Marys River Watershed Council: Rock Creek
2008 – 2017
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The following summary includes the data and discussion for Rock Creek.

The following review is the result of 10 years of monitoring effort. The last 6 years of that time series have been uninterrupted annual monitoring in Rock, Woods and Duffy Creeks. Shotpouch Creek was last surveyed in 2013. The goal of the project has been to quantify the response of cutthroat trout to restoration actions that occurred in designated Model Watershed subbasins over time. These were subbasins 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 Shotpouch Creek) and 2010 (Rock Creek). These subbasins were subsequently treated with focused restoration actions designed to restore the functionality of degraded system processes. The abundance of Cutthroat trout was chosen as the most likely indicator of interannual change. Cutthroat trout are the highest trophic level within the aquatic ecosystem 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, reductions in summer water temperatures associated with aggradation and increases in floodplain connectivity for the provision of winter refuge and supplemental water storage).

The stated goal for restoration planning in each of the treated subbasins 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 subbasin to subbasin, it is safe to say that addressing each of the identified 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 initially assayed for the existence of potential barriers to access that might affect seasonal habitat linkages. Culverts were replaced, bridges were installed and passage was provided at water intake dams (fish ladders). 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. In 2017, another high abundance year was observed in Rock Creek while the decline continued in Woods Creek. 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%). There have been sporadic, unsustained increases in abundance in Rock Creek (2014, 2017) that suggest the presence of environmental factors other than the abundance of high quality spawning and rearing habitat that limit the capacity of the native cutthroat population from taking advantage of the quantifiable increase in habitat quantity associated with restoration. Rock Creek on its best year exhibited a cutthroat population 50% higher than the first post-project year. Woods Creek has continued a steady decline in abundance and Duffy Creek a consistent increase in abundance. It is clear that continued monitoring is required for encompassing the types of meta population swings that are likely to be driven by environmental factors that exist on both the 5th field HUC scale and the 7th field HUC scale. We believe that the fluvial life history strategy (migrates throughout the river network) 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, environmental factors such as water quality (temperature and flow volume) drive the seasonal occupation of habitats which can be highly variable from year to year.

Figure 1

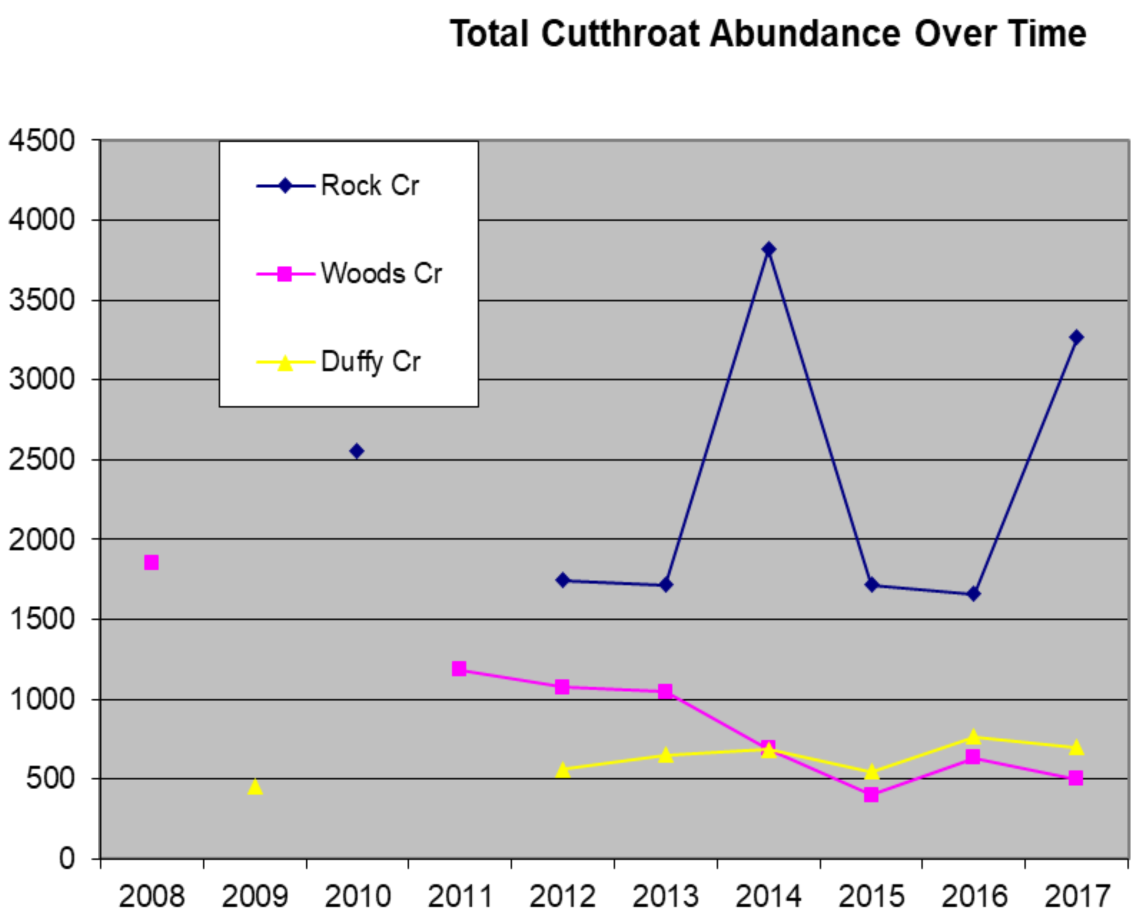


Table 1

2008 -2017 Model Watershed Abundance over time

(all fish numbers are expansions of a 20% census of pool habitats only)

Rock

Year	1+	2+ or >	Total Cuts	Sthd	
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
2017			2,840	0	Post project

Griffith

Year	1+	2+ or >	Total Cuts	Sthd	
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
2017			335	0	Post project

MF Rock

Year	1+	2+ or >	Total Cuts	Sthd	
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
2017			90	0	Post project

Rock Combined *Rock - Griffith - MF Rock*

Year	1+	2+ or >	Total Cuts	Sthd	
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
2017			3,265	0	Post project

Woods

Year	1+	2+ or >	Total Cuts	Sthd	
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
2017			500	0	Post project

Duffy

Year	1+	2+ or >	Total Cuts	Sthd	
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
2017			700	0	Post project

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 abundance for all pool habitats within the current distribution of cutthroat in each of the model watershed subbasins. 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 can 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.

A fundamental assumption has been made each year that the 20% random sample of pool habitats fairly represents the broad diversity of pool quality and complexity that exists in Rock Creek after the LWD treatments. This assumption is critical because a clear differential exists in habitat occupancy by cutthroat between highly complex treated pools and simple untreated pools.

In 2017 this assumption was tested to certify that the assumption remained valid after 10 years of structure maturation where treated pools were beginning to display much higher occupancy rates by cutthroat. To test the assumption that the 20% sample of all pool habitat (treated and untreated) still represented an accurate sample of treated pool habitats, two back to back (24 hr differentiation) snorkel inventories were conducted by different snorkelers. The first inventory sampled all pool habitats utilizing the standard RBA protocol (20% pool inventory). The second inventory conducted a 100% sample of all structure pools, those developed from multiple restoration actions and naturally occurring.

When the expanded estimates of cutthroat abundance were compared for mainstem Rock Creek utilizing the results from the 20% and the 100% samples, there was a 1.6 percent differential in reach scale cutthroat abundance (2,840 vs. 2,885). This is a value that exists well within the range of the variability normally attributed simply to different snorkelers. The comparison suggests that the 20% sampling methodology utilized in the RBA Inventory continues to fairly represent the broad range of habitat complexity present after significant restoration actions designed to improve channel complexity were implemented.

Results

In 2006, a pre-project RBA snorkel inventory was conducted in the Rock Creek subbasin 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 subbasin to justify the expenditure of significant resources for rectifying long-standing passage barriers (2 impassable water intake structures and 3 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).

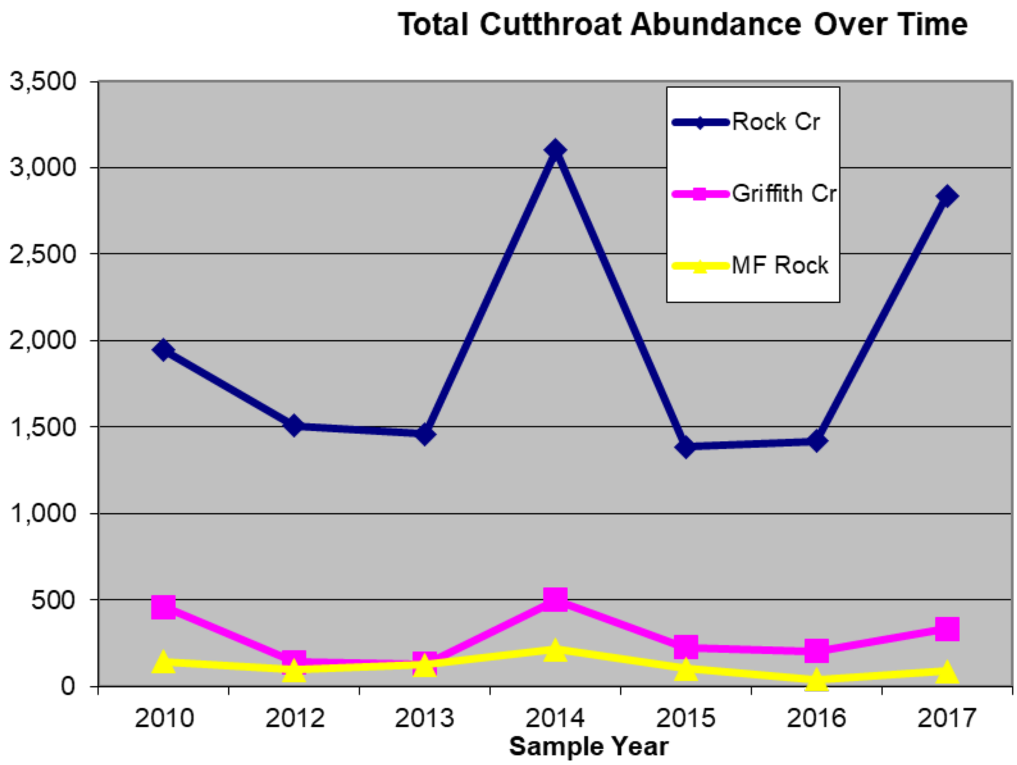
During the summer of 2010, a replicate of the May 2010 RBA census was conducted in September that was designed to answer an entirely different monitoring question, "How will the abundance and distribution of cutthroat in Rock Creek change over time in relation to efforts to address the greatest limitation 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, the shift in survey timing (May to September) 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 flow regimes.

Table 1 summarizes the total abundance of 1+ and older cutthroat observed in the 3 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 3 stream reaches combined) for the 2 subsequent sample years of 2012 and 2013. This decline was reversed in 2014 with a 50% increase in abundance when compared to the first post-project year of 2010. The 2016 sample resulted in a 35% decline in cutthroat and the 2017 sample posted a 28% increase in abundance when compared to the base line observed in 2010. 2016 was the lowest recorded abundance to date for the Rock Creek basin. The continued large fluctuation in abundance between 2010 and 2017 indicates that cutthroat are utilizing Rock Creek habitats seasonally and are not necessarily year around residents or even of Rock Creek origin.

Figure 2 suggests that the increase in total abundance observed in 2014 was observed in each of the 3 separate reaches of the Rock Creek survey (Rock mainstem, Griffith and MF Rock). Griffith Creek was the highest interannual increase in 2014 at 285%.

The high inter annual variability in abundance observed in figure 2 suggests that there are variables in play that extend beyond the physical habitat changes associated with restoration actions in the Rock Creek subbasin. The original hypothesis associated with post-project monitoring 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 a much larger Meta population extending into Greasy Creek and probably the Mary's River mainstem.

Figure 2



The inventory of 2014 observed a significant inter annual 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 deg F) appear to be receiving varying migration signals from year to year (strong attraction one-year, minimal attraction another). These upstream temperature dependant 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, where they generally have equal flow contributions, with Rock Creek warmer most years).

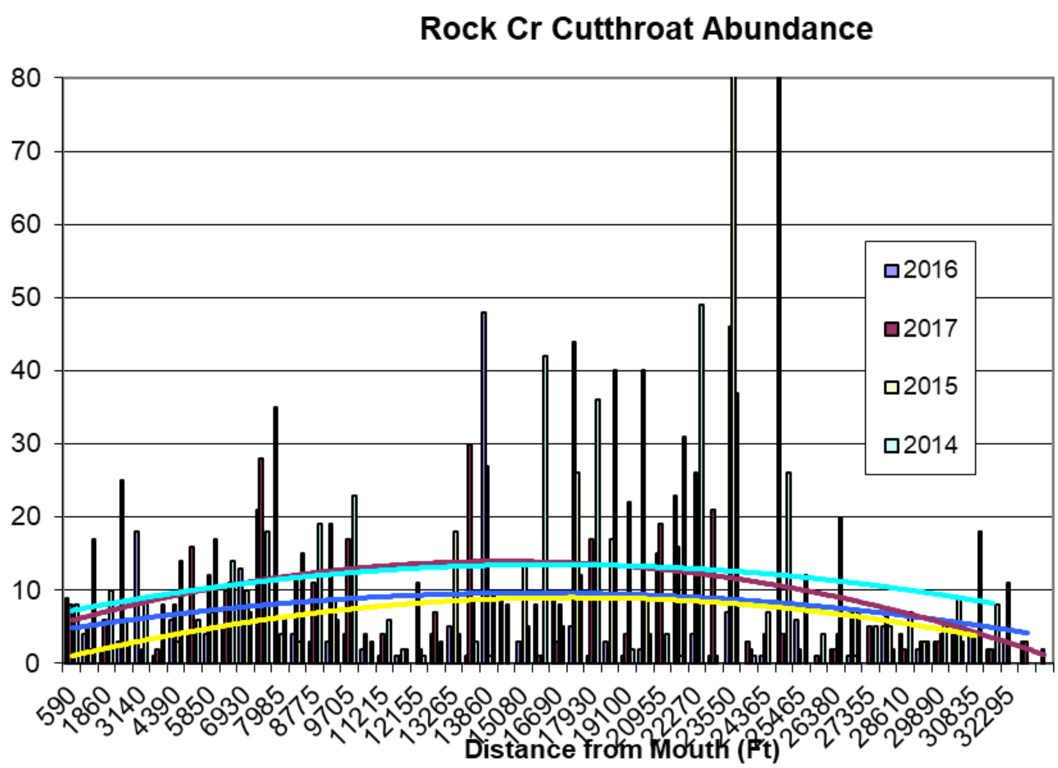
We are uncertain of the actual combination of environmental factors that predispose a migrating population to alter its pathway to summer thermal refuge from year to year. Issues to consider would likely be the range of fluvial winter migrations (do they extend into the mainstem Willamette or are they 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 6^{th} field level (based on the relative contributions of tributary temperatures compared to the mainstem Marys temporally). The selection of a summer rearing location (thermal refugia) could then be related to the rate of warming in the mainstem Marys, where quick warming selects for a lower basin tributary such as Greasy Creek and slower warming draws those fluvial migrants higher along the mainstem Marys migration corridor by the time a cooler tributary is selected (e.g., Tum Tum). These are larger basin scale queries that can only be answered with intensive telemetry and a much broader temperature monitoring strategy.

Figure 3 compares the differences in abundance and distribution (as described by fish / pool) of cutthroat in the mainstem of Rock Creek for the last 4 consecutive years. The comparison of annual trend curves represent 2 low abundance years (2015 / 2016) and 2 high abundance years (2014 / 2017). The primary anomaly observed in this profile of distribution is the higher abundance of cutthroat in the lower mainstem of Rock Creek in 2016 on a low abundance year. This suggests that the lower mainstem of Rock Creek may have been cooler in 2016 than previous low abundance years (higher abundance of upstream migrants from Greasy Creek in the lower 2 miles of Rock Creek). This may suggest that summer temperatures in this lower 2 miles improved in 2016 when compared to previous years (USFS temp data for the mainstem of Rock has been collected for each of these years at the Bridge after entering city property, RM 0.4). This temp data calculated the highest 7-day average maximum for the years portrayed in figure 3 at;

2014 – High abundance – 67.3 deg F
2015 – Low abundance – 68.8 deg F
2016 – Low abundance – 66.6 deg F
2017 – High abundance - 67.3 deg F

Figure 3



Discussion

The observed declines in abundance in Rock and 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 deg at the mouth of Greasy Creek and 38 days at or above 64 deg in Greasy Creek above the confluence of Rock Creek. Comparatively, there were only 36 days at or above 64 deg at the mouth of Greasy Creek in 2010 and 0 days above 64 deg in Greasy Creek above the confluence of Rock Creek in 2010. The cooler mainstem Greasy Creek years (2010, 2014 and 2017) were the highest observed abundance of cutthroat in Rock Creek and Griffith Creek (53 days above 64 deg at the mouth of Greasy Creek in 2014, 69 days in 2017). The large declines in abundance observed in 2015 followed this trend. There were 83 days at the mouth of Greasy Creek that exceeded 64 deg 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.

There was a single anomaly in this pattern observed in 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 would qualify as a cool water year for the mainstem of Greasy Creek that should have resulted in a high cutthroat abundance in Rock Creek. Instead, this was the lowest abundance year recorded in the 7year assessment. 2016 was the first year since monitoring efforts began where Rock Creek delivered cooler water at its confluence with Greasy Creek than the Greasy Creek mainstem. In the 2016 final report document we had hypothesized that there may have been a change in water plant management that created this positive change in the relative temperature profiles between Greasy Creek and Rock Creek at their confluence. In the final report document on Rock Creek temperature profiles provided to the City of Corvallis in March of 2017 by Barb Sugai (Addendum to the stream Monitoring Report of 2015) it was observed that flow volumes from a leaking dam valve at the base of the NF Rock Creek spillway was providing nearly ½ of the flow volume of Rock Creek on July 22. The report states that the flow volume from the bottom of the reservoir was 3-4 times greater in 2016 than measured historically because of the leaky infrastructure. This additional flow volume was high quality cold water from the bottom of the reservoir that was 56 deg F on July 22nd and 2 deg F colder that the remainder of the headwater flow volume from the SF of Rock Creek. This temperature differential is even greater during the period when the reservoir spillway is delivering warm surface water from the top layer of the reservoir exposed to extensive solar radiation. The Sugai report is clear on this impact, "The temperatures in the Rock Creek mainstem below the confluence (site 2123) drops over time as the spillway flow decreases".

Not by design, an appropriate experiment has been conducted in both 2016 and 2017 where the mainstem of Rock Creek was significantly augmented by cold water from a stratification off the bottom of the NF Rock Creek reservoir through a leaky control valve at the base of the earthen dam. In 2016, the surveys of cutthroat documented the lowest basin scale abundance recorded in a 7-year period. However, in 2017, the surveys observed the second highest estimate of abundance (Figure 2) in that same time frame. As discussed previously from the results in Figure 3, there was a distinct increase in cutthroat abundance observed in 2016 in the lower 2 miles of the mainstem of Rock Creek even though it was a low abundance year.

Our monitoring efforts do not reveal why two back to back years with cold water supplementation would have resulted in 1 poor cutthroat response year (2016) and one exceptional cutthroat response year (2017). We have suggested in previous final report documents that it is likely that upstream temperature migration triggers for the fluvial cutthroat life history strategy occur far downstream of the Rock Creek subbasin and that the temperature impacts occurring in the headwaters of Rock Creek (elevated surface spill temperatures from the NF Reservoir) play a critical role in relaying these temperature signals to cutthroat making migration choices in May at the confluence of Greasy Creek and the mainstem Marys River.

Another environmental factor at play in the large inter annual variation in abundance observed in Rock and Griffith Creek may be the role of variable summer flow volumes emanating from both Rock and Griffith Creek as a result of potential differences in withdrawals at the 3 water intake structures within the system. As seen in the table below, flows measured by Barb Ellis Sugai and reported in her 2016 summary (pages 28 – 29) show a higher average flow in Rock Creek mainstem below the confluence with the South Fork in 2014, especially earlier in the season. This may provide the main explanation for the Cutthroat abundance observed in that year.

Flow data from Barbara Ellis-Sugai's 2016 Report (pages 28 & 29):

Rock Creek Mainstem Flow below Confluence	Mid May Reading	Late May Reading	Early June Reading	Late June/Early July Reading
2014	48.16	23.3	13.69	4.89
2015	10.77	9.25	6.235	3.31
2016	No data	12.89	No data	3.55

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 increasing the temperature differential between Rock Creek and Greasy Creek, given the crucial temperature role Rock Creek plays as Greasy Creek's primary tributary has always been the primary restoration objective. Temperature probes have been in place 1,300 ft above the confluence of Rock Creek and 2,000 ft 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.

Unfortunately, the thermistor deployed in Greasy Creek above the confluence with Rock Creek in 2017 went missing and we therefore do not have that data for 2017. 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 management at the City's Rock Creek water plant.

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 in that 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 (17.8 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 an effective restoration plan, we should be taking a hard look at how the larger Greasy Creek subbasin of the Marys is functioning as a whole (this expands our ecosystem restoration planning focus beyond the confines of Rock Creek). What are the 5th field limitations to system function and what important seasonal services might individual tributaries (like Rock Creek) need to contribute so that the whole basin functions as a single cohesive system? 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.

A water intake retrofit for the NF Reservoir has been scheduled for 2018 that includes a replacement of the leaking dam valve at the base of the dam. The loss of cold water supplementation in May and June from the bottom of the reservoir (leaky valve) that mitigated for the elevated surface spill from the reservoir in 2016 and 2017 is likely to restore Rock Creek to a warmer temperature profile at the confluence with Greasy Creek that will reduce the use of Rock Creek as thermal refugia for native fluvial cutthroat during elevated summer temperatures in Greasy Creek and the mainstem Marys River. It is for this reason that MRWC has advocated for the installation of a semi-automated valve that would allow the City to relatively easily manage the reservoir level with bottom cold water releases rather than warm water top spills.

Continuing the search for socially acceptable solutions for improving water quality in Rock Creek and its tributaries remains the highest restoration priority within the Marys River Basin. The goal is simply: improve summer water quality (temperature) and quantity (flow).