Marys River Watershed Council
Final Monitoring Report to the City of Corvallis: 2008 – 2016
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The following summary includes the data and discussion for three sub-basins of the Marys River (Rock Creek, Woods Creek and Duffy Creek).

The following review is the result of nine years of monitoring effort. The last five years of that time series have been continuous annual monitoring. The goal of the project has been to quantify the response of cutthroat trout to restoration actions that occurred in designated Model Watershed sub-basins. These were sub-basins of the Marys River where thorough baselines existed for population abundance and water quality that were established in 2008 (Woods Creek), 2009 (Duffy Creek) and 2010 (Rock Creek). These sub-basins were subsequently treated with focused restoration actions designed to restore the function of disabled system processes. Cutthroat trout were chosen as a viable indicator species because they represent a high trophic level with the potential to benefit from the restoration of ecosystem processes (increases in channel complexity, increases in nutrient storage, increases in primary productivity, increases in access to existing habitats and increases in floodplain connectivity for the provision of winter refuge).

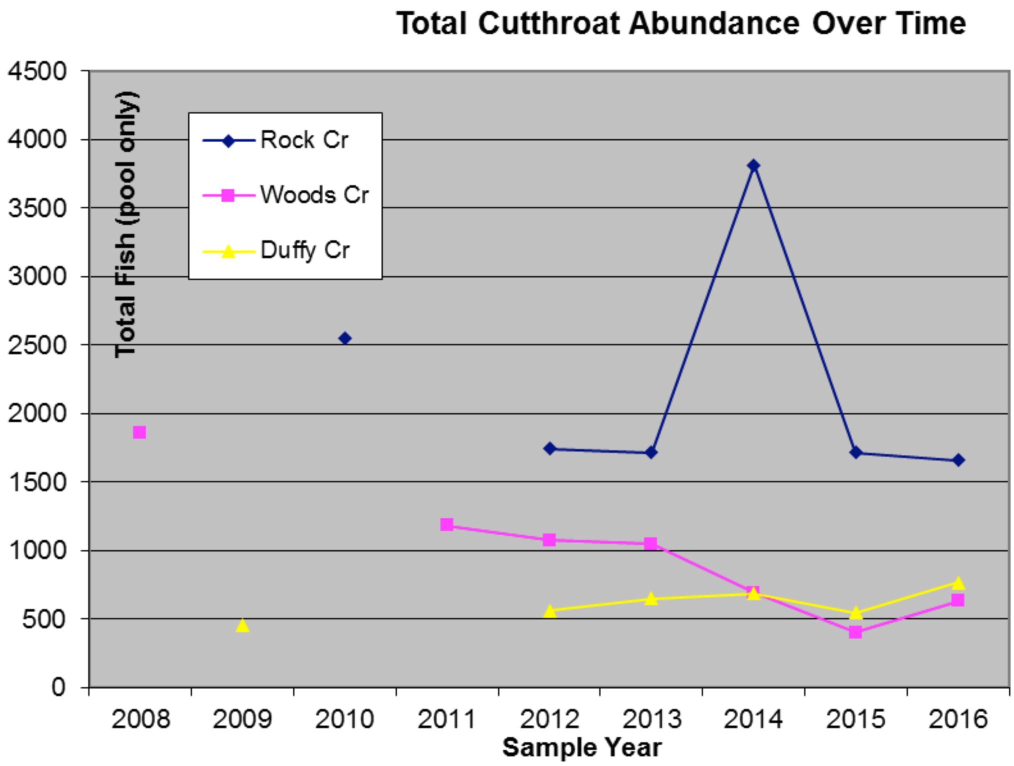
The stated goal for restoration planning in each of the treated sub-basins was to address the primary issues that appeared to limit system function. While the origin and magnitude of dysfunction for each habitat limitation differs from sub-basin to sub-basin, it is safe to say that addressing each of the identified potential limitations was important for achieving the goal of restoring normal system function for a diverse spectrum of both aquatic and terrestrial species with diverse life histories.

All of the treated streams were originally assayed for potential access issues that might affect seasonal habitat linkages. Culverts were replaced, bridges were installed and passage was provided at water intake dams. Care was taken to remove any impediments to access that might impact any life history stage of the cutthroat trout (adult, fry and parr during both summer and winter). All barriers to historically functioning cutthroat habitat were removed by the summer of 2013.

The results of project monitoring to date have been mixed with broad variation observed between years (Figure 1). In 2014 there was a significant response in Rock Creek while a continuing decline was being observed in Woods Creek that same year. Comparing initial population abundance (see pre-project years, Figure 1) to that observed at their lowest abundance year, cutthroat populations declined dramatically in Woods Creek (-78%), moderately in Rock Creek (- 35%) and increased in Duffy Creek (+20%). Contrarily, there have been increases in abundance in Rock Creek that although not sustained over time, have suggested the potential for radical increases in abundance. Rock Creek on its best year exhibited a cutthroat population 50% higher than the first post-year. Woods Creek has continued a steady decline in abundance and Duffy Creek a steady increase in abundance. It is clear that continued monitoring is a necessity for encompassing the types of meta population swings that are likely to be driven by environmental factors on a watershed scale and not at the 7th field scale.

We believe that the fluvial life history strategy of Marys River cutthroat plays a powerful role in determining when and where headwater habitats are utilized for their seasonal habitat attributes (spawning and incubation, summer thermal refugia). Because this migrating component of the meta population may have no affinity for their natal stream, then environmental factors such as water quality (temperature and flow volume) and food resources drive the temporal use of their home waters (Marys River Basin) that can be highly variable from year to year.

Figure 1



Methodology

Protocols involved the Rapid Bio-Assessment (RBA) methodology developed by Bio- Surveys, LLC for snorkel inventory. This is a random sampling strategy that is designed to gather a 20 percent census of all pool habitats in the watershed within the current distribution of cutthroat in each of the model watershed sub-basins. The results summarized in Table 1 are expansions of this 20% census. The method also collects pool metrics and classifies variations in habitat complexity.

Modifications were made to the historical data set to normalize the comparison of total cutthroat abundance between years. Unnatural dam pools exist above the City of Corvallis Water intake structures that typically hold very high numbers of cutthroat that over-estimate total abundance in an expansion of the 20% census. The average number of cutthroat / pool was calculated for each of these stream reaches (Rock Creek and Griffith Creek) and applied to the dam pool in years when these pools were encountered during the random inventory (calculations not provided).

An assumption is made each year that the random sample of 20% of pool habitats will fairly represent the broad diversity of pool quality and complexity that exists in Rock Creek.

Table 1 Combined Model Watershed Stream Summaries

Year	1+	2+	Total Cuts	Sthd	
Rock Creek					
2010	1,340	605	1,945	0	Post project
2012	985	525	1,510	0	Post project
2013	1,045	415	1,460	0	Post project
2014	2,220	880	3,100	0	Post project
2015			1,360	0	Post project
2016			1,415	0	Post project
Griffith Creek					
2010	405	55	460	0	Post project
2012	115	25	140	0	Post project
2013	115	15	130	0	Post project
2014	320	180	500	0	Post project
2015			215	0	Post project
2016			205	0	Post project
MF Rock Creek					
2010	145	0	145	0	Post project
2012	80	15	95	0	Post project
2013	115	10	125	0	Post project
2014	185	30	215	0	Post project
2015			80	0	Post project
2016			40	0	Post project
Rock Combined					
2010	1,890	660	2,550	0	Post project
2012	1,180	565	1,745	0	Post project
2013	1,275	440	1,715	0	Post project
2014	2,725	1,090	3,815	0	Post project
2015			1,715	0	Post project
2016			1,660	0	Post project
Woods Creek					
2008	745	1,110	1,855	10	Pre-Project
2011	575	610	1,185	0	Post project
2012	645	430	1,075	0	Post project
2013	695	350	1,045	50	Post project
2014	465	225	690	30	Post project
2015	260	140	400	0	Post project
2016			630	0	Post project
Duffy Creek					
2009	315	140	455	0	Pre-Project
2012	340	220	560	0	Post project
2013	490	160	650	0	Post project
2014	450	235	685	0	Post project
2015	360	185	545	0	Post project
2016			765	0	Post project

Rock Creek

Site specific conditions

The survey was initiated each year at the mouth of Rock Creek (confluence of Greasy Creek) and continued up the mainstem of Rock and its tributaries until increases in gradient diminished the potential of the aquatic habitat to provide significant cutthroat production. The survey included 11.2 miles of contiguous stream habitat. The start and end points of each inventoried stream segment were maintained between years for consistency.

The interannual comparisons of abundance contained in Table 1 have been modified (see modifications in Methodology section) from previous year's analyses to eliminate the sampling bias associated with the random encounter of the dam pools that exist above the water intake structures on both Rock Creek and Griffith Creek. Some years these two pools were encountered in the survey and some years they were not. The issue revolves around the expansion of the 20% sample when utilizing the high numbers of cutthroat observed in these uniquely productive man-made pools (Rock Creek intake dam pool not sampled in 2012, 159 cutthroat in 2013). Therefore absolute numbers are higher than reported in Table 1. On years when the intake pool was randomly selected for sampling, a calculated reach average was attributed to the intake pool for the total number of cutthroat and the actual number was not utilized in the final expansion of abundance. This facilitated more accurate interannual comparisons to quantify the change in abundance associated with the basin scale suite of restoration actions completed.

Extremely high water quality (cold summer temperatures) is continually observed in the headwaters of the Rock Creek sub-basin. All the headwater tributaries of Rock Creek originate from high coastal elevations and flow through largely intact Late Successional Reserves (LSR) on USFS property. Canyons are narrow, steep, heavily canopied and exhibit limited solar exposure on aquatic habitats. Wood densities are high, resulting in deep accumulations of transient bedload (sand, gravel and cobble). These deep bed loads of migratory substrate store summer flows in a hyporheic lens that protects and buffers the stream from exposure to direct sunlight and air.

Each of the major headwater tributaries (North Fork, South Fork, Middle Fork and Griffith Creek) eventually transition onto the City of Corvallis ownership, which is positioned lower in the watershed. The natural geomorphology of the City's ownership is described by wider floodplains and flatter channel gradients. These two natural features predispose the stream corridor to increased thermal impacts from air and solar exposure. Lower stream gradients (<2%) lengthen the window of solar exposure as a result of slower pool turnover rates. This condition is exacerbated by the east / west aspect of significant portions of the Rock Creek mainstem (below confluence of NF Rock). When you add the quantifiable decrease in stored bed load on City property (a result of low instream wood densities) to these other morphological differences, the stream begins to exhibit a warming trend outside the boundaries of the National Forest and below the confluence of the NF Rock Reservoir (Figures 2 &3 from Corvallis Watershed Stream Temperature Monitoring Summer 2012, Barbara Ellis-Sugai, Siuslaw National Forest; these sample sites are 0.5 miles apart).

Figure 2 **Temps Leaving USFS ownership**

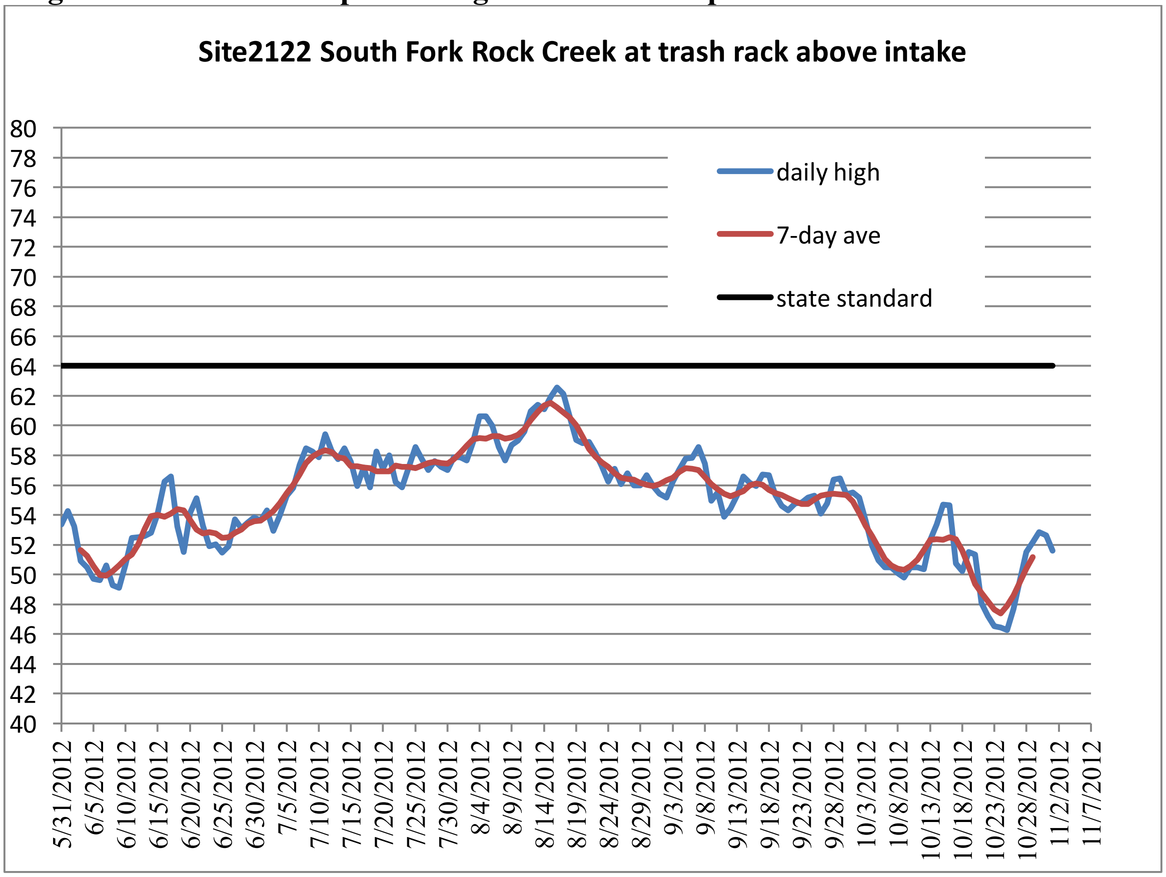
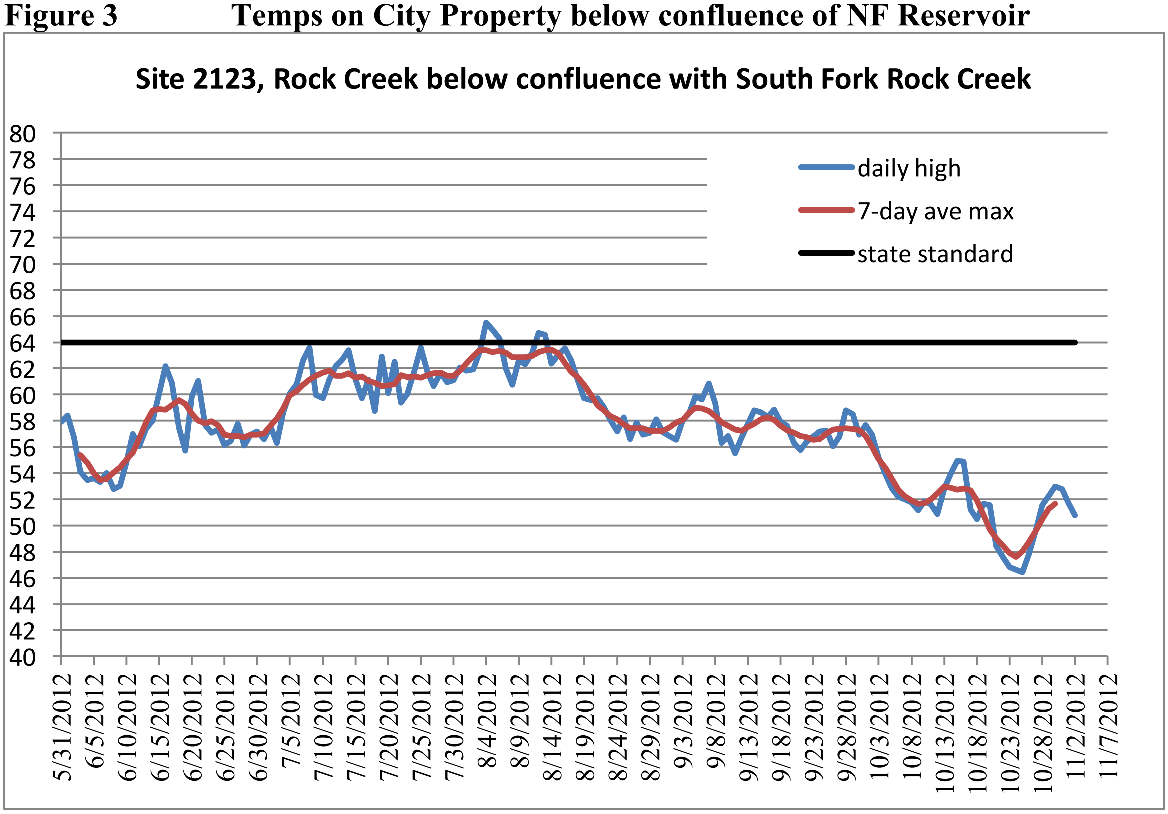


Figure 3 **Temps on City Property below confluence of NF Reservoir**



Results

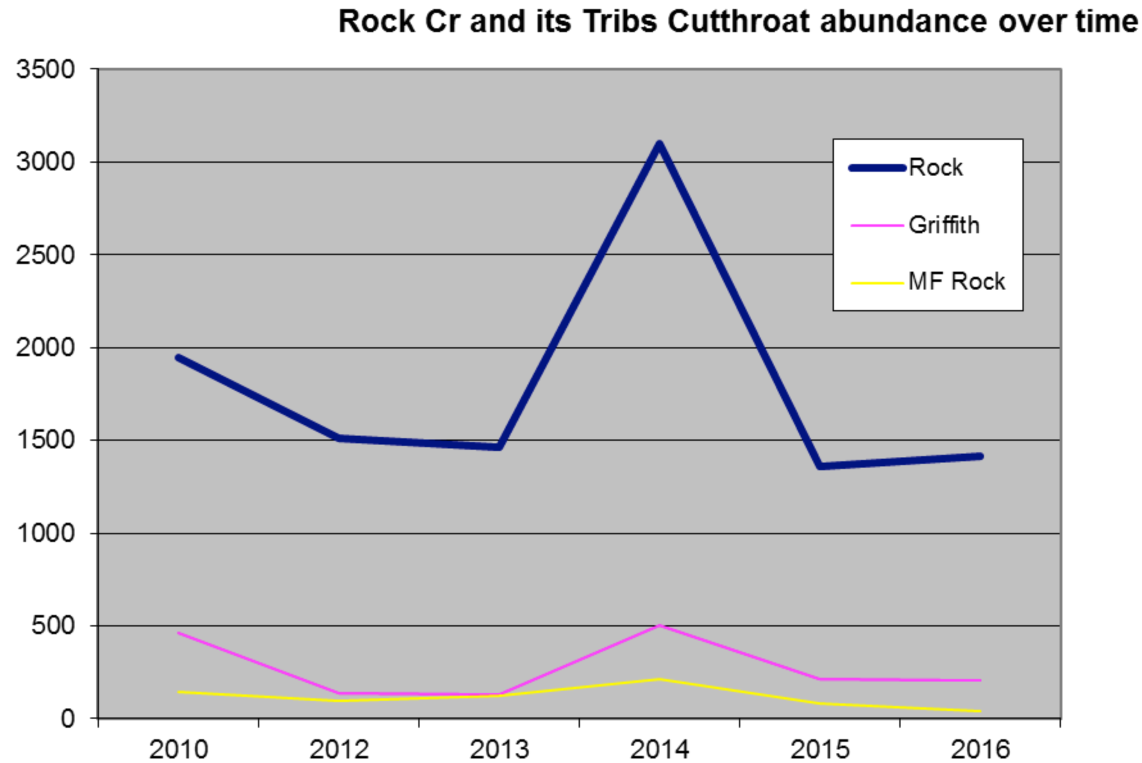
In 2006, a pre-project RBA snorkel inventory was conducted in the Rock Creek sub-basin and its tributaries to document the abundance and distribution of cutthroat trout prior to any of the contemporary restoration actions implemented by the Marys River Watershed Council (MRWC) and its partners. This 2006 effort (20% census) was conducted in May to coincide with peak adult spawner abundance and the timing was focused on documenting passage conflicts existing in the sub-basin to justify the expenditure of significant resources for rectifying long standing passage barriers (two impassable water intake structures and three perched culverts). Replicates of this census continued until 2010 and post-project inventories were utilized for pre- and post-project comparisons (a full description of these results can be found in Bio-Surveys, Post Restoration Monitoring Summary, 2010, MRWC archives).

During the summer of 2010, a replicate of the May RBA census was conducted in September that was designed to answer an entirely different monitoring question -- how will the abundance and distribution of cutthroat in Rock Creek change over time in relation to efforts to address the greatest limitation to system function, elevated summer temperature profiles in both Rock and Greasy Creek (Greasy Creek being a recipient of any cumulative temperature impacts originating in Rock Creek). By necessity, this formed a new baseline that no longer is relevant to the pre-project inventory conducted in 2006. Our hypothesis was that improvements in summer stream temperatures resulting from the restoration actions designed to capture bedload, aggrade the active summer channel and recharge floodplain terraces through hyporheic linkage would result in changes in the abundance of cutthroat during pinch period summer flows regimes.
Table 1 summarizes the total abundance of 1+ and older cutthroat observed in the three reaches of Rock Creek accessible to fluvial migrants (Rock Creek mainstem, Griffith Creek and MF Rock Creek). When compared to the first post-project summer census conducted in 2010, there was a 31.6% and a 32.7% decrease in abundance on the basin scale (all three stream reaches combined) for the two subsequent sample years of 2012 and 2013. This decline was reversed in 2014 with a 49% increase in abundance when compared to the first post-project year of 2010. However, continued sampling in 2016 resulted in a 35% decline in total cutthroat abundance when compared to the base line abundance observed in 2010. 2016 was the lowest recorded abundance to date for the Rock Creek basin. All hope is not lost however, because a large increase (50%) was documented in 2014 when compared to the first post-project year that was sampled (2010). The large fluctuation in abundance between 2014 and 2016 indicates that cutthroat are utilizing Rock Creek habitats seasonally and are not necessarily either full time residents or of Rock Creek origin.

Figure 4 suggests that the increase in total abundance observed in 2014 was observed in each of the three separate reaches of the Rock Creek survey (Rock mainstem, Griffith and MF Rock). Griffith Creek was the highest interannual increase at 285%.

The high interannual variability in abundance observed in Figure 4 suggests that there may be variables in play that extend beyond the physical changes associated with restoration actions within the Rock Creek sub-basin. Our original hypothesis was that improvements in basin scale linkages and habitat complexity would show an immediate and continual increase in cutthroat abundance. The declines observed initially in 2012 and 2013 were contrary to our hypothesis suggesting that our observations were being made on a larger and highly mobile population than existed in Rock Creek alone. Essentially we were not sampling a closed system (Rock Creek) but just a portion of the much larger Meta population extending into Greasy Creek and probably the Marys River mainstem.

Figure 4

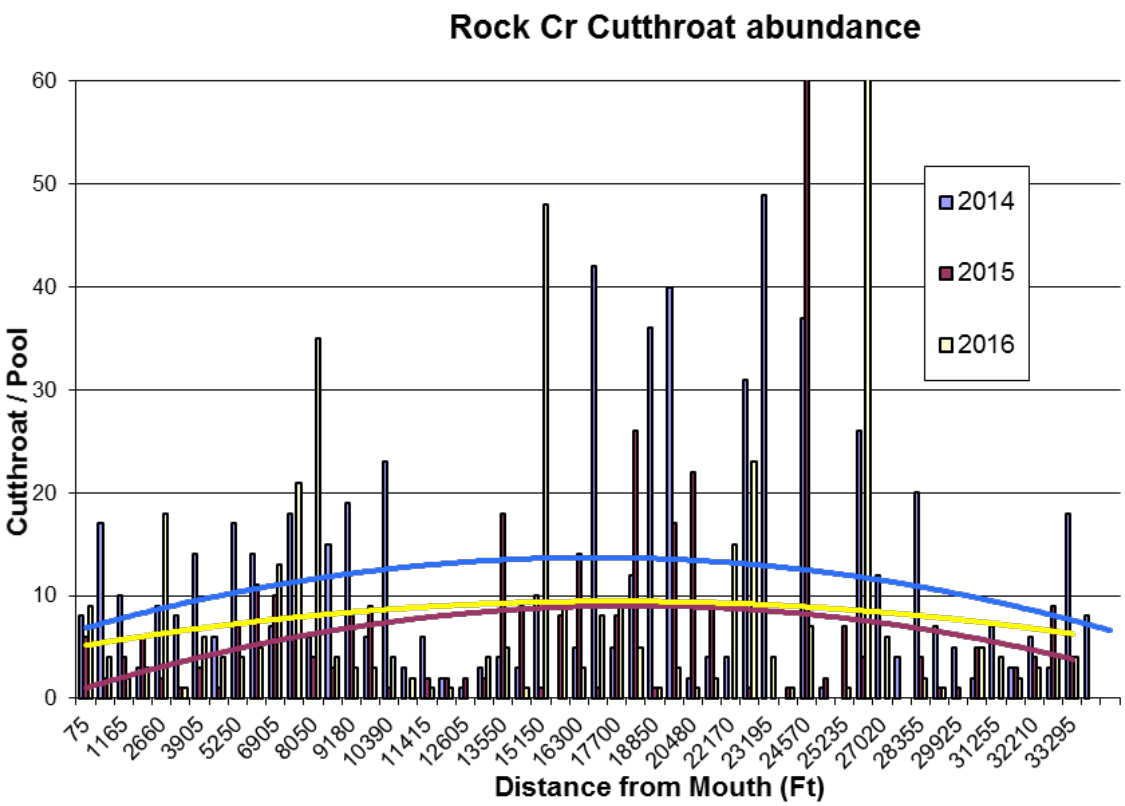


The inventory of 2014 observed a significant interannual increase in abundance when compared to the previous year, but then both the 2015 and 2016 inventories observed radical declines in cutthroat abundance on the basin scale suggesting again that seasonal abundance may be driven primarily by changes in habitat quality (flow and temperature) and not habitat quantity. Cutthroat migrating upstream from the mainstem Marys River or Greasy Creek in search of summer thermal refugia (temps below 64 degrees F) appear to be receiving varying migration signals from year-to-year (strong attraction one year, no attraction another). These upstream temperature dependent migrations logically orient migrants at each tributary confluence toward cooler upstream habitats. It would be counter-intuitive to believe that cutthroat faced with a temperature differential at a tributary confluence would elect to continue migrating up the warmer tributary given equal flow contributions, as is the case at the confluence of Rock Creek and Greasy Creek, Rock Creek is warmer (2012 Marys River continuous temp data station GR17 and 2012 USFS continuous temp data station 2128).

We are uncertain of the actual combination of environmental factors that predispose a migrating population to alter its pathway to summer thermal refuge from year-to-year. Issues to consider would likely be the range of fluvial winter migrations (do they extend into the mainstem Willamette or are they more localized to the mainstem Marys or even just Greasy Creek?). If they do range into the Willamette mainstem, then there is an opportunity for stream temperatures in the mainstem Marys to have an influence on the migration pathway as they encounter the Greasy Creek confluence. A cooler mainstem Marys (when compared to Greasy Creek.) may result in upstream temperature dependent migrants passing by the pathway that results in Rock Creek as a final destination. The opposite scenario could play out here as well. This suggests that the interannual variations in basin scale temperature profiles may be an important driver for summer abundance at the 6th field level (what are the relative contributions of tributary temperatures compared to the mainstem Marys temporally?). Could then the selection of a summer rearing location be related to the rate of warming in the mainstem Marys (quick warming selects for a lower basin tributary such as Greasy Creek, slower warming draws those fluvial migrants higher along the mainstem Marys migration corridor by the time a cooler tributary is selected (Tum Tum). These are larger basin scale queries that can only be answered with intensive telemetry and a much broader temperature monitoring strategy.

Figure 5 compares the differences in abundance and distribution (as described by fish / pool) of cutthroat in the mainstem of Rock Creek for the last three consecutive years. The comparison of the annual trend curve suggests that the lower mainstem of Rock Creek may have been cooler than the previous sampled years. This was observed by higher abundances of temperature dependent upstream migrants from the Greasy Creek mainstem in the lower two miles of Rock Creek. This may suggest that summer temperatures in this lower two miles improved in 2016 when compared to previous years (temp data was collected by the USFS for the mainstem of Rock in 2016 but was not available for this review).

Figure 5



Discussion

One of the hypotheses being tested in this review was that the observed declines in summer abundance in Rock Creek's coolest tributary (Griffith Creek mouth, site 2166, Appendix A Corvallis Watershed Stream Temperature Monitoring, Ellis-Sugai, 2013) in 2012 and 2013 were related to the notion that Griffith Creek plays a more significant role as summer temperature refugia when stream temperatures in the larger Greasy Creek basin are elevated. Thus we expected to see more fish in Griffith when mainstem Greasy Creek was warmer (2012, 2013, and 2015). However, fewer cutthroat were observed in Griffith in 2012, 13 and 15 (no temperature data for 2016) when mainstem Greasy Creek Greasy was warmer than observed in 2014. The observed declines in abundance in Griffith Creek occurred in years where the mainstem of Greasy Creek exhibited higher summer water temperatures. In 2013 there were 80 days at or above 64 degrees at the mouth of Greasy Creek and 38 days at or above 64 degrees in Greasy Creek above the confluence of Rock Creek (Marys River Annual Continuous Temperature Monitoring, archived data files). Comparatively there were only 36 days at or above 64 degrees at the mouth of Greasy Creek in 2010 and 0 days above 64 degrees in Greasy Creek above the confluence of Rock Creek in 2010. The cooler mainstem Greasy Creek years (2010 and 2014) were the highest observed abundance of cutthroat in Rock Creek and Griffith Creek (53 days above 64 degrees at the mouth of Greasy Creek in 2014). The large declines in abundance observed in 2015 followed this trend. There were 83 days at the mouth of Greasy Creek that exceeded 64 degrees and 63 days of exceedance above the confluence of Rock Creek making it the warmest year recorded with the greatest duration of exceedance both at the mouth and in the headwaters. In the most recent inventory, 2016, there were 55 days of exceedance at the mouth of Greasy Creek, 36 days of exceedance below the confluence of Rock Creek and 39 days above the confluence of Rock Creek.

This was the first year since monitoring efforts began that Rock Creek delivered cooler water at its confluence with Greasy Creek than the Greasy Creek mainstem. This is significant and suggests that there were changes in either water plant management or a positive response to restoration actions designed to store and sequester summer flows in a hyporheic lens or some combination of both. We have suggested in previous final report documents that it is likely that upstream temperature migration triggers occur far downstream of the Rock Creek sub-basin and that the cumulative temperature impacts occurring in the headwaters of Rock Creek play a critical role in relaying these temperature signals to cutthroat making migration choices at the confluence of Greasy Creek and the mainstem Marys River. The lack of a fish response to cooler flows at the confluence of Rock Creek and Greasy Creek may be related to the temporal trigger where Greasy Creek meets the mainstem Marys and not simply the temperature differential experienced at the confluence of Rock Creek and Greasy Creek.

There may be other environmental factors at play in the large interannual variation in abundance observed in Rock and Griffith Creeks that were not revealed in our monitoring efforts. This leads us to consider the possible role of variable summer flow volumes emanating from both streams as a result of potential differences in withdrawals at the three water intake structures within the system. It would be informative to compare summer flow volumes below both intake dams in 2015 and 2016. These are the back-to-back years where a temperature differential was quantifiable at the confluence of Rock and Greasy Creeks that shifted from Rock Creek being warmer in 2015 to Rock being cooler in 2016 (described by the cooling influence of Rock Creek on the mainstem of Greasy below their confluence in 2016).

Because the Greasy Creek mainstem always exceeds DEQ water quality standards for temperature and this condition can be sustained for long continuous periods between July and September, it follows that the observed temperature differential between Rock and Greasy Creek (Rock Creek exhibiting a cooler temperature profile than Greasy Creek) in 2016 may indicate a cooling trend in Rock Creek that could have a positive influence on the lower mainstem of Greasy Creek. Reducing the temperature contribution of Rock Creek, both as a benefit to Rock Creek salmonid habitat and for its cumulative impact on mainstem Greasy Creek, has always been the primary restoration objective of the MRWC. Rock Creek summer temperature profiles were identified in the 2006 Corvallis Watershed Forest Stewardship Plan as the most significant limitation to the viability of salmonid populations within Rock Creek (page 25) and readdressed in the 2013 update as a positive factor in restoration treatments undertaken to date, as well as having the potential for negative impacts on fish and aquatic macroinvertebrate populations (page 16). Temperature probes have been in place 1,300 feet above the confluence of Rock Creek and 2,000 feet below the confluence of Rock Creek for multiple years. Data collected from these two stations document that Rock Creek, since monitoring began in 2008, has always been warmer than the mainstem of Greasy Creek above its confluence until 2016. The reversal of the temperature differential between these sites in 2016 should be portrayed as a significant success and a realization of project goals and objectives. Sustaining this differential is important and may take continued temperature monitoring to facilitate adaptive withdrawal management within the City's Rock Creek drinking water system.

Maintaining Rock Creek as functional temperature refugia (cooler than the mainstem of Greasy Creek at its confluence) has significant survival implications for the larger Meta population (elevated stream temperatures are known to impose stress on salmonids that reduce survival rates directly and indirectly). Therefore, the commonly stated management objective of not exceeding DEQ water quality standards (18 C) in the mainstem of Rock Creek is merely a general guideline for evaluating water quality compliance. It does not attempt to consider the relevance of water quality (and its origin) to larger ecosystem processes. To take what we have learned about the basin scale distribution of variable temperature profiles and the resultant impact on cutthroat distribution (our chosen indicator species) to the next level of designing a constructive restoration plan, we should be taking a hard look at how the larger Greasy Creek sub-basin of the Marys is functioning as a whole (this extends our focus beyond the confines of Rock Creek). What are the 5th field limitations to system function and what important seasonal services might individual 6th or 7th fields need to contribute so that the whole basin functions as an ecosystem. Because Rock Creek is the premier source of high water quality for the Marys (volume and temperature), it has always represented the greatest opportunity for restoration and aquatic conservation in the Marys River basin. This has played out in Rock Creek in the form of an extensive public investment in restoration planning and restoration actions on both City and small private ownerships. The goal continues to be simply, improve summer water quality (temperature) and quantity (flow).