapooia as well as select mainstem reaches. Survey records from U.S. Bureau of Fisheries inventories in the 1940’s noted numerous log jams throughout the mainstem channel with one reportedly 100 yards long (around USGS RM62) then thought to be an anadromous barrier, (McIntosh et al. 1990). 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. Much of the wood in the Calapooia was removed by extensive log drives beginning in at least 1878 and extending through at least 1911(Farnell 1980). What remained would have been lost in the catastrophic winter flows of 1964. The systems inability to replace this wood (limited wood delivery potential from either upslope debris flows or riparian canopies) currently cripples the recovery of system function.

Could this contemporary decline in channel roughness (historically provided by large wood) and the resultant reduction in the abundance of headwater spawning gravels impact the capacity of the system to produce salmonid juveniles? The results of the spawning gravel inventory for the Calapooia and its headwater tributaries are presented in table 2.

Table (2)

Stream Segment	Spawning Gravel (sqm)	Potential redds (>1sqm for tribs) (>2sqm mainstem)	Estimated Female sthd (1.5redds/female)	Estimated adult carrying capacity 1:1 m/f ratio
Calapooia	510	255	170	340
Side Channel B	22	22	15	30
Biggs	0			
Blue	3	3	2	4
Hands	2	2	1	2
King	9	9	6	12
McKinley	1	1		
NF Calapooia	11	11	7	14
Potts	20	20	13	26
Trib B	0			
Trib C	6	6	4	8
United States	7	7	5	10
TOTAL	**591**	**336**	**223**	**446**

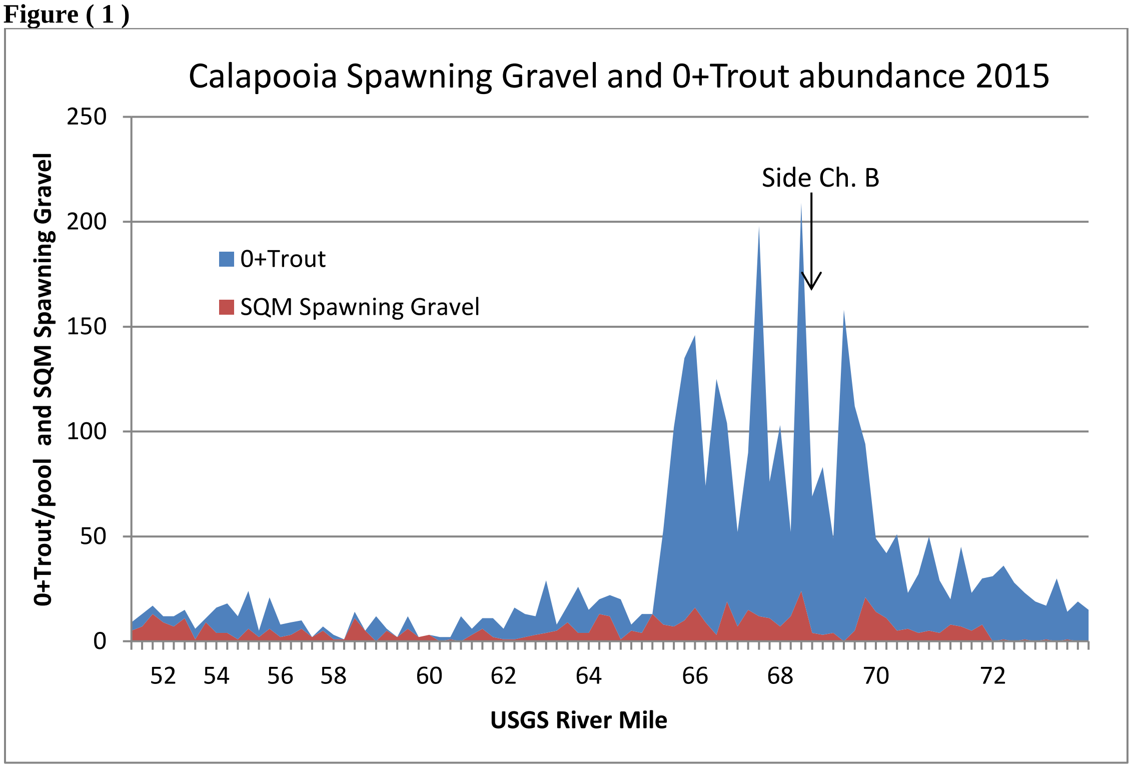
- Only mainstem Calapooia gravels above USGS RM50.9 were included in this analysis. Abundant gravels exist below this point but the likelihood of them contributing significantly to sthd smolt production are low because of summer temperature limitations and increased predation from warm water invasive species.
- 1.5 redds / sthd female grand mean from ODFW West Fk Smith River Life Cycle Monitoring Study

The adult capacity of 446 summarized in Table 2 is a generous estimate that utilizes a minimum redd size of 1 sqm for all tributaries, well below the norm for steelhead redd observations (2sqm minimum, ODFW Coastal Steelhead Spawning Survey Procedure Manual, 2011). We elected to drop the minimum to 1 sqm because tributaries contained very few 2 sqm patches of gravel yet steelhead were present suggesting utilization. The estimate was calculated utilizing a minimum redd size of 2 sqm for the mainstem (ODFW CSSS). The final estimated carrying capacity of 446 adults is very close to the current modeled abundance of 415 presented in the Upper Willamette Recovery Plan (2011).

Testing the hypothesis that the abundance of spawning gravel could potentially limit the Calapooia basin capacity for producing wild steelhead smolts appears to be a viable hypothesis.

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 us in the development of future monitoring and restoration planning.

Figure (1)



Based on the distribution of the 0+ age class of trout displayed in figure 1 (which includes 0+ age steelhead, resident rainbow and native cutthroat), it appears that most spawning in the mainstem Calapooia is occurring between RM 65 and RM 71. Side Channel B (also in this zone) contributes an additional 338 0+ trout and 22 sqm of spawning gravel to this peak production area. What appears to be underutilization of the spawning gravel resources around USGS RM 64 and USGS RM 52 is likely due to any one of these 3 conditions; 1) upstream juvenile migration of the 0+ age class out of the temperature limited mainstem habitats in search of cold water refugia (assumes that spawning is occurring here), 2) high 0+ mortality from existence of thermal barrier (assumes that spawning is occurring here), 3) under seeded by spawning adults (no spawning is occurring here).

Within this peak production zone are the confluences of Potts Cr (USGS RM 65), King Cr, and NF Calapooia (USGS RM 69.9) indicating potential contributions to mainstem rearing abundance is emanating from these tributaries also. King Cr was the only tributary (above USGS RM 45.5) exhibiting anadromous potential that was not included in the snorkel inventory due to sampling decisions that prioritized additional mainstem inventory miles to describe the end of anadromous steelhead distribution. A one mile reach of King Cr was included in the spawning gravel inventory revealing no adult barriers to passage and higher spawning capacity (9 sqm of gravel) than other tributaries of its size and gradient (average 7.1%). Uncommonly high wood complexity was observed with full spanning remnant conifers interacting with the channel, storing and sorting spawning gravel.

Figure 1 informs our understanding of both the spatial distribution of spawning gravel and its current use. Clearly if spawning gravels exist but steelhead are not utilizing them for spawning or the spawning that is occurring is resulting in low egg/fry survival rates, then all spawning gravels are not of equal significance (see recommendations).

The total stream miles currently being utilized by adult steelhead for spawning in the Calapooia and its tributaries is approximately 26 (this estimate assumes limited steelhead spawning potential exists below USGS RM 50 based on the absence of the 0+ age class observed in the RBA in 2015). Historically cooler summer stream temperatures would have extended summer rearing potential further downstream where additional spawning gravel resources exist. A survey conducted in1958 from the town of Holley (USGS RM 45.5), to the mouth of Potts Creek (USGS RM 65) documented 73 steelhead adults (live and dead) and 427 redds (Willis et al. 1960). No direct contemporary comparison of spawning potential exists because the 2015 spawning gravel counts began at RM 50.9. However, based on the current distribution of the 0+ age class (few or none below USGS RM 50) and an overall low abundance below the confluence of Potts Cr (USGS RM 65) it appears that either spawning is limited (low adult escapement), spawning is unsuccessful or fry mortality rates are currently high in this historically functional stream segment.

Habitat quality (in the Calapooia system) has declined over time related to changes in the delivery and storage of large wood, modifications in gravel deposition, a reduction in the frequency and depth of pools, a reduction in hiding cover for adult and juvenile fish, and a reduction in functional spawning areas (WRI 2004). The lack of large wood complexity in almost all of the Calapooia and its tributaries is the fundamental missing building block that historically would have influenced all of these variables. The lack of wood complexity results in the net transport of spawning gravels out of reaches exhibiting the optimum gradients for storing and sorting gravels to low gradient reaches where it is more likely to be burdened with silt and sediment and higher summer temperature profiles that reduce salmonid survival. A Weyerhaeuser evaluation of riparian conditions along the main channel and other fish bearing tributaries of the Calapooia done in 1998 found that 64% of riparian zones are bordered by vegetation that has low near term potential for providing LWD and only 14% of channels were bordered by stands that had high current potential for providing LWD.

SITE SPECIFIC OBSERVATIONS

Site specific observations within this document have been organized into mainstem, side channels, and significant tributaries reviewed in alphabetical order. Following each major heading is a summary table that lists its contribution to salmonid production by species.

These production estimates are based on an expansion of the 20% snorkel sample in pools only and therefore do not constitute an entire production estimate for the basin. These estimates greatly under-estimate the standing crop of 0+, steelhead, and cutthroat because a significant component of their summer population is rearing in riffle/rapid and glide habitats that were not inventoried. In addition, there is also production for cutthroat that extends upstream beyond the end-point of most surveys. The information below can be utilized to establish a baseline for trend monitoring for subsequent survey years on the basin scale and by tributary. It also provides a comparison of the relative production potential between tributaries that can be utilized as a foundation for prioritizing restoration actions (some streams play a much more significant production role).

Calapooia Mainstem

The Calapooia Mainstem inventory included 29.1 miles of stream habitat beginning at the Holley Bridge (USGS RM 45.5) and extending upstream to USGS RM 74. Anadromous salmonid distribution extended to a 9ft. bedrock falls at USGS RM 72.9. Low salmonid abundance was documented throughout the majority of the inventory with the only stream habitats observed near full capacity being those of one side channel, a few small pockets of cold water refugia, and a 4.5 mile section of the upper mainstem above the confluence of Potts Cr (USGS RM 65). During the summer of 2015, the Calapooia mainstem (including its side channels) was rearing most of all the salmonids observed in the inventoried portion of the basin totaling: 81.6% of all 0+ trout parr, 96.9% of all steelhead (age classes 1+, 2+), 100% of resident rainbow (3+ and older), and 56.6% of all cutthroat.

Summer salmonid distribution patterns describe the existence of 3 distinct stream segments (figure 2). These morphologically and biologically distinct segments are described as follows; 1) a 10.5 mile reach extending from the start point at the Holley Bridge (USGS RM 45.5) to approximately 1 mile above the Weyerhaeuser gate (USGS RM 56), this segment encompasses the downstream beginning of anadromous fish distribution, contained a small (secondary) spawning peak of 0+ age class trout, and contained critical areas of thermal refugia where the highest abundance of older age class fluvial cutthroat were observed; 2) a 9.5 mile reach extending to USGS RM 65.5 (just above the confluence of Potts Cr.), exhibited very low salmonid abundance, severe summer temperature limitations, lack of any significant thermal refugia and low pool complexity. This reach is effectively serving as an upstream thermal barrier to salmonids winter rearing in the lower mainstem and engaged in thermoregulatory migration behavior in the summer; and 3) the remaining 8.5 miles of the upper mainstem, contained the bulk of the summer rearing salmonids, the highest quality spawning and rearing habitats, the coolest stream temperatures and the physical limitation to anadromous distribution (falls). In depth discussion of the habitat qualities and fish distribution patterns observed in these three reaches is continued below.

Figure (2)

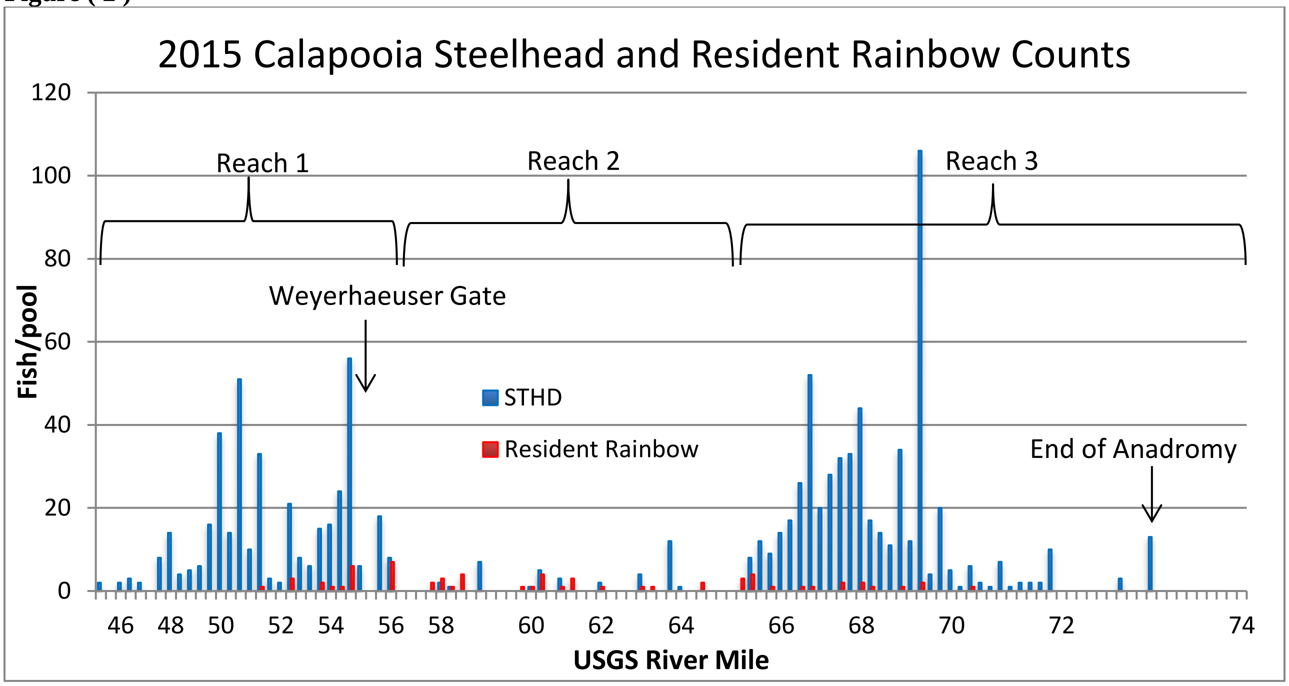


Figure (3)

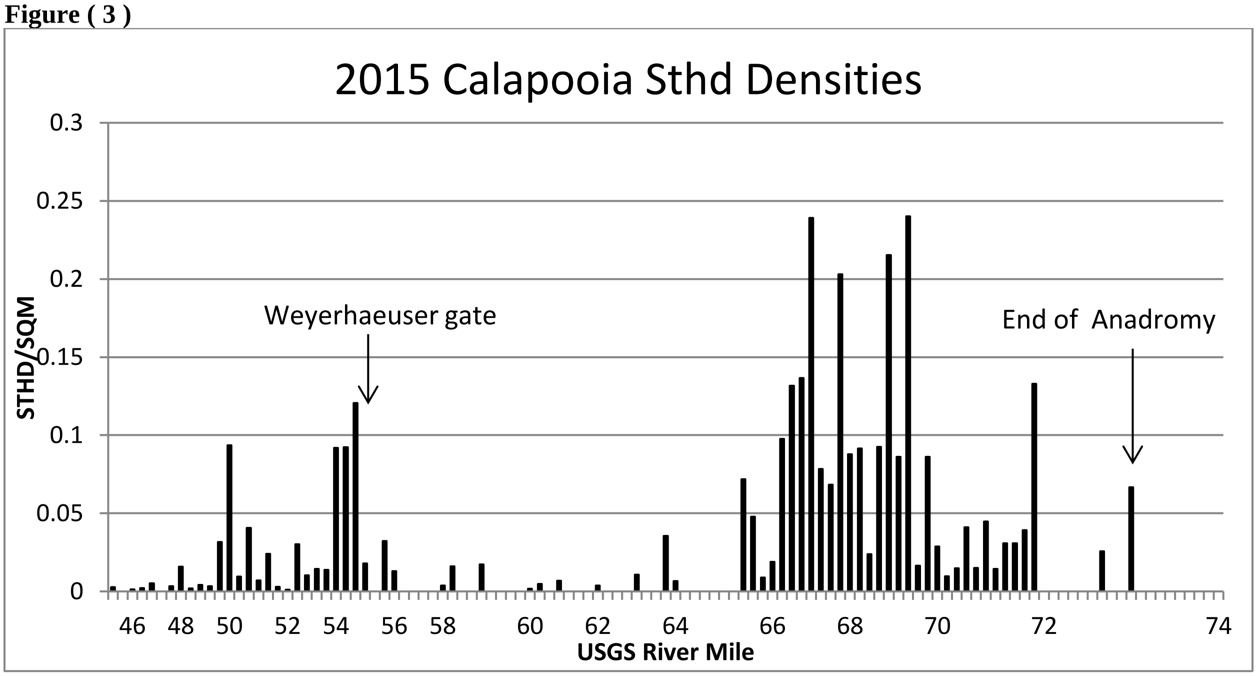


Figure (4)

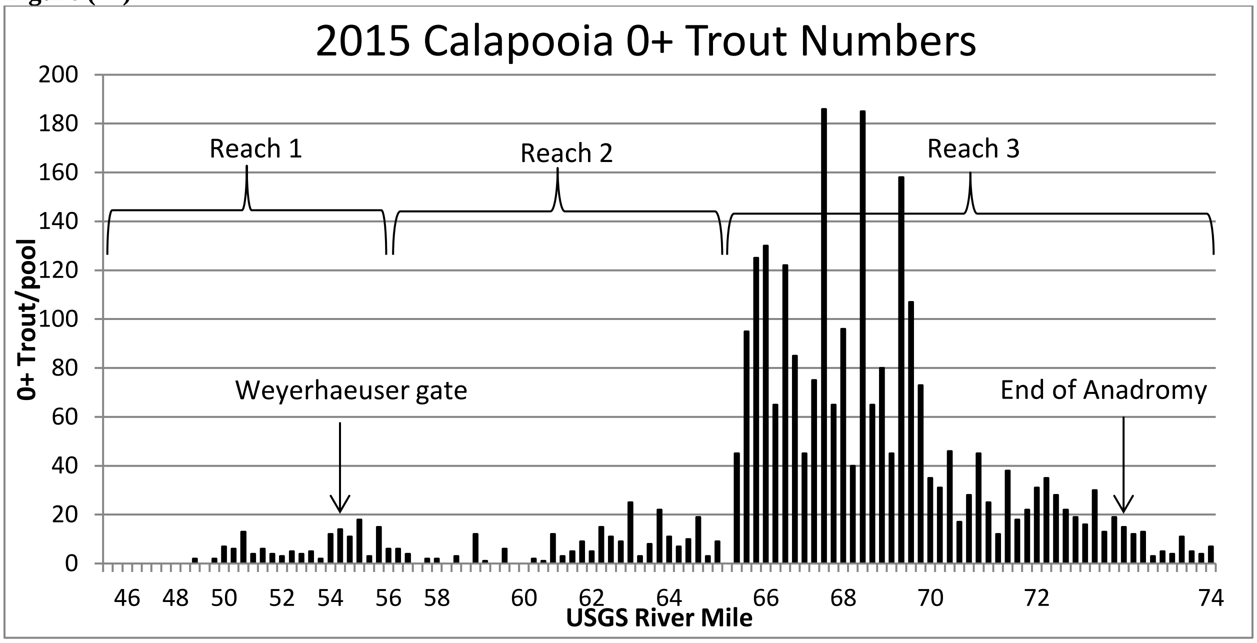


Figure (5)

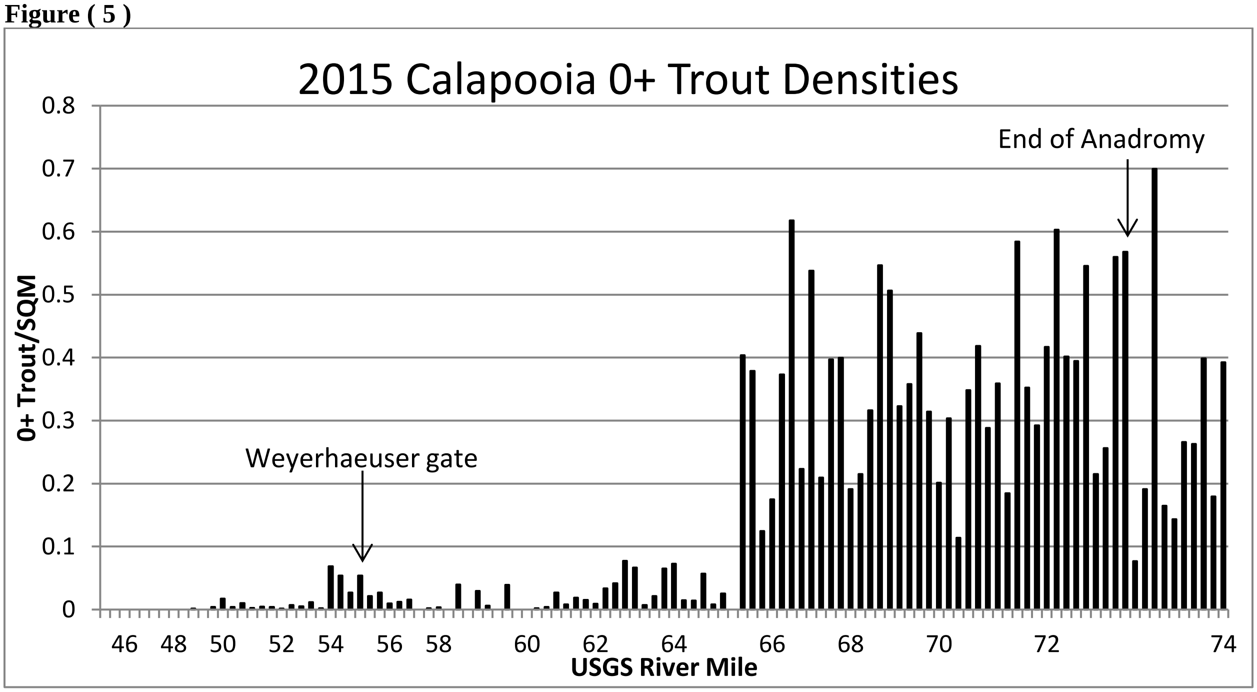


Figure (6)

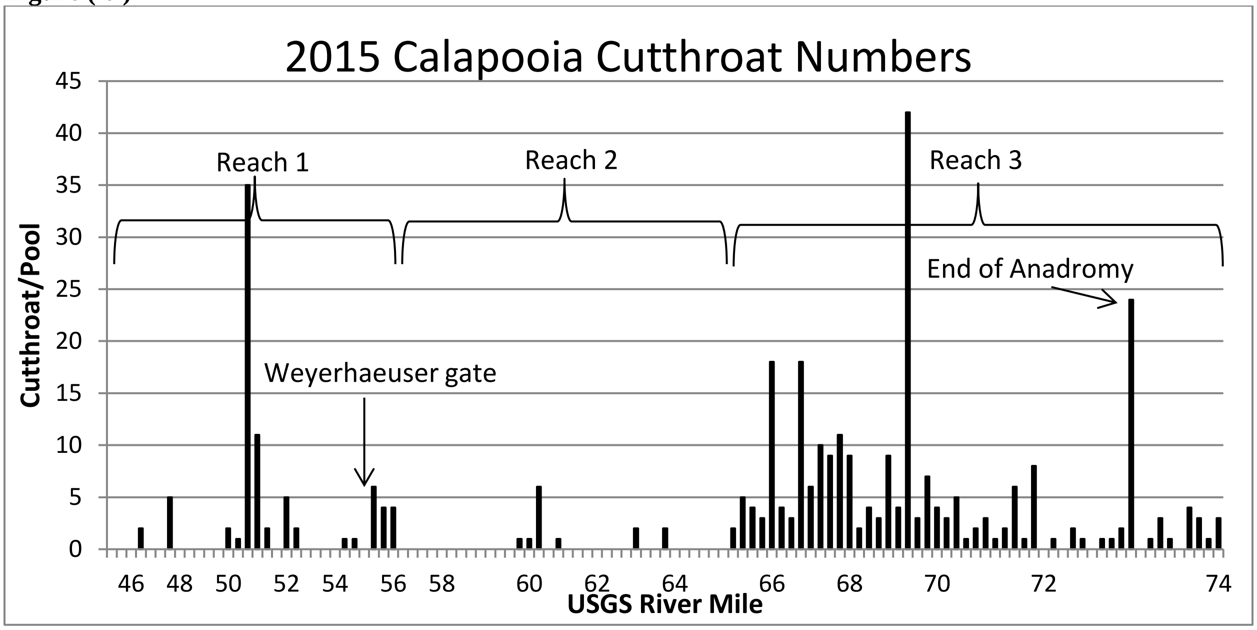
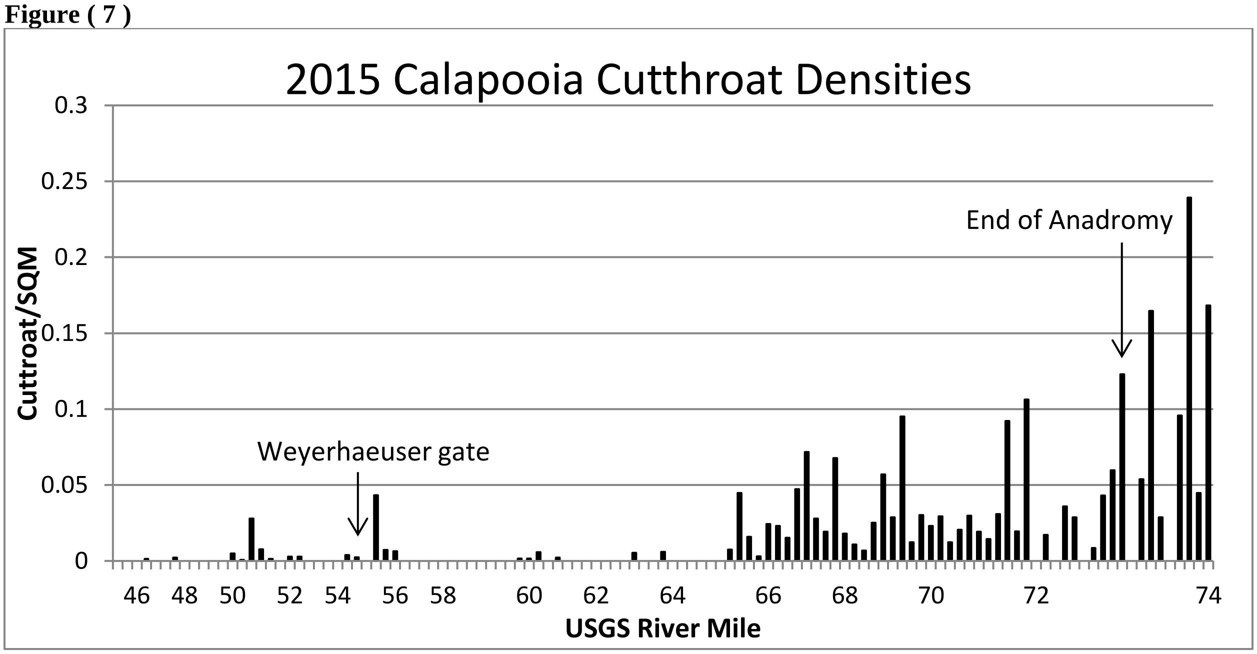


Figure (7)



The lower 49 miles of the lower mainstem Calapooia River is characterized by terraces and floodplains comprised of deep alluviums adjacent to the majority of the basin's agricultural land use. It is our opinion after conducting the RBA inventory that due to severe water quality limitations in the lower 45.5 miles of the mainstem, the potential for summer rearing salmonids is limited. Because this segment of the system was not included in our inventory, some isolated pockets of thermal refugia associated with unknown ground water linkages may exist.

Reach (1) begins at the Holley Bridge and extends 10.5 miles upstream, spanning a geologic unit transition from these deep alluviums to the forested uplands, foothills, and steep canyons cut by the upper mainstem and its tributaries through the basaltic and andesitic lava flows of the western cascades. This reach accounts for 37% of the inventory's lineal mainstem habitats within the range of anadromy and was observed rearing: 4.9% of the 0+ trout parr, 37.7% of the steelhead (age class 1+, 2+), 21.4% of the cutthroat, and 32.3% of the older age class resident rainbow. As a metric of relative abundance the most functional one mile segments of habitat within this reach were rearing: 509 steelhead/mile, 275 0+ trout/mile, 213 cutthroat/mile and 46 resident rainbow/mile. This reach exhibited the highest temperature profiles with maximum daily temps of 19˚C - 23˚C (very near lethal thresholds) recorded from 7/31/15-8/7/15.

Within this reach, mixed age classes and mixed species of salmonids were observed seeking thermal refugia in groundwater seeps and cold hyporheic flows accumulating in shallow alcoves at the heads of some unique pools (photo 1). These fish were also observed congregating in pools at the confluences of a few small cold tributaries (photo 2). These refugias were very limited in surface area and abundance with only 7 observed, each one occupied by high densities of predominantly larger (2+ and older) mixed species of salmonid. One such refugia, a shallow alcove at the head of a pool accumulating cold hyporheic flows, at USGS RM 52, was observed rearing 125 mixed age class trout at a density of 1.11 fish/sqm. This value is ten times greater than the average of densities (combined steelhead and cutthroat) observed in other pool habitats of this size within the inventory. In addition, the majority of these fish were huddled close together at the head of the alcove below a small root wad where temperatures were coolest (16˚C). Congregating in these small shallow refugias is clearly a last resort for these salmonids as adjacent stream temperatures reached and exceeded lethal thresholds. With this condition comes exponentially higher stress and survival risks associated with predation; inter and intra specific competition for food and oxygen; and the potential for rapid transmittal of disease.

Photo (1) <u>alcove at head of pool receiving cold hyporheic flow</u>~~cold hyporehicly linked alcove at head of pool~~

The lower 3.5 miles of Reach (1), (RM 45.5-49) was characterized by low average gradient (0.38%), high solar exposure, wide and predominantly shallow channel, and abundant gravel accumulations. Cold water refugia in this 3.5 miles was limited to the pool habitats at the confluences of Sawyer Cr (16.2˚C with mainstem temp at 23˚C) (USGS RM 48) and Pugh Cr (USGS RM 48.7). A few deep holding pools were observed, but most exhibited marginal thermocline development.

0+ trout and resident rainbow were absent from this section of the reach and cutthroat were limited to the just cold water refugias. From the start point, steelhead were consistently present in low densities rearing at 51 sthd/mile with surveyor notes indicating discoloration and lesions on some fish. Abundant suckers, pike minnow, red-sided shiners, long nose, and speckled dace were present throughout. Sunfish and western pond turtle were also documented around USGS RM 48.

Around USGS RM 49 the Calapooia enters the forested uplands and foothills with a stream habitat transition characterized by an increase in average gradient (1.05%); flood plain interaction and channel meander confined by a distinctly narrower canyon resulting in increased shading from a coniferous riparian and steep canyon walls. These characteristics extend 1.7 miles to RM 50.7.

The next morphological transition occurs near USGS RM 50.7 exhibiting a decrease in average gradient (0.24%); increased channel meander and floodplain interaction; deep bedload accumulations of mobile substrate creating 2-3ft. vertical gravel/cobble lifts at the heads of pools. These were functioning to create subsurface flows between pool units that resulted in hyporheic expressions of cold water into habitats accessible to temperature dependent migrants in the next pool downstream. These unique refugias (along with cold tributary confluences) were observed being utilized by high densities of cutthroat and steelhead (mostly 2+ and older). Four distinct sites exhibiting thermal refugia were documented within this zone (Map 1): 1) at USGS RM 50.7, a steep cold (12˚C) tributary entering mid-pool (mainstem above tributary documented at 19˚C) over bedrock was observed with numerous fish congregating at confluence; 2) at USGS RM 50.9, a cold alcove at the head of a pool fed by hyporheic expression and subsurface flow from a small tributary was observed on 7/31 with no fish utilizing the refugia and again on 8/7 with 45 larger age class cutthroat and 5(2+) steelhead occupying the refugia; 3) at USGS RM 52 (previously discussed), a cold (16˚) alcove at the head of a pool (mainstem above 20˚C) fed by hyporheic expression also exhibited high densities; and 4) at USGS RM 52.2 a cold 2nd order tributary near the head of the pool was congregating older age class cutthroat. This site exhibits high potential for enhancement with the trib channel paralleling the mainstem for 100-150 ft within the mainstem floodplain. Within stream segment 2, all salmonid abundances increased. Resident rainbow and juvenile whitefish were first observed in this section. This very unique and precious channel morphology extended approximately 2 miles before the morphological conditions transitioned enough to eliminate the gravel lifts required for hyporehic expression.

Map (1)

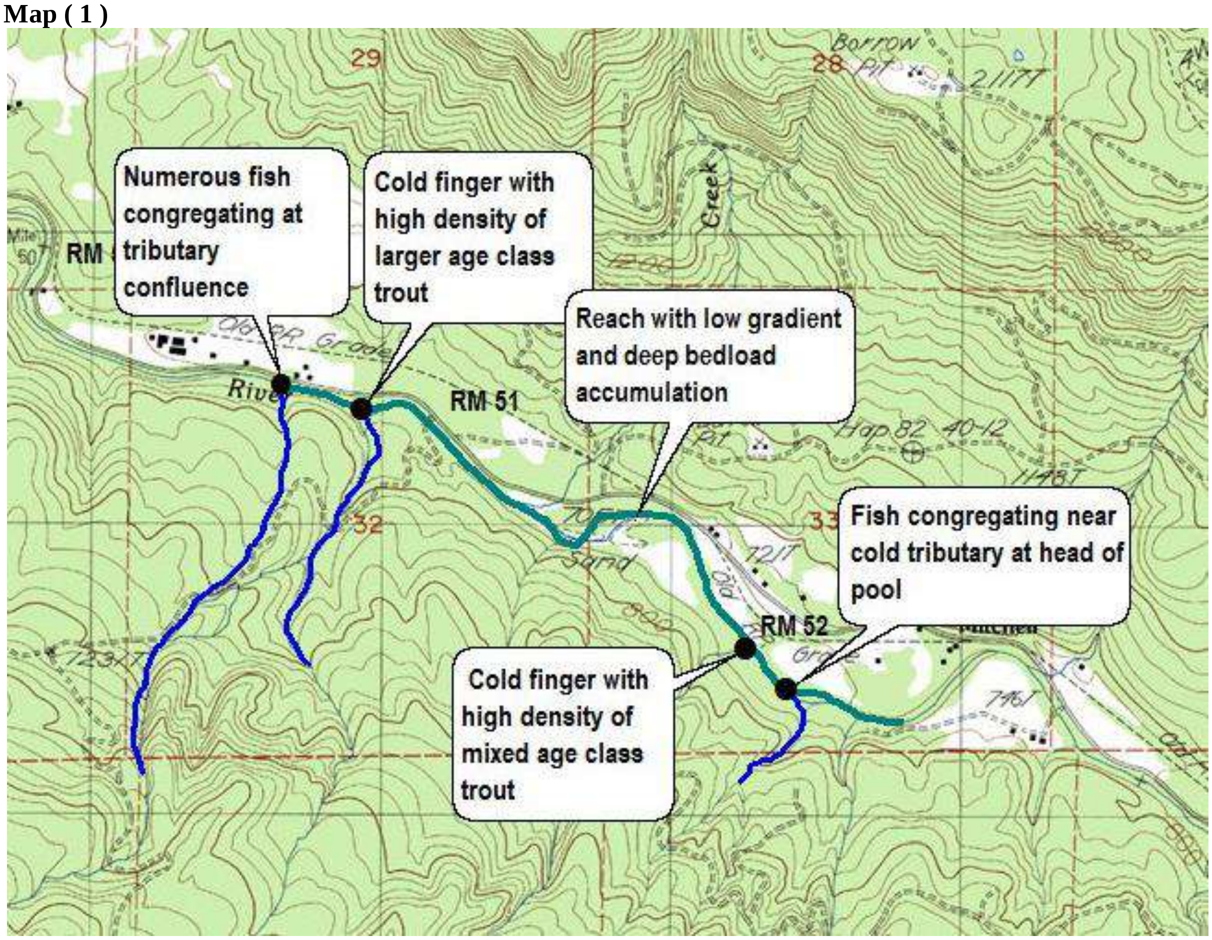


Photo (2) Older age class cutthroat congregating in cold plume at minor trib confluence

Over the remaining 3.3 miles of Reach (1) the average gradient increases to 0.8%, channel meander is restricted as the canyon tightens and is more gorge like, several bedrock intrusions occur that establish permanent hydraulic controls and an increase in boulder/cobble substrates is observed (reduction in gravel). 0+ trout densities exhibited a small spike indicating nearby spawning occurred within this zone. Steelhead, cutthroat and resident rainbows were observed congregating in the higher quality pool habitats with other pools nearly vacant. One thermal refugia was observed at USGS RM 55.6, where a cold seep from a bedrock cliff enters the top of a high complexity pool. This pool exhibited high abundances of 0+ trout, steelhead, Cutthroat, and resident rainbow. This pool marks the upper end of reach (1) and the beginning of a persistent thermal barrier to upstream temperature dependent migration during peak summer temperatures (the next reach lacks intermittent thermal refugia). A few deep holding pools exhibiting the habitat characteristics required by adult spring chinook were observed in this section, but highly concentrated summer recreational use (swimming) renders them incompatible with the needs of resting adults.

Reach (2) begins at USGS RM 56 extending 9.5 miles to USGS RM 65.5 (just above the confluence of Potts Cr.). This reach exhibited a dramatic decline in rearing densities for all salmonids except the older age class resident rainbow. This reach comprised 34.9% of the lineal mainstem habitats within the range of anadromy and was observed rearing: 8.1% of 0+trout parr, 3.9% of steelhead (1+, 2+), 4.6% of cutthroat and 43.1% of resident rainbow (3+ and older). As a metric of relative abundance the most functional one mile segment of this reach was rearing: 70 steelhead/mile, 252 0+ trout/mile, 40 cutthroat/mile, and 43 RR/mile. Stream habitats were characterized by an average gradient of 1%; long boulder runs separated by bedrock intrusions (photo 3); channel meander confined by steep hill slopes; and wide, shallow riffle/rapid habitat with high solar exposure.

The decrease in salmonid abundance within this reach was the combined result of three primary factors: 1) high summer temperatures and the lack of well distributed thermal refugia (as observed in reach 1). This dramatically reduced functional rearing capacity and resulted in forcing an evacuation of the pool habitats in an attempt to find thermal refugia in the headwaters. 2) High summer temperatures that increased the risk of predation associated with migration out of the reach (especially for the 0+ age class as they attempt to swim through pool habitats containing large resident cutthroat and rainbow). 3) A quantifiable decrease in the abundance of spawning gravel in the lower half of the reach (figure 1).

Only 1 thermal refugia was documented in this reach near the head of the pool at the confluence of Blue Cr (USGS RM 57.8). This pool contained high numbers of older age class cutthroat, resident rainbows, and steelhead. Resident rainbow trout and adult mountain whitefish were the only fish whose abundance increased within this reach. The only evidence of the presence of spring chinook within the Calapooia basin was a lower jaw bone of an adult (photo 19) in a deep resting pool that was discovered near the top of this reach at USGS RM 64.5.

Several significant tributaries enter within the reach (2): Biggs Cr (USGS RM 57.65), Blue Cr (USGS RM 57.8), Trib B (USGS RM 59.1), McKinley Cr (USGS RM 60.9), Hands Cr (USGS RM 64), and Potts Cr (USGS RM 65). Low densities of steelhead indicating upstream migration out of the mainstem and utilization of the cold water refugia within the tributary habitats was observed in all but one (Hands Cr), with Potts Cr being the only trib exhibiting density profiles that indicated steelhead spawning events occurred. Rearing capacities and refuge for temperature dependent migrants within the tributary habitats is limited due to shallow pool structures and lack of channel complexity. These tributaries will be discussed in depth below.

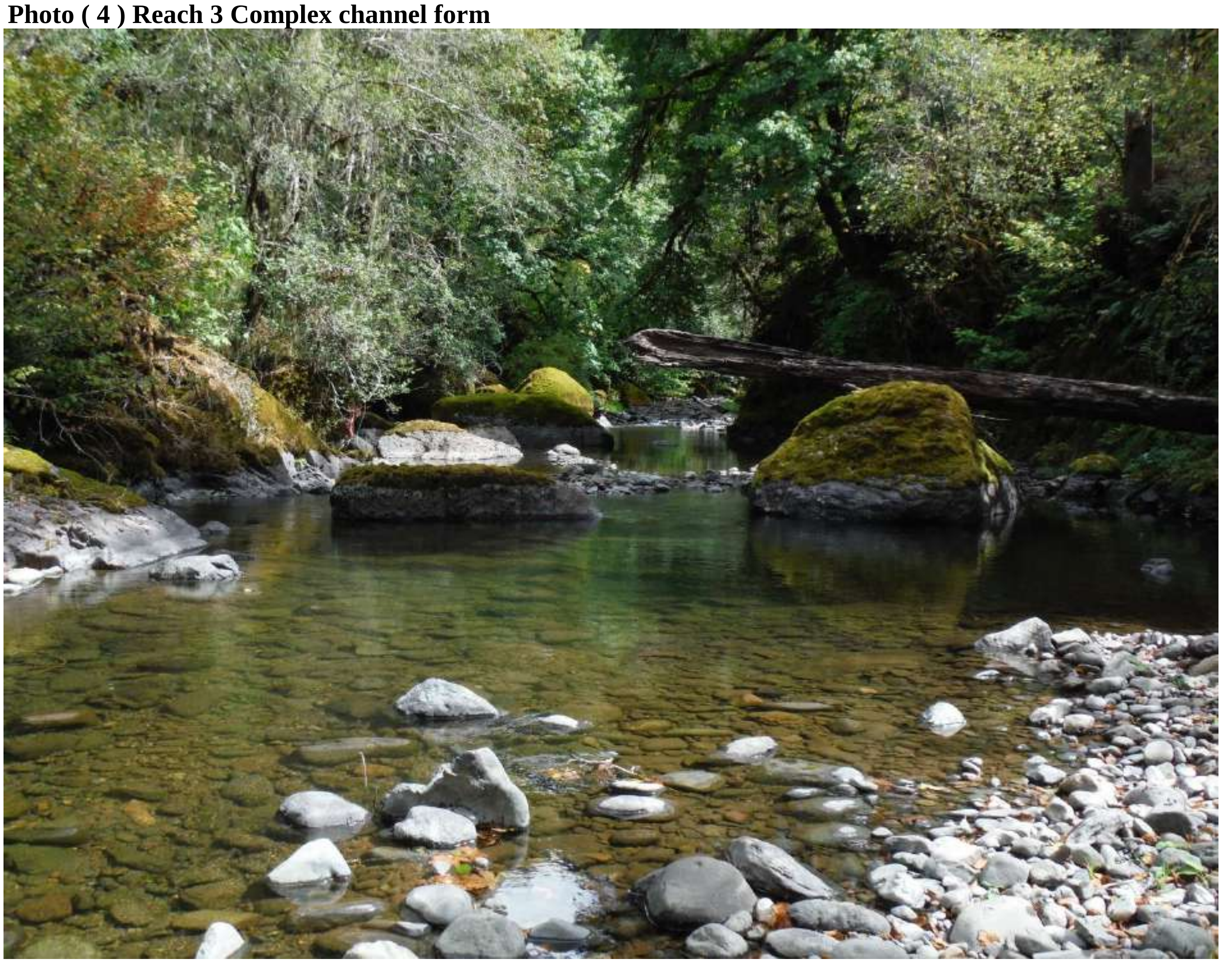
Photo (3) Simplified cobble / small boulder runs (no pool scour, thermal magnets) in reach 2

Reach (3), consisting of the remaining 8.5 miles of the upper mainstem extended from USGS RM 65.5 through the end of anadromy at RM 72.9 and on to the end of the survey at USGS RM 74. This reach contained less than a 1/3rd (28%) of the lineal mainstem habitats (within the range of anadromy) but was rearing a large majority of the population: 87% of 0+trout parr, 58.4% of steelhead (1+, 2+), 74% of cutthroat, and 24.6% of resident rainbow. As a metric of relative abundance the most functional one mile segment of stream habitat within reach (3) was rearing 2,132 0+ trout/mile, 709 steelhead/mile, and 263 cutthroat/mile.

Daily maximum stream temperatures recorded in this reach during peak summer temperature profiles dropped to 11˚C - 13˚C. This decline in peak summer temperatures in reach 3 is responsible for the provision of the majority of the entire basins critical summer refugia for rearing. The dramatic spike in salmonid abundance and densities observed at the beginning of this reach (figures 2 - 7) is largely due to a gap in time between survey dates. The inventory of reach (3) was conducted on 7/23/15 and reach (2) was conducted on 8/6/15. This two week period during peak or near peak summer temperatures is when reactive behavioral thermoregulation in salmonids is most acute. This gap in survey timing allowed for an unknown component of the population to escape reach 2 and find refuge in reach 3 leaving the previously occupied habitats (in the upper end of reach 2) nearly vacant. It is likely that the abundances of all species of salmonids in reach 3 that we have reported in this document dramatically under estimate actual fish abundance during the peak temperature pinch period (see recommendations). Our survey timing was excellent to document the evacuation of reach 2 but failed to catch the full magnitude of the importance of the habitats in reach 3 (conclusions will be the same).

Several significant tributaries and side channels enter within this reach: North Fork Calapooia (USGS RM 69.9) was the only tributary in the reach with juvenile distribution profiles indicating the occurrence of steelhead spawning events (discussed below); Trib C (USGS RM 70.9) is an important cold water contributor and contains remnant large conifers in the riparian capable of contributing significant complexity, but anadromous salmonid potential was limited by consecutive sill log / boulder falls; United States Cr (USGS RM 71.6) will be discussed below; Treadwell Cr (USGS RM 73) and Trib D (USGS RM 73.1) are high gradient and enter above anadromous salmonid distribution; and Side Channels A (USGS RM 67.8) and B (USGS RM 68.6) will be discussed below.

Photo (4) Reach 3 Complex channel form



The first 4.5 miles of reach (3), from USGS RM 65.5-70 (just above the confluence of the NF Calapooia), exhibited the highest potential in the basin for both the spawning and rearing of salmonids. This section of high quality stream habitat was characterized by an average gradient of 1.5%; cool summer temperature profiles; increased abundance and sorting of spawning gravels (37.1% of the entire inventories total); increased channel complexity and refuge in the form of massive boulders, bedrock intrusions; and increased off channel habitat in the form of complex side channels and braids.

This 4.5 mile section of mainstem anchor habitat comprised just 12% of the inventoried stream miles (mainstem, side channels, and tributaries combined) but was observed summer rearing a disproportionately large portion of the basin's total salmonid population: 55.4% of all 0+ trout parr; 51.8% of all steelhead, 30% of all cutthroat, and 24.6% of all resident rainbow. Steelhead were rearing here at an average density of 0.1 fish/sqm (still well below full seeding capacity) with a density peak for steelhead of 0.24 fish/sqm observed at USGS RM 69.5. In this same pool, high counts for both steelhead (106 fish) and cutthroat (42 fish) were documented. 0+ trout were rearing at an average density of 0.35 fish/sqm (well below assumed full seeding at 3 fish/sqm) with the highest pool count (186 fish) observed at USGS RM 66.85. The highest densities for cutthroat (0.23 fish/sqm) and 0+ cutthroat (0.7 fish/sqm) were both observed above the end of anadromy where inter specific competition for resources did not exist.

Photo (5) Natural recruitment of old growth wood

The only side channel habitat observed exhibiting significant summer rearing potential was Side Channel B which enters within the anchor described above at USGS RM 67.8 and extends for 720 ft. This side channel provided approximately 505 sqm of high complexity pool habitat and 22 sqm of spawning gravel. Within Side Channel B the peak densities of 0+ trout (1.26 fish/sqm), steelhead (0.4 fish/sqm), and cutthroat (0.5 fish/sqm) and the average densities of 0+ trout (0.87 fish/sqm), steelhead (0.14 fish/sqm), and cutthroat (0.15 fish/ sqm) were considerably higher than that observed in the adjacent mainstem pool habitats.

Photo (6) side channel B

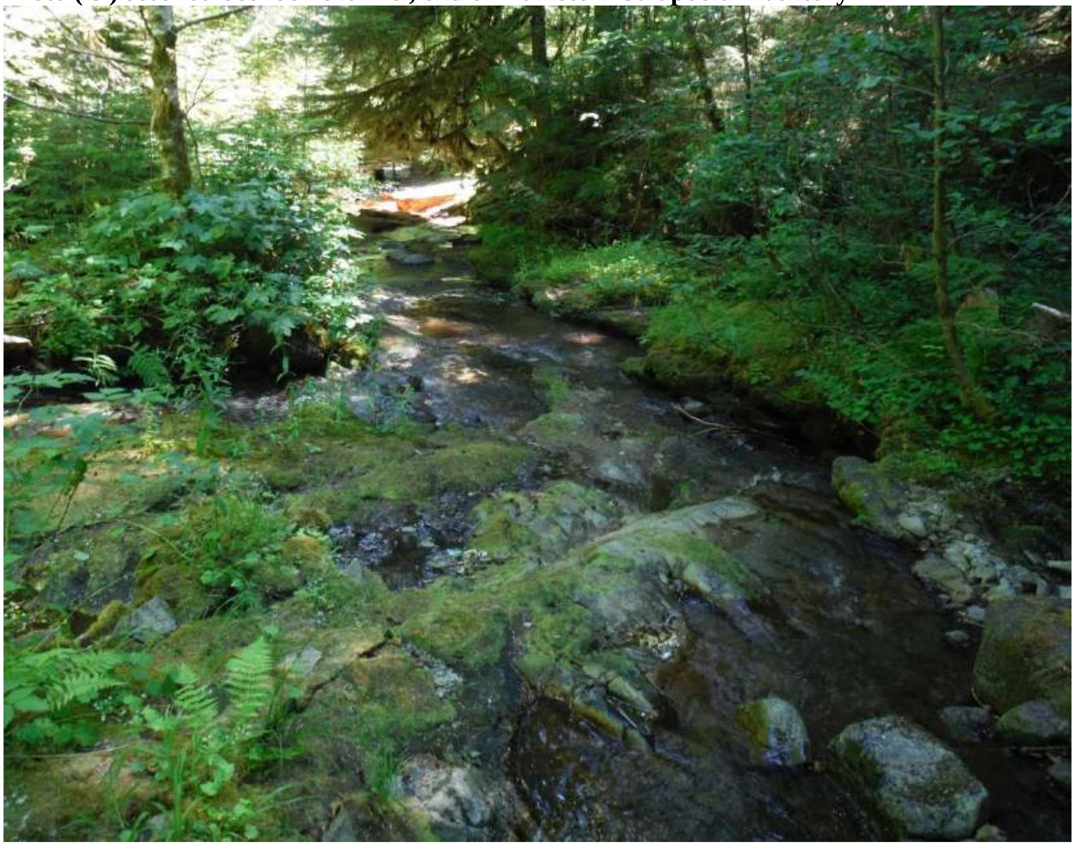
The next section of reach (3) extends from USGS RM 70 to the 9ft falls (photo 7) terminating anadromous distribution at USGS RM 72.9. Average gradients are variable in this 2.9 mile segment and range from 1.8% - 4.3% (in an upstream progression). Other stream habitat characteristics remain similar with an increase in large wood complexity and full spanning log jams. Salmonid abundances quickly decline here starting shortly above the confluence of the North Fork along with a moderate decrease in abundance of spawning gravel. Resident rainbow distribution ended at USGS RM 70.3.

Around the confluence of United Sates Cr (USGS RM 71.6), surveyors noted: old growth coniferous riparian, channel braiding and floodplain interaction, high wood complexity, broad gravel tailouts, and evidence of old redds. Above this point (around USGS RM 72) and extending to the end of anadromy a near absence of spawning gravel (4 sqm) was observed in addition to a continued decline in salmonid abundance (figure 2). Steelhead were rearing at 74 fish/mile with intermittent pool presence and for the first time cutthroat abundance at 99 fish/mile exceeds that of steelhead. 0+ trout abundance declined to 1085 fish/mile while densities remained consistent. Adult resident rainbows were not observed in this upper end of 0.mykiss distribution. Some of this reduction in abundance can be related to the 60% reduction in the average pool size of mainstem habitats above the confluence of the NF Calapooia.

Photo (7) end of anadromous salmonid distribution

This reach extended an additional 1.1 miles above the falls that terminated anadromous salmonid distribution at USGS RM 72.9. Cutthroat and 0+trout above the falls were rearing 73 cutthroat/mile and 290 0+ trout /mile. The value of these isolated native cutthroat genetics (above the influence of anadromy) is extremely high and suggests that special care should be extended in basin scale management plans to maintain the integrity of the habitat and protect this isolated deme of the population from O.mykiss degradation. The inventory did not extend to the end of cutthroat distribution. Above the falls, average stream gradients increased to 6%. The stream habitat is characterized by scoured bedrock and boulder, shallow pools, limited gravel sorting, high solar exposure and inadequate riparian cover (photo 8). A significant reduction in mainstem flow was observed above the confluence of Trib D at USGS RM73.1, which was estimated to contribute 20% of the total summer flow volume.

Photo (8) scoured bedrock channel, end of mainstem Calapooia inventory



Year	0+	Sthd	Cut	Rainbow
2015	14,295	4,865	1,715	325

<u>Biggs Cr</u>

Biggs Cr enters the mainstem at USGS RM 57.5. The inventory extended 1.14 miles upstream where canyon confinement and bedrock/boulder substrate limit further anadromous spawning and rearing potential. Average gradient of the inventoried reach was 6.6%. The spawning gravel inventory documented no suitable spawning sites for adult steelhead.

Steelhead parr were observed in low densities averaging 0.11 fish/sqm, with intermittent pool presence. This abundance expanded to 25 fish/mile and juvenile steelhead presence was likely the product of temperature dependent upstream migration out of the mainstem Calapooia. 0+ trout densities were low averaging 0.51 fish/sqm and expanding to 276 fish/mile. Cutthroat abundance remained low throughout the majority of the inventory averaging 0.46 fish/sqm and expanding to 171 fish/mile.

A fair abundance of legacy LWD was noted along the periphery of the active channel with no significant interaction with the thalweg. The result of this loss of full spanning old wood has been the development of homogenous cascades over small boulders and cobble with limited capacity to trap, sort and store spawning gravel. The riparian canopy was noted as primarily deciduous and lacking the conifer component that was removed prior to OFP guidelines were established in 1971. Biggs Cr is a valuable cold water contribution to a temperature limited reach of mainstem habitat. This will always be the highest use objective for management of the Biggs Cr catchment, protection of water quality and quantity as it relates to cumulative impacts (positive or negative) to the mainstem. Biggs Cr is not a significant target for aquatic restoration focused on salmonid production.

Figure (8)

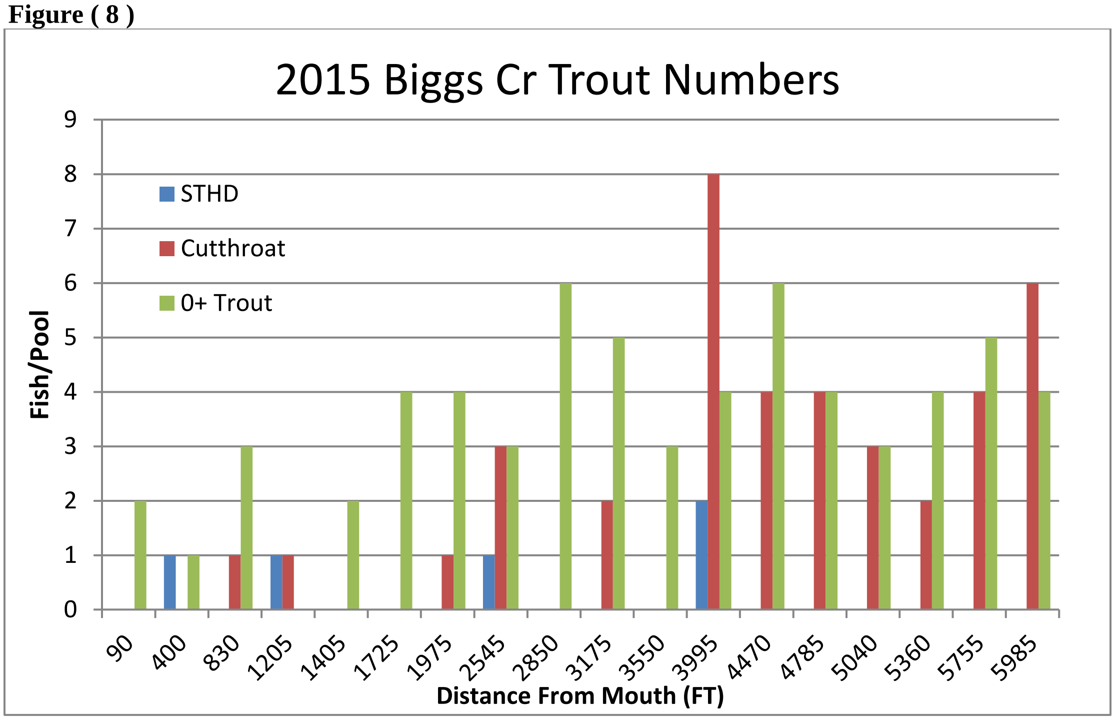


Figure (9)

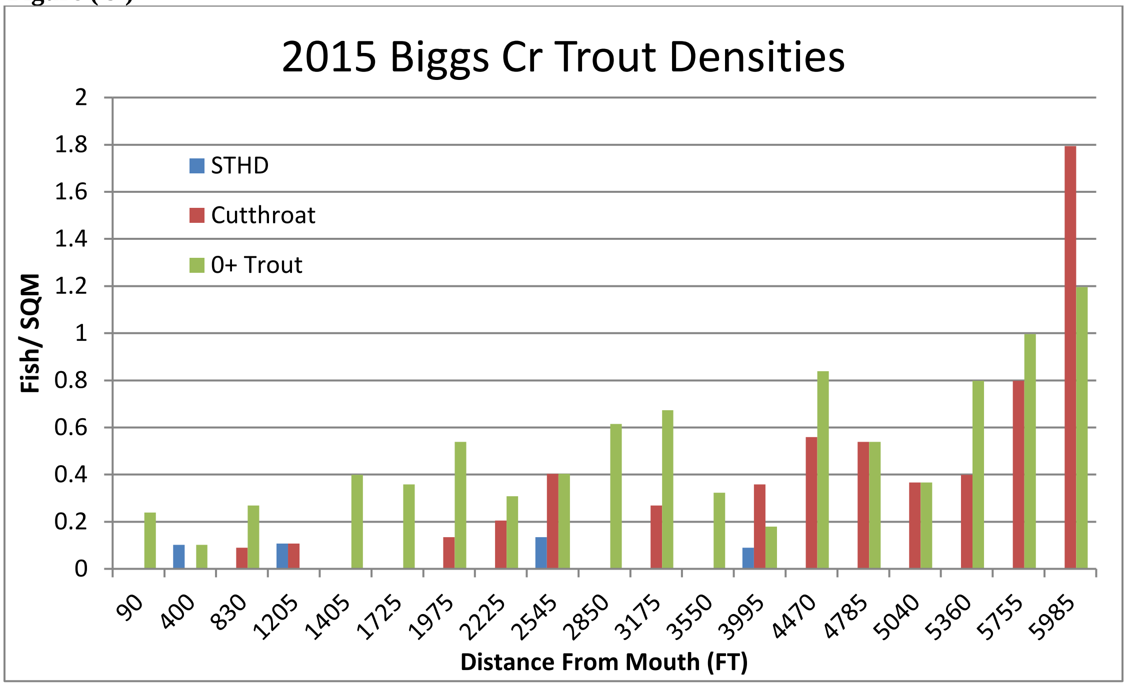


Photo (9) Biggs Cr channel characteristics

Year	0+	Sthd	Cut	Rainbow
2015	315	25	195	0

Blue Cr

Blue Cr enters the mainstem at USGS RM 57.8. The inventory extended 0.4 miles upstream where an 11ft boulder/sill log falls terminates anadromous potential. Blue Cr was observed with high wood complexity of remnant large conifers and an abundance of mobile gravel substrates. Average gradient for the inventoried reach was 7.5%. Summer rearing potential is limited by gradient and a shallow pool structure. Blue Cr is a valuable contributor of cool summer flows in a temperature limited reach of the mainstem. This will always be the highest use objective for management of the Blue Cr catchment, protection of water quality and quantity as it relates to cumulative impacts (positive or negative) to the mainstem. Blue Cr is not a significant target for aquatic restoration focused on salmonid production.

High densities of salmonids were observed seeking thermal refuge in the mainstem pool at the confluence with Blue Cr. One steelhead was observed in one sample pool (figure 11) indicating the presence of a temperature dependent migration out of the mainstem Calapooia. In addition, the distribution of cutthroat (figure 11) indicates a similar upstream temperature dependent migration with pool densities higher in the first 1,200 ft. Calapooia. 0+ trout densities were moderate averaging 0.62 fish/sqm.

Pic (10) Blue Cr

Photo (11) Blue Cr, ephemeral end of anadromy

Figure (10)

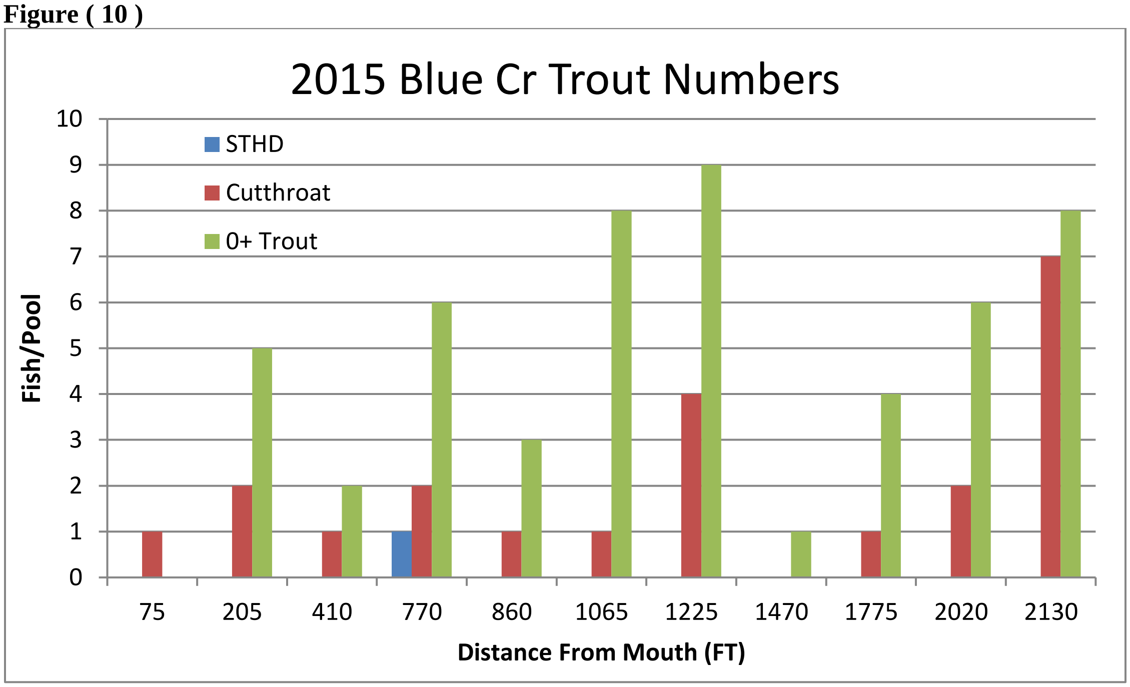
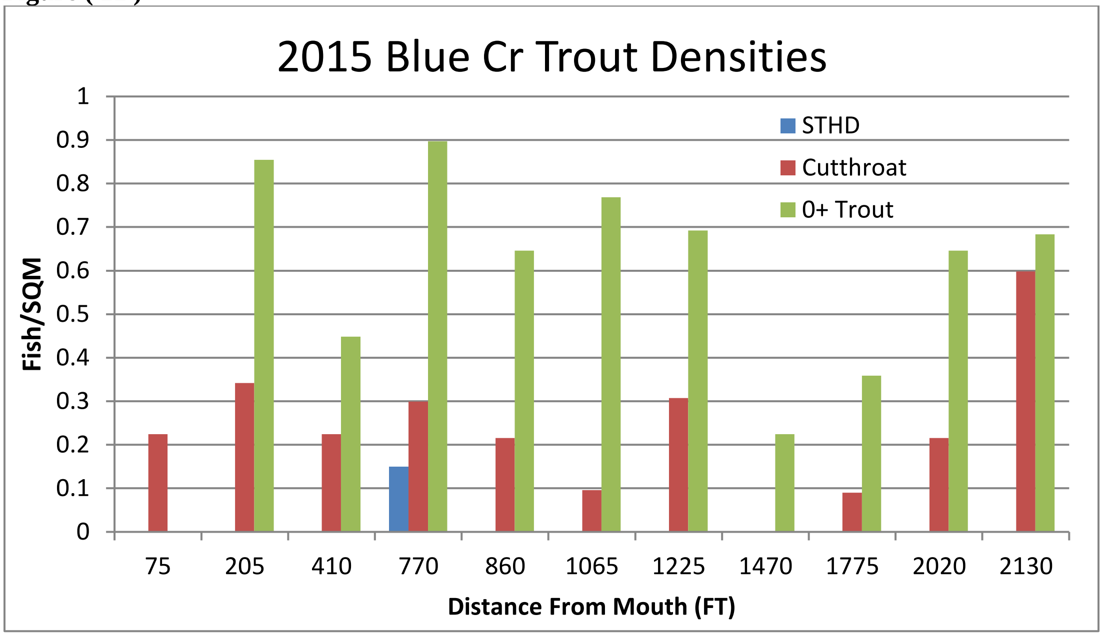


Figure (11)



Year	0+	Sthd	Cut	Rainbow
2015	180	5	60	0

Hands Cr

Hands Cr enters at USGS RM 64. The inventory extended 1.02 miles with an average gradient of 6.85% and no anadromous barriers were observed. Subsurface summer flows at the confluence with the mainstem Calapooia that extend 250 ft upstream develop a barrier for salmonids to upstream temperature dependent migrations out of the mainstem. Stream channel morphology and habitat characteristics mirror those observed in Biggs Cr. No steelhead were observed in Hands Cr. The spawning gravel inventory documented just 2 sqm of functional gravel in the 1 mile inventory.

0+ trout abundance was moderate averaging 0.63 fish/sqm of pool habitat expanding to 315 fish/mile. Cutthroat abundance was low and averaged 0.22 fish/sqm at75 fish/mile.

Hands Cr is not a focal area for salmonid restoration strategies except where that strategy might encompass the enhancement of tributary water quality and quantity to improve conditions that limit salmonid distribution and production in the mainstem Calapooia.

Photo (12) Hands Cr summer habitat. Limited potential for gravel retention.

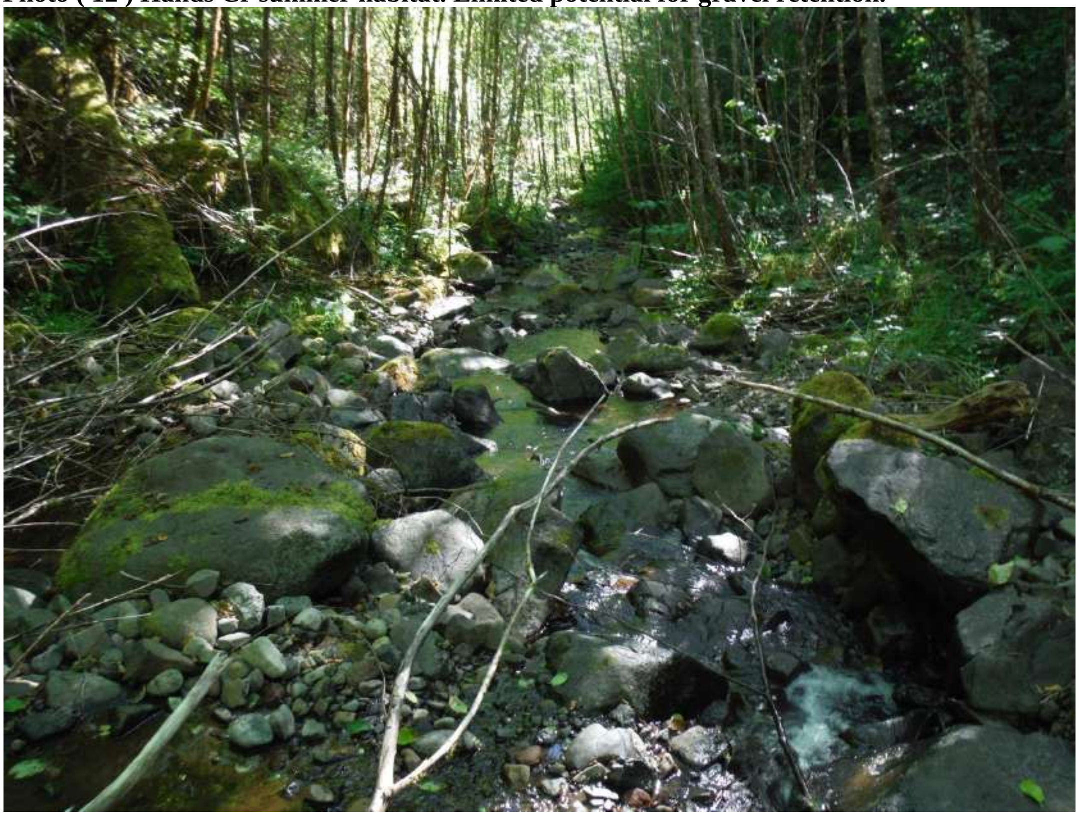


Figure (12)

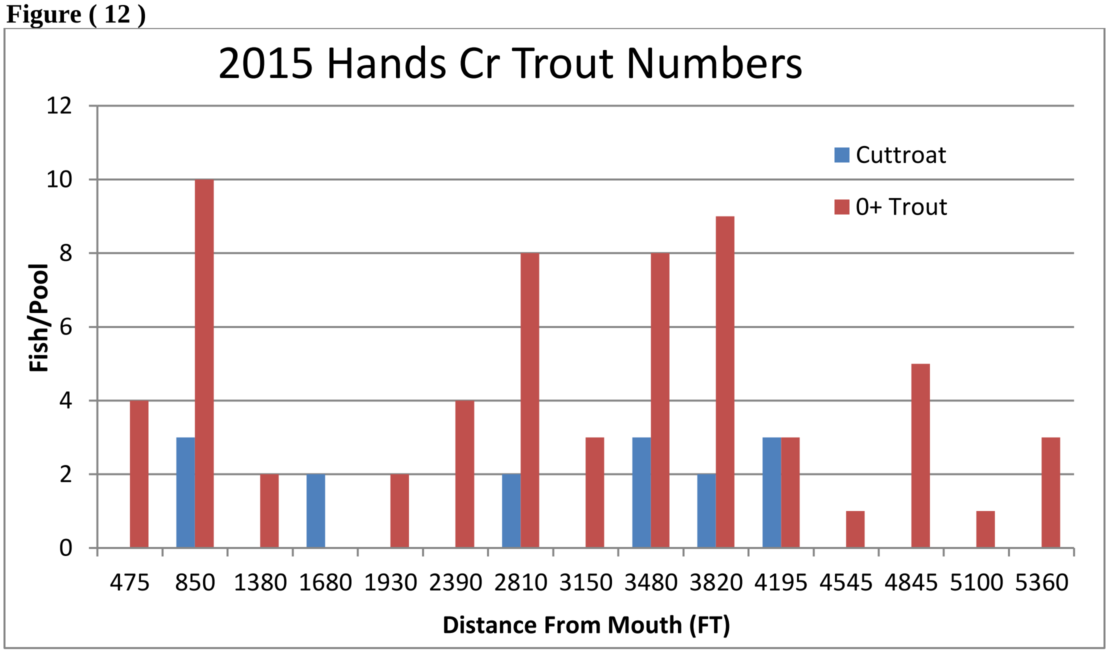
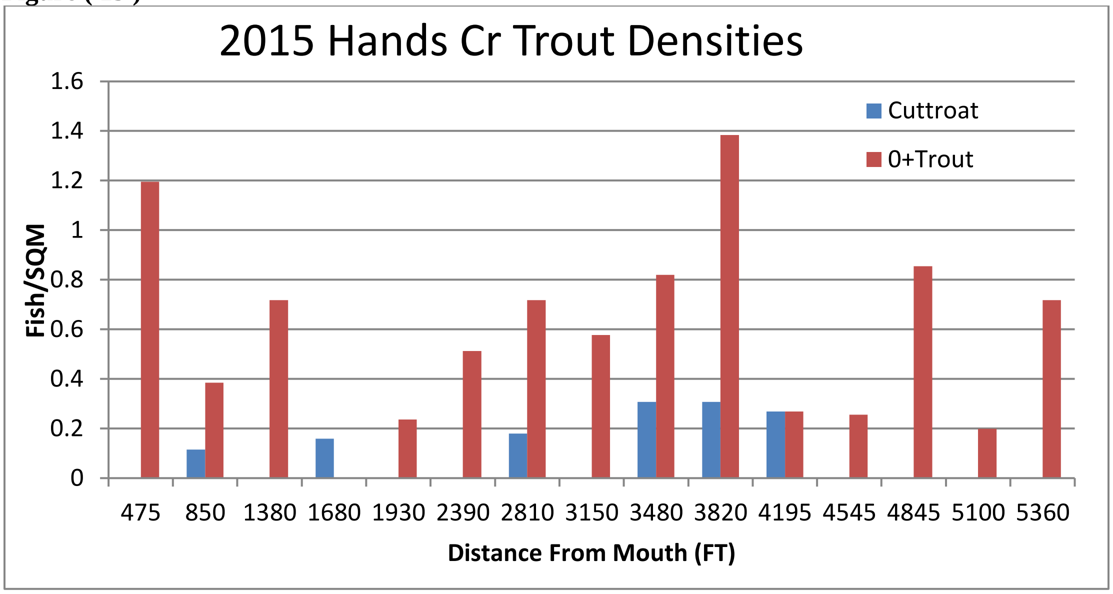


Figure (13)



Year	0+	Sthd	Cut	Rainbow
2015	315	0	75	0

McKinley Cr

McKinley Cr enters at USGS RM 60.9. The inventory extended 0.26 miles with an average gradient of 6.4% to a series of boulder/bedrock falls terminating anadromous salmonid potential. Access to thermal refugia in McKinley Cr for summer rearing is also limited by a juvenile barrier just above the confluence with the mainstem Calapooia.

Steelhead were observed in the pool directly below the juvenile barrier along with the highest density of 0+ trout indicating upstream migration out of the mainstem. As observed for most tributaries of the mainstem Calapooia, the primary planning goal is to protect and enhance riparian corridors for the long term maintenance of water quality and quantity to benefit the temperature limited mainstem Calapooia.

Year	0+	Sthd	Cut	Rainbow
2015	100	10	20	0

North Fork Calapooia

The North Fork Calapooia enters the mainstem at USGS RM 69.9. The inventory extended 1.7 miles. Anadromous salmonid potential is terminated by a 10 ft bedrock falls with a large log/debris jam at RM 1.4.

The inventory included one tributary (Trib A) of which anadromous potential was terminated just above its confluence with the NF (at RM 0.5) by a tight log jam of legacy old growth wood followed by a series of consecutive perched sill logs. Steelhead were observed in Trib A in one pool just above the confluence. This pool is below a failed culvert with a 6 inch perch and the topside is blocked by a 1ft sill and steel debris cage. There is no salmonid based justification for replacing this culvert because there is no access to any additional habitat above the culvert as a result of back to back natural barriers.

Figure (14)

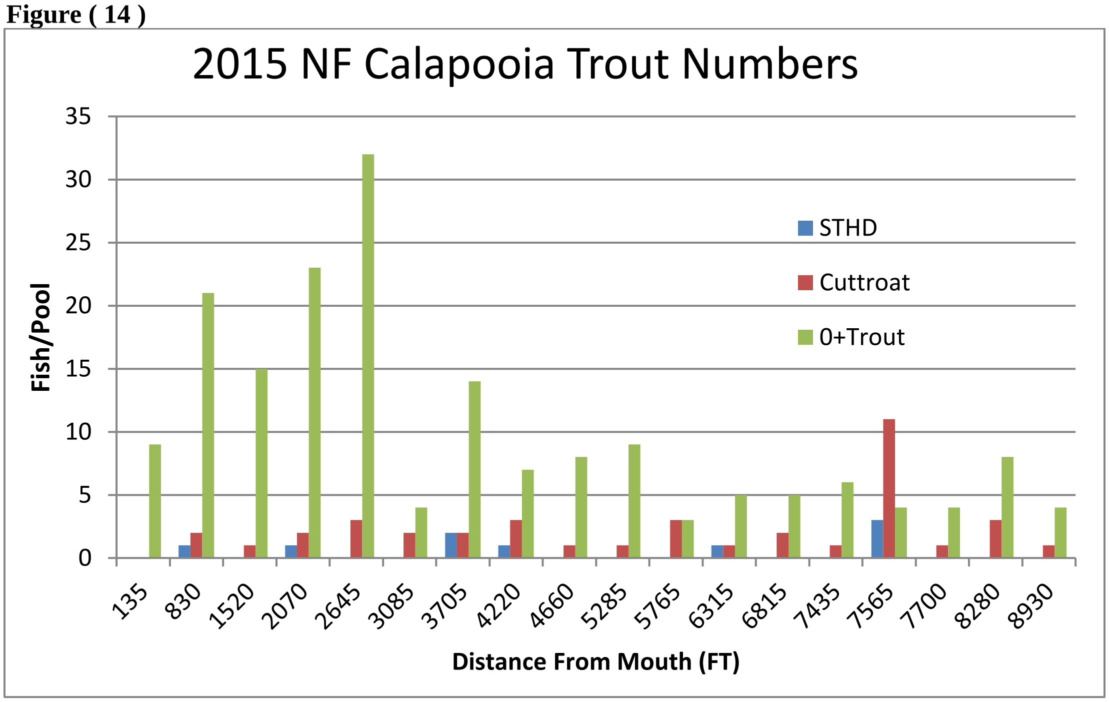
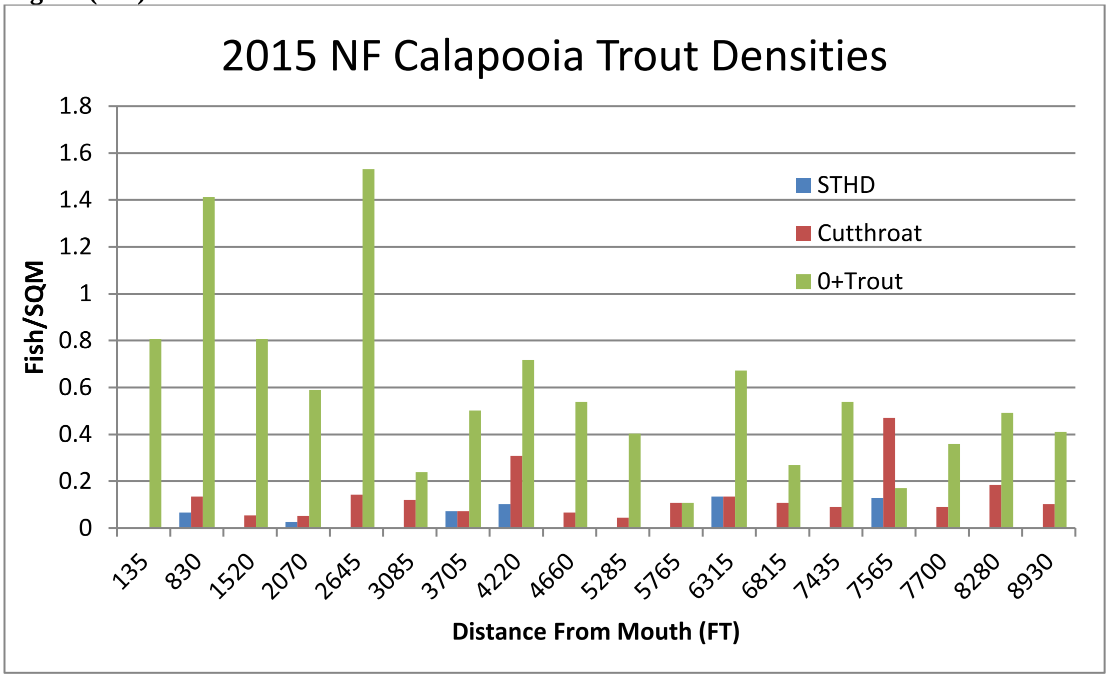


Figure (15)



Steelhead abundance was low at an average pool density of 0.09 fish/sqm with intermittent pool presence throughout the range of anadromy. Steelhead were present at 31 fish/mile.

55.3% of 0+trout abundance was observed in the lower 1/2 mile of habitat at an average density of 1.03 fish/sqm (figure 15). Temperature data collected at the confluence documented that the NF was slightly warmer (10.5˚C) than the mainstem (10˚C) above its confluence indicating that the higher 0+ trout abundances are likely the result of steelhead spawning events occurring in the NF and not related to temperature dependent migrations out of the mainstem Calapooia. This conclusion supports a previous observation that steelhead abundances in the mainstem Calapooia (both older age class and the 0+ age class) increase below the confluence of the NF (an indication that some steelhead spawning and incubation is occurring in the NF).

Cutthroat abundance was low with an average density of 0.13 fish/sqm expanding to 118 fish/mile and a peak density of 0.47 fish/sqm observed in the plunge pool below the falls.

The lower ½ mile of habitat was characterized by an average gradient of 3.4%, boulder/cobble substrate with limited gravel sorting, shallow pools, and a general lack of channel complexity. Beginning around the confluence of Trib A (RM 0.5) and extending 0.3 miles upstream, the highest quality habitat was observed with an increase in average gradient (4.8%), high wood complexity (treatment reach with LWD), deep bedload accumulations of mobile gravels, and channel braiding over a wide interactive floodplain.

Photo (13) braided channel over wide floodplain in NF Calapooia

The remainder of the aquatic corridor to the falls exhibited a gradient increase to 5.5%, a narrowing canyon and diminishing floodplain potential. The spawning gravel inventory documented no suitable steelhead spawning sites in the upper ½ mile of inventoried habitat.

Photo (14) falls

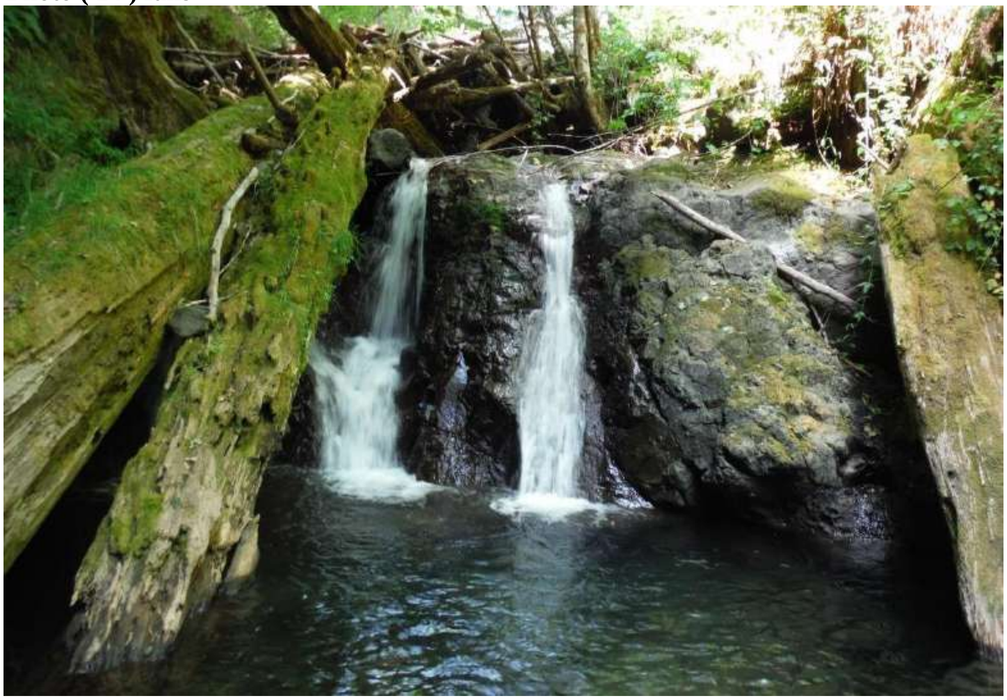


Photo (15) trib A of NF Calapooia culvert

Year	0+	Sthd	Cut	Rainbow
2015	1045	45	265	0

Potts Cr

Potts Cr enters at USGS RM 65. The inventory extended 1.5 miles with anadromous distribution ending at RM 1.18 just below the confluence of Trib A where a 4ft ephemeral log/debris jam with a shallow jump pool currently terminates both adult and juvenile passage. The average gradient was 3.5%. The stream habitat was characterized primarily by boulder/bedrock/cobble dominated substrates, a narrow canyon and a well shaded coniferous riparian zone. Areas of increased bedload retention and improved channel complexity within the range of anadromy were all located around the few LWD structures sites.

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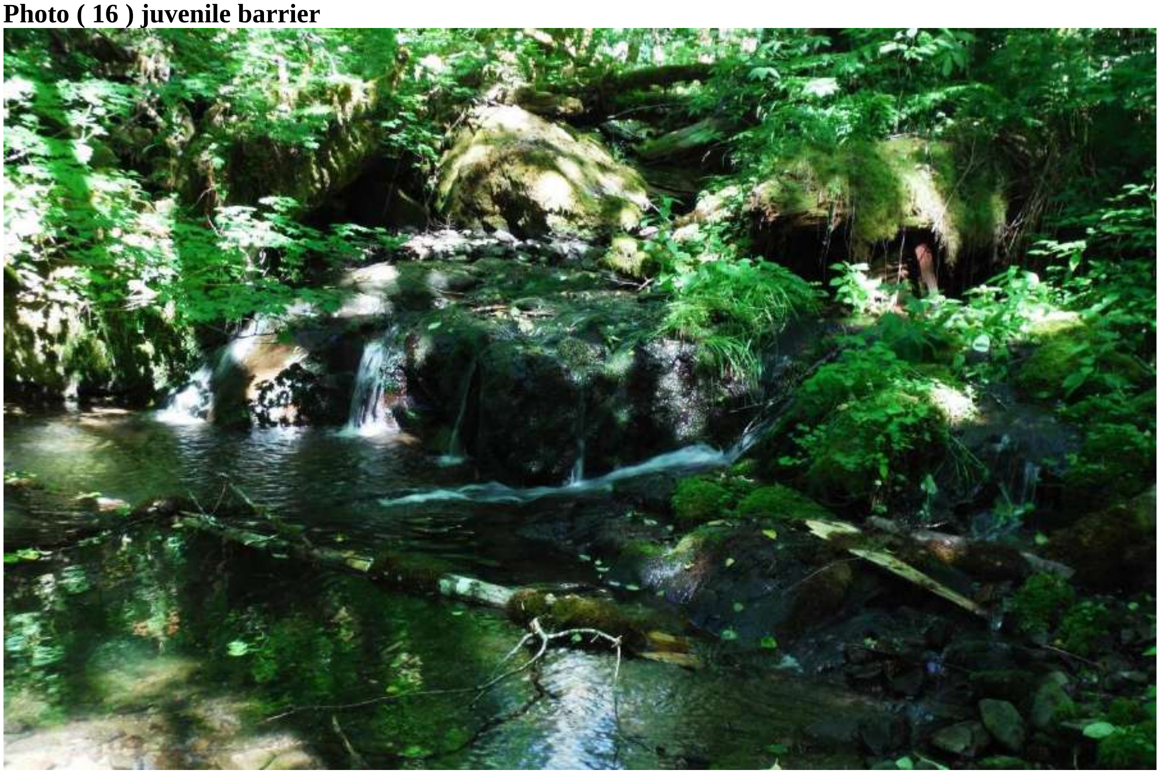
Photo (16) juvenile barrier



Salmonid distribution within the range of anadromy suggests that the lower end of Potts Cr is being targeted by upstream temperature dependent migrants from the mainstem Calapooia seeking thermal refuge (figure 16). Unfortunately they are being blocked by a natural barrier. 40% of the 0+ age class was observed in the first ¼ mile of the inventory with the highest density of 1.6 fish/sqm observed in the first sample pool below a 2.5ft bedrock falls that functions as a juvenile barrier especially later in the summer as flows diminish.

In addition, because of the broad distribution of steelhead parr in Potts Cr (6,230 ft) it is likely that steelhead spawning occurred in Potts. Steelhead abundance was low throughout with a peak density of 0.27 fish/sqm observed at RM 1.18 in the pool below the log jam falls that currently terminates anadromy.

Cutthroat distribution exhibited an increasing trend of abundance moving upstream with peak densities of 1.7 fish/sqm at RM 1.18 in the pool below the log jam falls and 1.9 fish/sqm at RM 1.29 in a pool directly above an enormous log jam extending 100ft. Deep bedload accumulations are impounded above this jam with subsurface flows at this pool tailout limiting downstream movements of cutthroat and concentrating densities. These cutthroat pool densities were among the top 3 highest recorded in the Calapooia basin in 2015.

Figure (16)

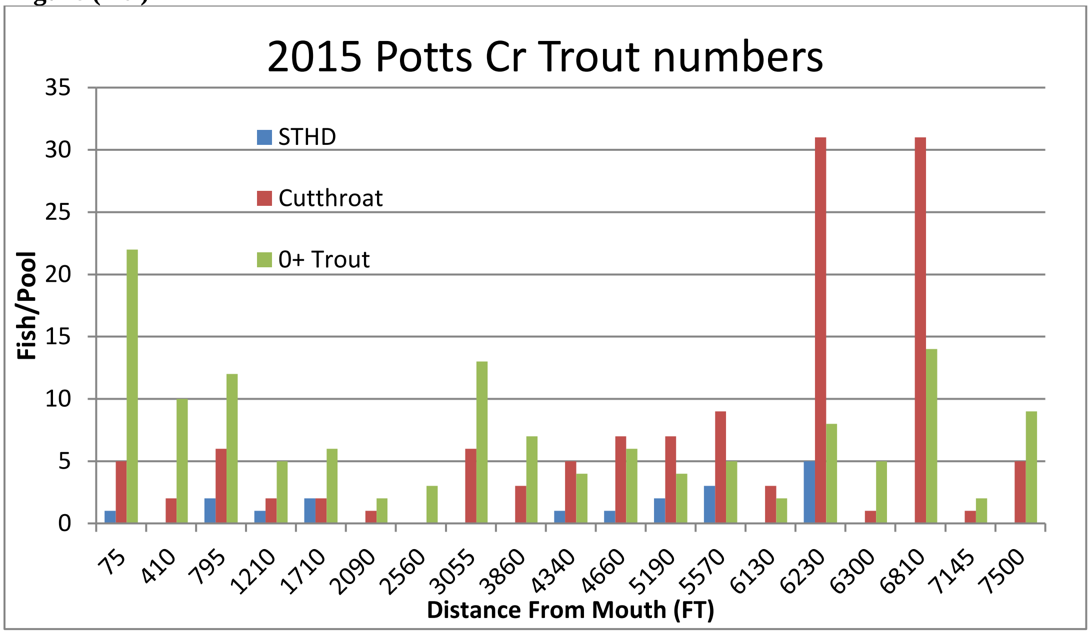


Figure (17)

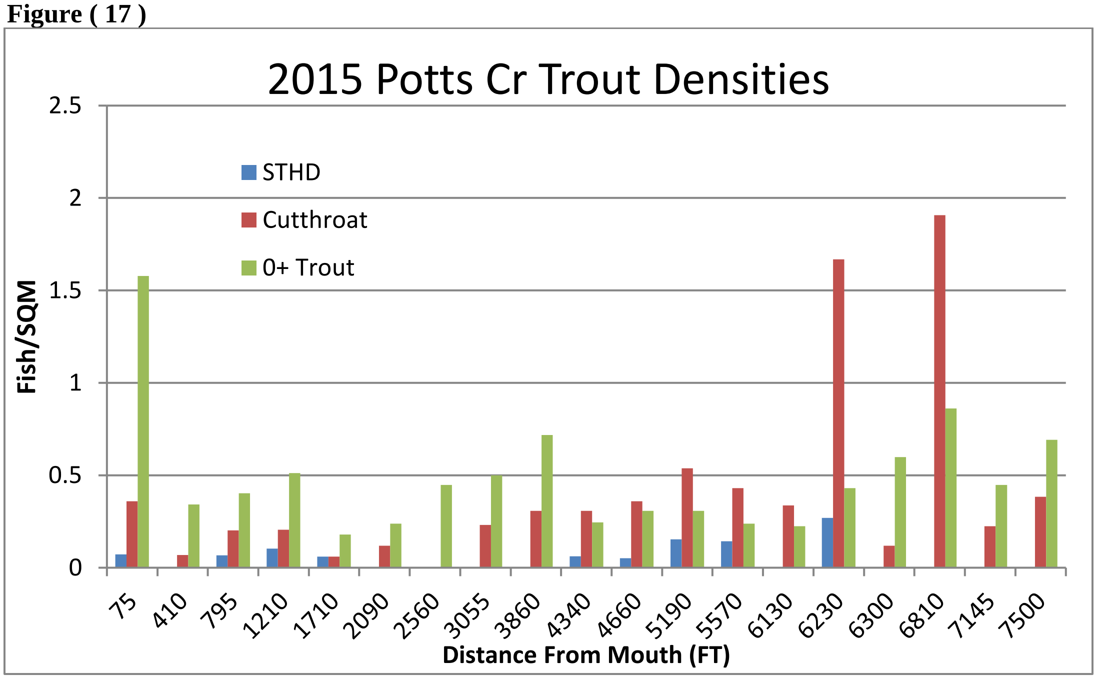


Photo (17) LWD structure sites in Potts Cr

Year	0+	Sthd	Cut	Rainbow
2015	745	65	525	0

Trib B

Trib B enters the mainstem Calapooia at USGS RM 59.1. The inventory extended 1 mile with no barriers to passage observed. The confluence was described as med/high gradient over cobble and small boulder. One steelhead was observed in the first pool. Salmonid potential is limited by high gradient (avg. 7.58%) and lack of spawning gravel. Trib B is however a valuable contributor of cold water in a temperature limited reach.

Cutthroat were rearing at an average density of 0.25 fish / sqm and 0+ trout at 0.53 fish/sqm, both well below densities considered seeded in high quality habitats.

Year	0+	Sthd	Cut	Rainbow
2015	255	5	90	0

United States Cr

United States Cr enters at USGS RM 71.6. The inventory extended 0.36 miles upstream with no permanent barriers to adult passage observed. Just above the confluence a large log jam comprised of legacy old growth wood with a deep accumulation of mobile gravel may present an ephemeral adult barrier to migration. High gradients (avg. 8.17%) and a boulder/ bedrock dominated stream channel confined in a tight canyon also morphologically limit the tributaries capacity for providing high quality salmonid habitat. Several sqm of spawning gravel were observed in the lower gradient first 100 meters of the inventory.

Photo (18) United States Cr and LWD jam just above confluence

Year	0+	Sthd	Cut	Rainbow
2015	255	5	90	0

ADULT SPRING CHINOOK RESTING COUNT

The spring chinook resting count inventory encompassed a majority of the previously inventoried mainstem reach and extended an additional 9.5 miles downstream to the deconstructed Brownsville Dam site (USGS RM36). This inventory was conducted between 8/25/15 and 9/3/15 in an attempt to quantify the abundance of adult spring chinook returning to the Calapooia basin and holding in mainstem thermal refuges until maturation and spawning. In addition the 100% pool census allowed us for the first time to describe the location and metrics of all potential thermal refugia available to spring chinook adults above RM 36. Spring chinook would have historically entered the Calapooia basin in late spring/early summer (the majority of the run ascending Willamette Falls April and May, with peak passage in mid-May) and migrated upriver to resting pools in close proximity to their final spawning destination. Sexual maturation would occur while resting in the deepest thermal refugia and finally spawning would peak between Sept 15 and Oct 15 (peak redd counts occurring during this window in other Willamette tributaries).

Our inventories revealed no evidence of a spawning population of spring chinook within the inventoried portion of the basin (above USGS RM 36). This was the result of a 100% snorkel census of every pool in 37 miles of the mainstem Calapooia from the Brownsville dam site to the end of anadromy at the falls at RM 72.9. There were no live adults observed, no redds and not a single residual spring chinook parr observed in the 20% snorkel survey conducted earlier in the summer. The only evidence observed of the presence of spring chinook was an adult jaw bone (photo 19) discovered in a dive pool at USGS RM 64.5. Because of the extreme lack of wood complexity in most mainstem Calapooia pool habitats, any small number of resting spring chinook would likely be easily harvested by an abundant otter population. It is unlikely (but possible) that spring chinook are summer resting or spawning in the Calapooia basin below RM 36. The severity of mainstem temperature profiles below this location suggest that mortalities would be extreme.

Photo (19)

Several morphologically suitable holding pools (deep) were observed and thoroughly investigated within the scope of the inventory. Their qualities and locations are detailed in Table 3 and on figures 18-23. Overall, high quality holding pools of sufficient depth with an adequate volume of thermal refugia (generally established by a thermocline) are very rare in the most critically temperature limited reaches of the mainstem (below USGS RM 65). Pools with varying levels of temperature stratifications were more common but many lacked sufficient depth and volume of cold water to be functional spring chinook resting pools. Pools experiencing high volumes of summer recreational use were surveyed to verify presence / absence but not included in Table 3 as potential adult resting sites for future monitoring.

In historic populations, pre-spawning impacts were principally the result of high summer water temperatures, harassment and poaching. A survey of 27 female spring chinook carcasses in the Calapooia in 2003 observed that all 27 fish died prior to spawning (Schroeder and Kenaston 2004). Naturally low summer flows in the Calapooia basin are aggravated in a cumulative progression downstream by water withdrawals (permitted and unpermitted). These additional flow reductions in the mainstem aggravate an already tenuous situation by increasing temperatures and reducing flow volumes. In addition to the numerous past and present DEQ 303(d) listings (page 3), the lower 43 miles of the mainstem was cited as ‘water quality limited’ from ‘flow modification’ affecting salmonid spawning and rearing; resident fish and aquatic life.

Photo (20) pool #13 (Table 3)

There is limited information available to accurately estimate the historical abundance of spring chinook in the Calapooia basin. Based on early (1898) Willamette falls escapement counts and relative distribution estimates provided in the Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins (3% to the Calapooia basin) the historical abundance of spring chinook was estimated at 9,500 adult fish. Parkhurst et al. (1950) reported the 1941 run was approximately 200 adults and estimated suitable habitat for 9,000 fish. Willis et al. (1960) estimated the run at only 100–500 fish. Mattson (1948) estimated the run at 30 in 1947. More recently, Nicholas (1995) considered the run extinct, with limited future production potential (Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. U.S. Dept. Commerce. NOAA Tech. Memo. NMFS-NWFSC-73, 311 p). Attempts to artificially augment the population with hatchery adult out planting were terminated in 2005 due to the failure to produce viable spawning recruits to the population. No management action has to date succeeded in producing a self-sustaining population of spring chinook in the Calapooia basin.

Table (3)

Pool #	Lat & Long	Dimensions (ft)	Notes
1	N 044˚ 22’ 34.7111” W 122˚ 55’ 04.0464”	395x40 8ft deep	Undercut bank No thermal refugia
2	N 044˚ 22’ 31.2153” W 122˚ 54’ 31.6074”	415x35 10ft deep	Undercut bedrock bank No thermal refugia
3	N 044˚ 22’ 26.9021” W 122˚ 53’ 23.1798”	450x50 15ft deep	Undercut bank with root wads Thermal refugia, med/high potential
4	N 044˚ 21’ 44.0651” W 122˚ 52’ 46.6484”	400x40 20ft deep	Deep cut along basalt intrusion Thermal refugia, high potential
5	N 044˚ 21’ 42.0012” W 122˚ 49’ 15.3247”	225x65 10ft deep	Cool thermocline at bottom
6	N 044˚ 19’ 47.4568” W 122˚ 44’ 52.5818”	550x40 15ft deep	Undercut bedrock bank Cool thermocline at bottom
7	N 044˚ 19’ 39.0938” W 122˚ 44’ 40.6445”	460x45 10ft deep	Cold thermocline at bottom from contribution of Pugh Cr
8	N 044˚ 19’ 23.8762” W 122˚ 43’ 58.5613”	355x55 8-10ft deep	Deep pool, no significant thermocline Low potential
9	N 044˚ 16’ 05.0284” W 122˚ 34’ 15.2103”	280x40 15ft deep	Basalt trench, marginal thermocline About 100 adult whitefish in pool
10	N 044˚ 15’ 05.1225” W 122˚ 30’ 19.8138”	110x25 10ft deep	Marginal Thermocline
11	N 044˚ 14’ 54.7148” W 122˚ 30’ 14.5261”	70x30 12ft deep	Marginal thermocline, deep cut along basalt intrusion
12	N 044˚ 14’ 28.0428” W 122˚ 29’ 02.6211”	200x40 10-15ft deep	Core rearing habitat, not temperature limited
13	N 044˚ 14’ 12.0736” W 122˚ 27’ 56.5074”	180x40 15ft deep	Core rearing habitat, not temperature limited, high potential

Figure (18)

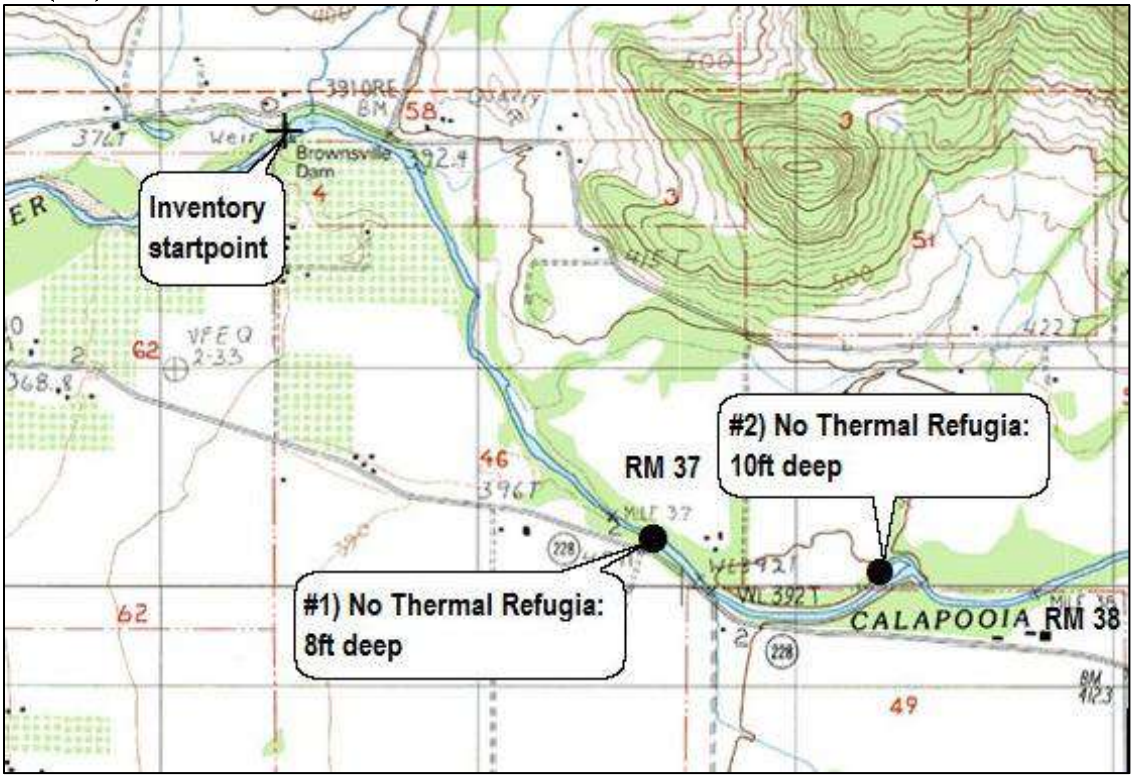


Figure (19)

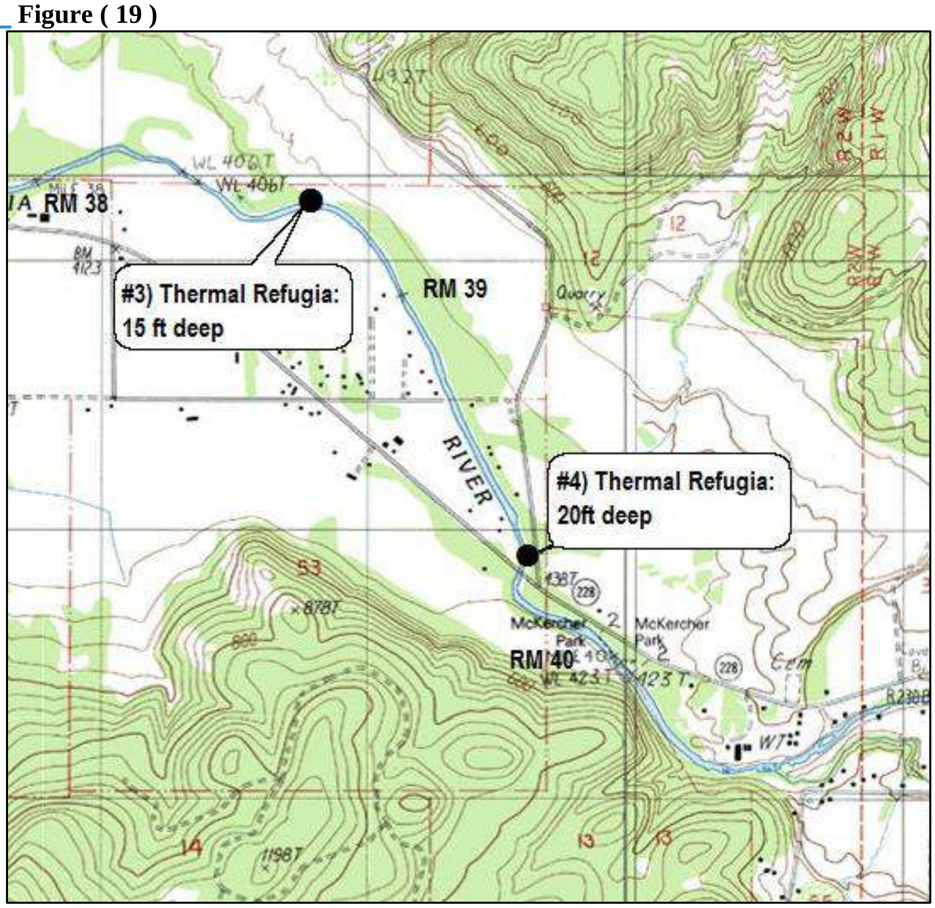


Figure (20)

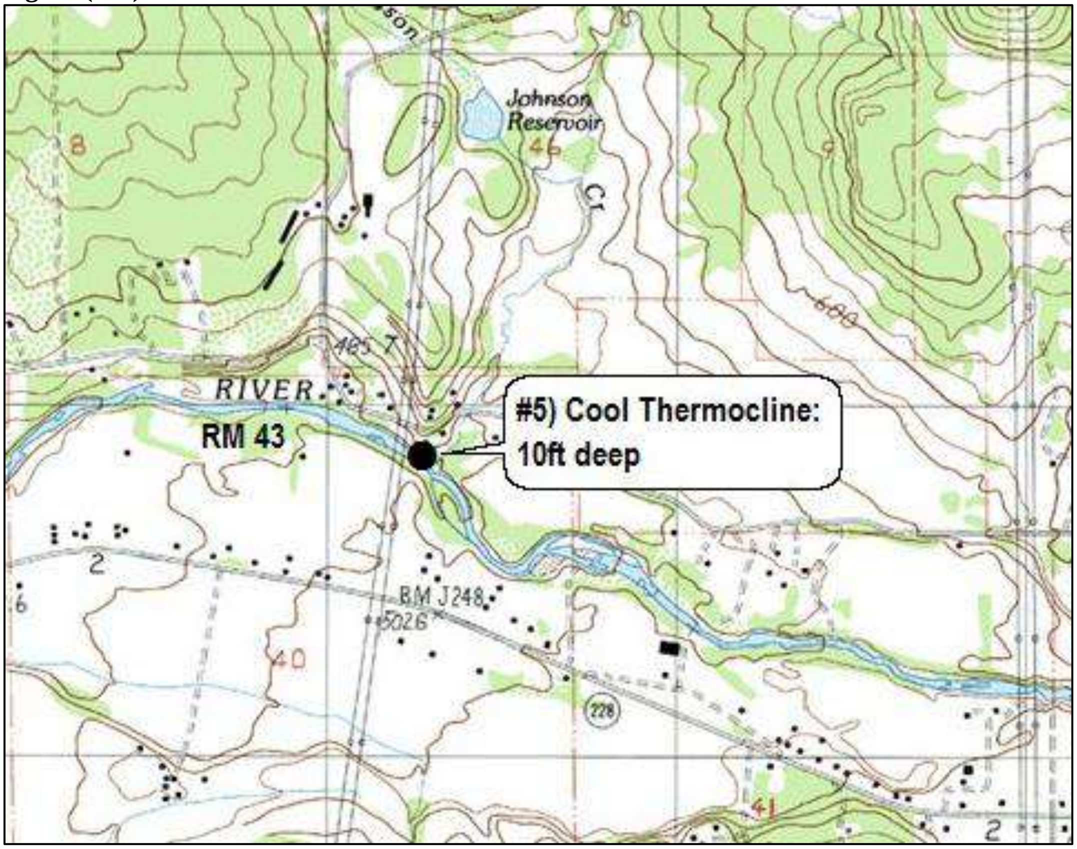


Figure (21)

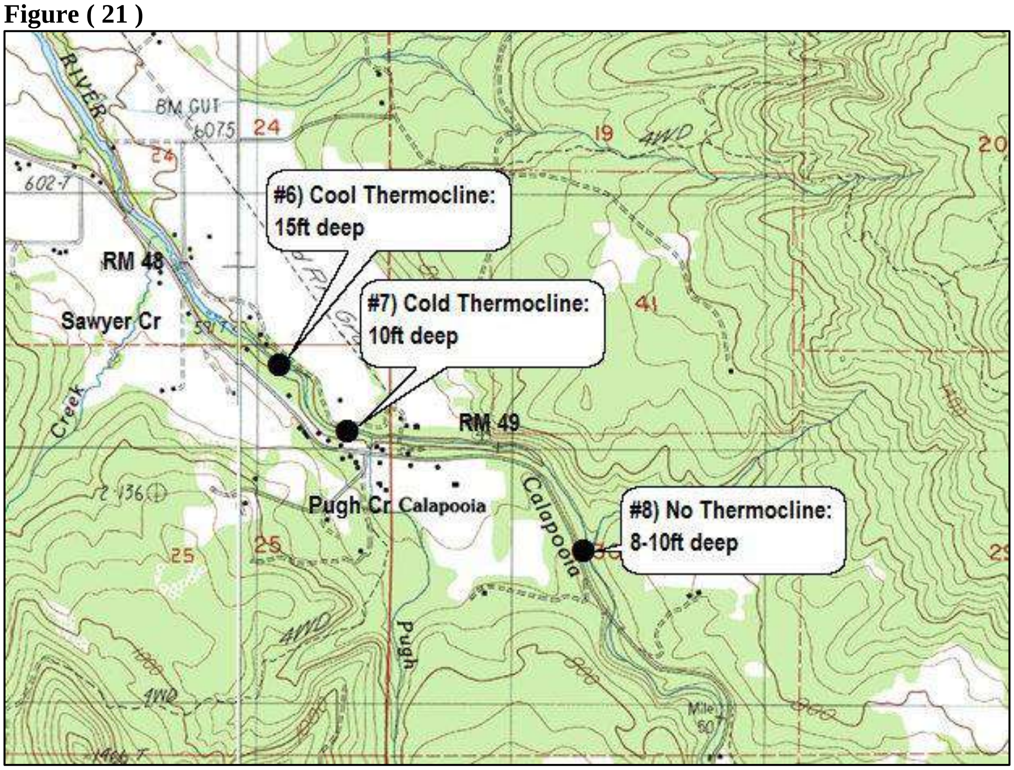


Figure (22)

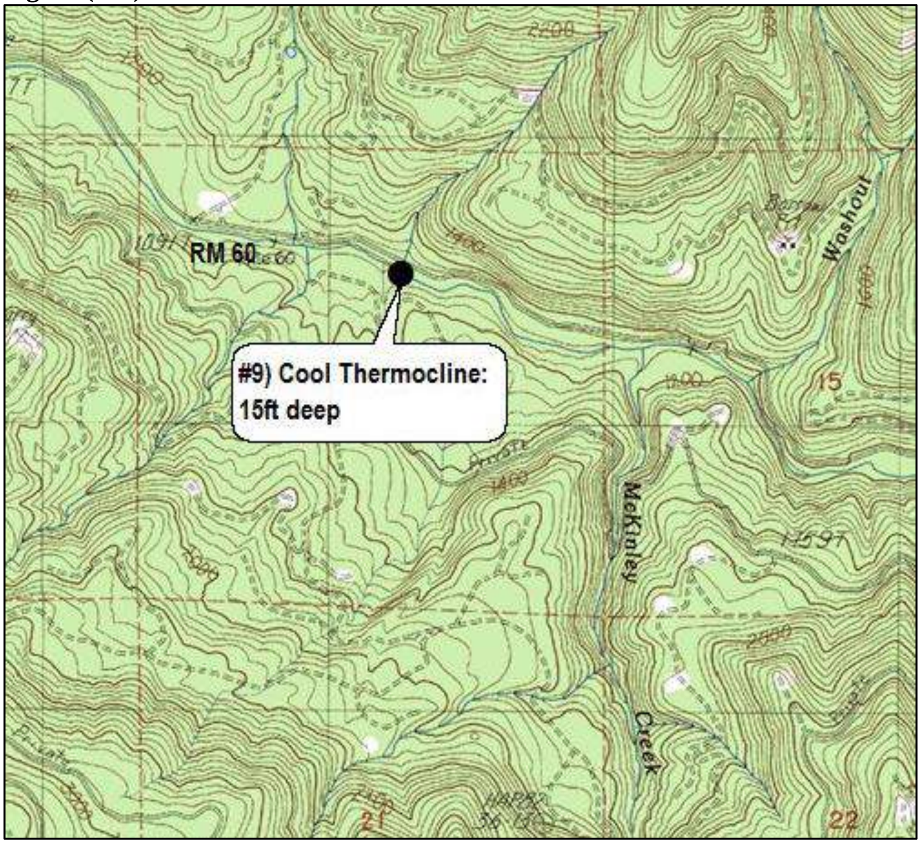
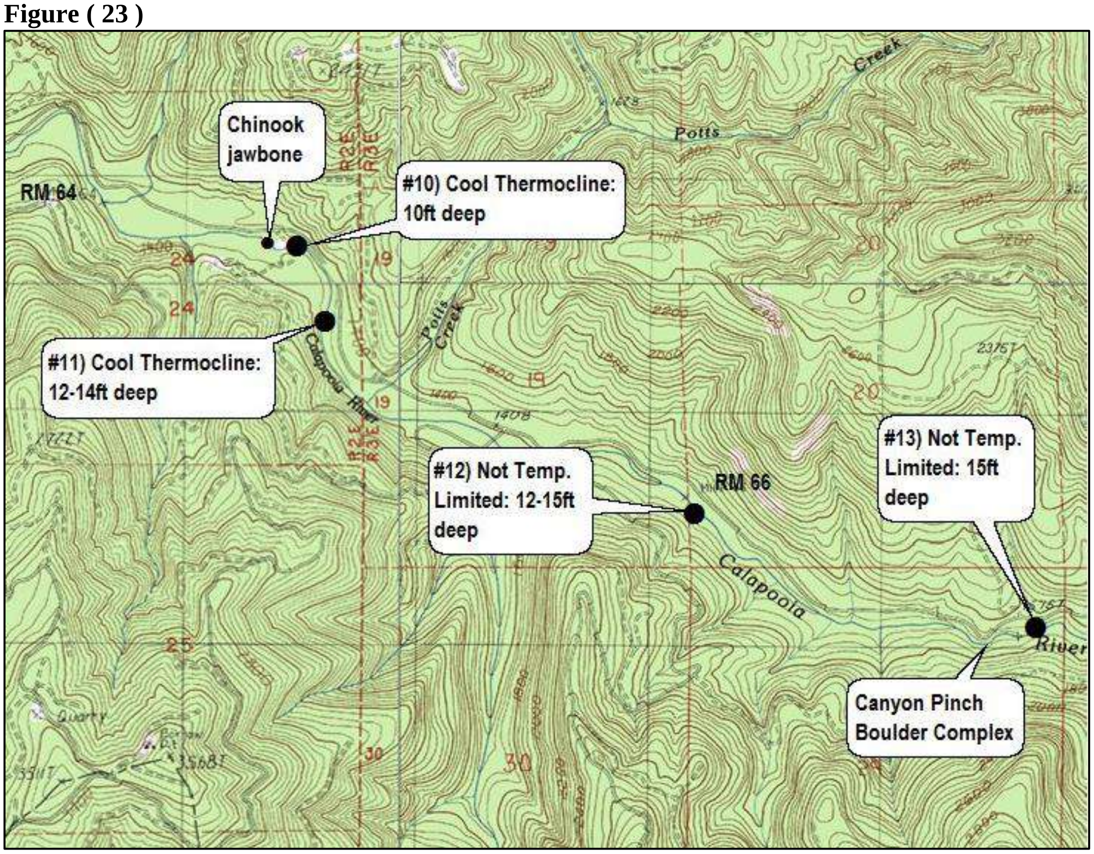


Figure (23)



Discussion

Utilizing salmonid abundance and distribution as an indicator of system function to guide restoration planning comes with some fundamental assumptions : 1) Focusing a restoration plan around the recovery of salmonid populations suggests that we believe what will be accomplished in the name of restoration will positively impact all other components of the system and do no harm to other species or processes ; 2) That the investment in salmonid recovery is merely a surrogate for an investment in watershed health that has trickle down implications for all the downstream users in the greater Willamette basin.

Utilizing the clues revealed in this inventory to expose relationships and linkages utilizes both what has been observed (fish abundance, distribution, relative temperatures, species composition, channel morphology, etc.) and what is implied (example, certain fish distribution patterns indicate upstream temperature dependent migrations). It is our job to utilize what limited information we have gathered to guide managers in the development of a biologically defensible restoration plan that attempts to address habitat limitations in a prioritized fashion. Clearly there is a need for additional data to verify the relationships that have been identified as drivers for salmonid survival and thus recovery. Many of the questions that have been developed within the scope of this inventory can be pursued further in subsequent years and thus have been captured in the "recommendations" section of this document.

How does the inventory inform our understanding of potential seasonal habitat limitations?

If we consider the 3 primary seasonal habitat needs of all species of salmonids, we are forced to partition the issues existing in the Calapooia basin into the following 3 categories; spawning habitat, summer rearing habitat and winter rearing habitat. We have generated a spawning gravel estimate for steelhead within the scope of this inventory to address the question "could the abundance of spawning gravel be the primary seasonal habitat limitation for steelhead production in the basin". That inventory estimated that there was at least enough suitable spawning gravel for sustaining a population of 446 adult winter steelhead (table 2), males and females combined. The modeling of winter steelhead contributions from the Calapooia basin to adult escapement above Willamette Falls ranges from 4.5% - 6% with an estimated historic contribution of 8% (WLC-TRT). Utilizing the last 10 year average of adult winter steelhead escapement over Willamette Falls (5,680) these modeled contributions suggest a current average range of escapement to the Calapooia of 256-341 adults. The estimates of spawning gravel abundance generated in the 2015 RBA suggest that the current abundance of spawning gravel would not limit the population until an escapement of approximately 446 adults (interestingly the 8% modeled historic contribution would be resulting in 454 steelhead adults to the Calapooia utilizing the last 10 year average escapement over Willamette Falls).

Because the observed abundance of the 0+ age class collapses below RM 65 it is possible that spawning steelhead below this point are experiencing very low egg/fry (or fry/parr) survival rates associated with rapid warming trends in the mainstem. Additional data collection will be required to address this question but hypothetically, only the spawning gravels above approximately RM 65 should be considered as functional (313 sqm, including side channel B). This suggests that 41% of the mainstem spawning gravels documented in table 2 may be only modestly contributing to production because of low egg/fry survival rates. In this scenario, the gravel resources above RM 65 and in the tributaries becomes the source of a seasonal habitat limitation to the population at current Willamette Falls escapement levels (this amount of gravel only providing incubation habitat for 288 adults).

Addressing the issue of a potential summer habitat limitation guides us to the conditions observed in the mainstem Calapooia during the 2015 RBA snorkel inventory where there are fish distribution profiles that suggest the presence of a thermoregulation issue for salmonids that appears to be driving summer distribution and ultimately survival (implied). If you review the results presented in figure 2, you will note the presence of a 9 mile stream segment that is nearly devoid of salmonids during peak summer temperature profiles between RM 56 and 65. Most salmonids must evacuate this reach for some unknown time frame or perish. This results in concentrating the summer rearing population in the 8 miles of functional anchor habitat between RM 65 – 72. This suggests that a severe summer habitat limitation exists in the system. All of the carrying capacity of the habitat that exists between RM 56 – 65 for both spawning and summer rearing is nullified when summer temperatures render it uninhabitable (this assumes that the 0+ age fry are not capable of an upstream migration to thermal refugia).

What this means is that other habitats must at least temporarily provide for the temperature dependent migrants forced out of reach 2 and into reach 3. Even this super imposition of summer rearing juveniles in reach 3 isn't bringing the summer rearing densities in reach 3 to full seeding levels.

You will also notice in a review of figure 2 that there is a stream segment between approximately RM 50 and 56 that continues to exhibit fish use even during the most severe temperature pinch periods and is clearly doing a better job in the provision of habitat than the evacuated segment between RM 56 – 65. This is a condition generated from the fundamental differences in channel morphology described on pages 20-23. Essentially the channel in the upper end of reach 1 (as a result of gradient and valley width) is developing large gravel depositions that present 2-3 ft vertical lifts between pool habitats. None of this fundamental channel morphology exists in either the lower end of reach 1 or in all of reach 2. This is a very significant difference that creates a highly valuable (and rare) habitat type within the mainstem Calapooia. This unique condition is allowing for the development of a hyporehic lens of water to flow through these large gravel depositions and to express itself on the downstream side of the bar at the head of a side channel, backwater or alcove. These unique spots are providing almost all of the pinch period thermal refugia that is being crowded into by all salmonid species to get through the lethal temperature windows in the adjacent mainstem.

Addressing the 3rd seasonal habitat need of salmonids in our review of potential habitat limitations forces us to consider the question "is there a lack of winter habitat in the system that might be the bottleneck for steelhead production". The winter habitat needs of different species of salmonids are not all equal. Winter habitat is commonly referred to as off channel, low velocity and existing on connected floodplains. In the case of steelhead, these attributes are not required components of functional winter habitat. Steelhead parr require only the channel roughness provided by large cobble and small and large boulders to effectively attain winter cover. Therefore, the fact that the mainstem Calapooia has been documented as extremely low in wood complexity and containing only a few functional side channels does not detract from its ability to provided adequate winter refugia in the form of complex substrate.

We have consistently focused in this discussion on steelhead and not the other salmonids observed co-inhabiting the Calapooia and its tributaries. Steelhead are the listed species of concern and O.mykiss is the most abundant species by far and extremely limited information is available for resident cutthroat populations. In most cases we are assuming that a restoration plan focused on steelhead will have positive benefits for other salmonid species.

In summary, without further data collection to evaluate the potential of a differential in egg/fry survival for spawning gravels above and below RM 65, this inventory is concluding that the abundance of functional summer habitat (below 64 deg) is the primary seasonal habitat limitation for salmonids in the basin. This suggests that addressing summer water quality and quantity should be the primary target of any future restoration or recovery planning effort. Until the abundance and distribution of functional summer habitats are expanded, Calapooia steelhead will be faced with an annual bottleneck to survival.

How does the inventory guide us in the development of a prioritized restoration plan?

Because we have described the actual locations of and the mechanisms that are currently providing thermal refugia in the mainstem Calapooia to listed winter steelhead and native cutthroat, it is possible to develop a phase 1 strategy for the protection and enhancement of these unique habitats that are at risk of disappearing. In addition, there may be additional opportunities to create similar habitats in reach 2 where the morphological conditions are appropriate as a phase 2 tactic.

We have highlighted the existence of the thermal barrier between RM 56-65 that eventually denies temperature dependent migrants access to cool head water reaches. Aggrading bedload in this reach to create gravel lifts similar to that observed in reach1 specifically addresses the primary limiting factor (by providing a hyporehic lens) and seeks to link two disjointed reaches with a thermal bridge during peak summer temperature profiles. Increasing sinuosity by lifting the active channel to encompass any isolated floodplain terraces will also benefit the primary limitation. This could be accomplished with boulder weir complexes distributed throughout reach 2.

Large wood projects in the mainstem Calapooia would not be effective at addressing the primary seasonal habitat limitation nor would they be structurally feasible. Large wood projects in the tributaries have some benefit (see recommendations) but will likely not be the projects that are capable of moving the dial significantly toward recovery. Restoration tactics in the tributaries should focus on improving the quantity and quality of summer flows.

Protecting existing refugia and creating and enhancing other potential sources of refugia is high on the list for restoration and stock recovery planning (see recommendations). The side channels and alcoves that currently are providing most of the thermal refugia are at high risk of avulsion. They could be stabilized with point bar wood jams that allow over topping during peak winter flows but are capable of denying the river complete winter access. These bars could immediately benefit from a planting strategy to stabilize bedload and create longevity for the known thermal refugias.

RECOMMENDATIONS

- The RBA has provided some temperature data and fish distribution clues that suggest severe summer temperature limitations exist in the mainstem Calapooia. Consider the deployment of thermistors during the summer of 2016 for validating the relationships documented in this inventory between lethal mainstem temperature profiles and key thermal refugia. This is critical in crafting a basin scale restoration plan that addresses actual habitat limitations and will be important for establishing a baseline for recovery monitoring.

- LWD treatments in tributary reaches that displayed the potential for significant fish production first (Potts and NF Calapooia) and then lesser tributaries second. 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 the lesser 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 (this addresses the identified primary seasonal habitat limitation; critical to lethal summer temperatures for salmonids in 89% of their lineal range). What is the value of considering spawning habitat in the tributaries if there is an abundance in the mainstem? Increasing spawning potential in tributaries that enter low in the basin may encourage life history diversity by providing late arriving adult steelhead (May), that encounter elevated warming mainstem temperatures, access to functional tributary spawning habitats. This could build contemporary resilience in the population to conditions (warming trends) that exist today.

- Expanding complexity (boulders, root wads, LWD) and the refuge surface area of pool habitats at tributary confluences in mainstem pools where fish populations are concentrating to seek thermal refugia during peak summer flows. These dependable sources of cool water are critically valuable to all salmonid species and age classes for use as refugia during high temperature periods. Increasing the complexity and the capacity of these identified habitats is high priority.

- Consider the importance of the tributaries identified in this document as critical cold water refugia 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.

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

- Consider lobbying ODFW for a special fishing restriction on the Calapooia that closes the mainstem to all angling between July 15 and August 31. Because all lower mainstem native cutthroat and T&E wild winter steelhead parr have been observed seeking spatially limited thermal refugia during this time period below USGS RM 65 it is clear that there is the potential for stress related mortality associated with angling. Another viable option for an angling closure would encompass just the mainstem above USGS RM 45.5 (Holley Bridge). No T&E winter steelhead parr were observed below this point during peak summer temperatures.

- Protecting, conserving and/or retaining riparian buffers on cold type N contributions to the mainstem Calapooia. A complete inventory of tributary contributions (volume / temperature) would be required for prioritizing high value targets for the development of potential conservation easements to protect water quality and quantity.

- Because Sthd spawning gravels between RM 65 and 72 have been identified as highly functional and a limited resource. It would be responsible to extend exceptional measures to conserve and enhance those gravel resources currently known to exist in this 7 mile reach of the mainstem. Those measures could include a designated no fishing zone, a call out in planning documents that may be influential in managing upslope sediment sources that could degrade gravel quality in the reach. Boulder weirs could be considered in this high value spawning reach to augment existing gravel resources.

- Identify wsthd redd locations in the priority spawning reach (between RM 65 and 72) and in the low survival spawning reach (RM 52 - 60) to cover with emergent fry traps to quantify relative egg to fry survival rates. This continues to refine our knowledge base in an attempt to identify the key habitat limitations in the system. Hypothesis is that stream temperatures are too warm in the lower reaches contemporarily for high egg/fry survival rates.

- Establish an annual snorkel inventory reach in the highest quality 7 miles of aquatic habitat to monitor trends in salmonid abundance over time RM 65 - 72. Conduct these surveys at an identical time each year near the first week of August.

- Because it appears that a significant portion of older age class cutthroat and steelhead are holding in the limited thermal refuge observed in reach 1 and not proceeding through the thermal barrier of reach 2 to the headwaters, consider a radical enhancement technique for expanding and maintaining these known refugia. Design a solar powered ground water recirculating system that pumps mainstem flows underground for cooling (similar to a heat pump) that can be ported to the proper backwater or alcove for maintaining and enhancing known thermal refugia. Improving the survival rate of the listed steelhead parr observed utilizing this unique habitats could boost smolt production.