City of Bend Bridge Creek Water System
2017 Tumalo Creek Fish Monitoring Report

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In accordance with the monitoring requirements for the Operation of the City of Bend Bridge Creek Water System (start-up 4/2016), under Special Use Permit with the Deschutes National Forest, fish populations in Tumalo Creek are to be monitored to assess effects from operation of the new system. Monitoring is to occur annually during 2016-2018, then every other year through 2024.

Pipeline Operations and Management Plan:

Monitoring will be conducted by Deschutes National Forest Fisheries personnel after the new system is in operation. A total of 5 sites will be surveyed annually in late summer for 3 years, then biennially over the next 6 years. This schedule is subject to change based on an annual evaluation of the monitoring program by staff from the City of Bend, Deschutes National Forest, and other stakeholders. One monitoring site will be above the City of Bend project area (between the junction with Bridge Creek and Tumalo Falls) and 4 sites will be within the affected area of Tumalo Creek within Sub-reach A1. Further, the 4 sites within Sub-reach A1 will include two sites within Sub-reach A1RR (upper and lower) and two sites within Sub-reach A1B. The 4 sites within the affected area will be those previously surveyed in the 2011 fisheries survey of Tumalo Creek. The one site above the project area will be a new site, the Control Site. Each site will be 200 meters in length. The survey crew generally consists of two snorkelers and one data collector/safety person. Typically, one site per night will be surveyed per crew.

Methodology:

Snorkeling was chosen as the monitoring method as it offers a reasonably efficient and cost effective tool to assess population trends, relative abundance, distribution, and assemblages of the fish community, with little disturbance to fish, which is common in electrofishing surveys. The infeasibility of deploying block nets common to electrofishing Mark-Recapture or Depletion surveys to determine population estimates also led to the selection of snorkeling as the monitoring method. The high velocities and discharge volumes of Tumalo Creek make it infeasible to deploy block nets at most sampling sites.

Potential limitations of collecting suitable data from snorkeling include: difficulty in observing young-of-the-year age classes due to preferred shallow depths and concealment under cover, startling fish while moving through the survey area, error in size estimations, counting the same fish more than once, difficulty in observing fish in heavy cover, difficulty in accurate counts in dense populations, and wrongly identifying species, especially when multiple species are present, experience and ability of individual snorkelers, and poor visibility which is common after storms due to increased turbidity.

Tumalo Creek has several characteristics that make it suitable for snorkeling and having a reasonable success rate in collecting suitable data: good visibility, moderate depths (<5 feet maximum), moderate cover, and the presence of fish limited to salmonids, which maintain their position in the water column and are easy to observe and identify. In addition, most monitoring sites on Tumalo Creek have only two species, with a maximum of three, reducing the potential for misidentifying species.

To address the potential limitations and improve data collection on Tumalo Creek, surveys are conducted in an upstream direction, with two snorkelers moving at the same pace, each occupying a lane of approximately 15-20 feet wide. The sampling effort is similar between reaches and between years, as each 200 meter reach is sampled

in approximately 1-1.25 hours. Communication between the snorkelers on fish observed toward mid-channel reduces the probability of counting those fish twice. Snorkelers are trained on species identification prior to participating and utilize methods such as known "length of glove" to calibrate length measurements underwater.

All surveys are done at night, well after sunset, in late summer into fall. This duplicates the methodology utilized in 2011, reduces bias in observations, and, coupled with repeating the same reaches year after year with the same methodology, standardizes the sampling effort. There is evidence night snorkeling is more effective at observing salmonids than day snorkeling as winter approaches (water temperatures <9°C) due to nocturnal nature at this time.

Site Descriptions:

Control (Site 32): This site is characterized by relatively high gradient (2.74%) with cobble and small boulder substrate, bankfull widths of 25 to 30 feet, no side channels, and low amounts of large woody debris. The site is primarily riffle habitat with depths generally less than 3 feet.

Site 22 (A1-RR Upper): This site is within the Tumalo Creek Bridge to Bridge Restoration Project area, and is characterized by relatively moderate gradient (1.67%), high volumes of LWM, and cobble and gravel substrate along with the boulder vane structures. The site is a mixture of riffle and pool habitats, with depths up to 5 feet. The site also includes a low gradient side channel (22SC) that is a mixture of very shallow and narrow riffle and pools 2-4 feet deep, with silty bottoms. The riffles are too shallow to snorkel and the site has very heavy brush cover.

Site 23 (A1-RR lower): This site is within a canyon area and is characterized by moderate gradient (2.06%), and riffle and swift glide habitat, with little pool habitat and moderately low LWM. Substrate is primarily cobble/gravel with small boulders. Depths are generally less than 3 feet

Site 18 (A1-B): This site is within the canyon and is characterized by high gradient (3.24%), car-sized boulders, abundant LWM, and a diversity of substrate and habitat types, with depths of up to 5 feet.

Site 29 (A1-B): This site is characterized by relatively low gradient (1.16%), gravel/cobble substrate with some small boulders, low LWM, and is dominated by riffle habitat and contains one pool. Large amounts of aquatic moss is found growing on the substrate along the stream margins. While generally less than 2.5 feet, the one pool is approximately 4 feet in depth.

2017 Results: During 2017, all five planned monitoring sites were surveyed by night snorkeling between the dates of 9/06/17 and 10/6/17.

Table 1 below displays the data collected in 2017, along with results from 2011 and 2016. The data collected in 2011 is considered baseline data, prior to new project operations, which began in April, 2016. A Control site was not established in 2011, as the main objective for that survey was to determine the presence or absence of bull trout during the planning phase of the project.

Table 1. Tumalo Creek Fish Snorkel Monitoring

2011, 2016, 2017

Site	Sub-Reach	Date Sampled	Lat/Long	River Mile	Grad. %	Water Temp °C	Method	Length Surveyed (m)	ONMY YOY	ONMY <100 mm	ONMY 100-199 mm	ONMY 200-299 mm	ONMY >300 mm	Total ONMY	SAFO YOY	SAFO <100 mm	SAFO 100 -199 mm	SAFO 200 -299 mm	SAFO >300 mm	Total SAFO	SATR YOY	SATR <100 mm	SATR 100-199 mm	SATR 200-299 mm	SATR >300 mm	SATR >500 mm	Total SATR	Total Fish
32	Control	11/1/16	N44.03180 W121.56523	16.1	2.74	3.1	NS	200	0	7	8	2	0	**17**	0	0	11	0	0	**11**	0	0	0	0	0	0	**0**	**28**
32	Control	9/6/17	N44.03180 W121.56523	16.1	2.74	9.0	NS	200	0	51	52	0	0	**103**	0	5	9	0	0	**14**	0	0	0	0	0	0	**0**	**117**
22	A1-RR (upper)	9/2/11	N44.0298 W121.555739	15.5	1.67	6.7	NS	200	0	2	36	9	1	**48**	0	2	64	6	0	**72**	0	0	0	0	0	0	**0**	**120**
22	A1-RR (upper)	9/19/16	N44.0298 W121.555739	15.5	1.67	6.7	NS	200	0	11	42	6	0	**59**	0	8	18	0	0	**26**	0	0	0	0	0	0	**0**	**85**
22	A1-RR (upper)	9/6/17	N44.0298 W121.555739	15.5	1.67	9.0	NS	200	0	19	69	6	0	**94**	0	16	19	0	0	**35**	0	0	0	0	0	0	**0**	**129**
22 SC	A1-RR (upper)	9/2/11	N44.0298 W121.555739	15.5	1.14	9.4	NS	160	0	9	18	0	0	**27**	0	87	39	9	0	**135**	0	0	0	0	0	0	**0**	**162**
22 SC	A1-RR (upper)	10/5/16	N44.0298 W121.555739	15.5	1.14	5.0	NS	160	0	0	1	0	0	**1**	0	52	33	2	0	**87**	0	0	0	0	0	0	**0**	**88**
22 SC	A1-RR (upper)	9/6/17	N44.0298 W121.555739	15.5	1.14	9.0	NS	160	0	0	0	0	0	**0**	6	20	45	1	0	**72**	0	0	0	0	0	0	**0**	**72**
23	A1-RR (lower)	9/2/2011	N44.042842 W121.478581	10.5	2.06	9.0	NS	200	3	9	68	1	0	**81**	1	9	30	3	0	**43**	0	0	0	0	0	0	**0**	**124**
23	A1-RR (lower)	9/26/17	N44.042842 W121.478581	10.5	2.06	6.7	NS	200	0	54	63	14	0	**131**	0	15	11	0	0	**26**	0	0	0	0	0	0	**0**	**157**
18	A1-B	9/14/11	N44.04303 W121.464698	9.6	3.24	10.0	NS	200	0	5	88	11	0	**104**	0	1	22	2	0	**25**	0	0	0	0	0	0	**0**	**129**
18	A1-B	9/28/17	N44.04303 W121.464698	9.6	3.24	8.3	NS	200	0	36	176	0	0	**212**	0	2	8	0	0	**10**	0	0	0	0	0	0	**0**	**232**
29	A1-B	8/30/11	N44.052291 W121.41028	6.5	1.16	13.5	NS	200	0	22	83	14	0	**119**	0	1	19	2	0	**22**	0	0	0	0	0	0	**0**	**141**
29	A1-B	10/12/16	N44.052291 W121.41028	6.5	1.16	6.1	NS	200	19	37	56	6	0	**118**	0	3	10	1	0	**14**	0	0	2	0	0	0	**2**	**134**
29	A1-B	10/6/17	N44.052291 W121.41028	6.5	1.16	5.0	NS	200	0	25	42	3	0	**70**	1	2	2	1	0	**6**	0	0	0	0	0	0	**0**	**76**

NS = night snorkel
YOY = young of year
ONMY = redband trout
SAFO = eastern brook trout
SATR = brown trout

Monitoring Site Data:

Figure 1. Control Site Data 2016-2017

The Control Site was established in 2016 and repeated in 2017. The numbers of redband trout were significantly larger in 2017 compared to 2016, increasing from a total of 17 to 103. Similar increases were seen in both the <100 mm and 100-199 mm size classes. No large redband trout (>200 mm) were observed in 2017. Brook trout numbers had little change between 2016 and 2017, increasing slightly from 11 to 14 total fish.

Figure 2. Site 22 Data 2011, 2016, 2017

Site 22 experienced an increase in redband trout between 2016 and 2017 in both the <100 mm and 100-199 mm size categories, while the large trout remained similar. Overall, the redband trout numbers increased from 59 to 94. Brook trout numbers were similar between 2016 and 2017, but slightly increased from 26 to 35. For trend analysis, 2011 data is also presented, although this was before the establishment of the Control site. The trend

since 2011 has been an overall increase in redband trout and an overall decrease in brook trout numbers. Within the side channel, no redband trout were observed in 2017, but just one was observed in 2016. Brook trout numbers decreased from 87 to 72. The side channel is filling in with silt and is difficult to snorkel because of significant shallow depths and heavy brush. Starting in 2018, the side channel may be electrofished rather than snorkeled.

Figure 3. Site 23 Data 2011, 2017

Site 23 was not monitored in 2016. A comparison between the 2011 and 2017 data is displayed above. The trend in fish populations is an overall increase in redband trout, from 81 to 131 total. Significant increases in the <100 mm and 200-299 mm sizes were responsible for the increase. Overall, a decrease in brook trout was observed, dropping from 43 to 26 fish observed.

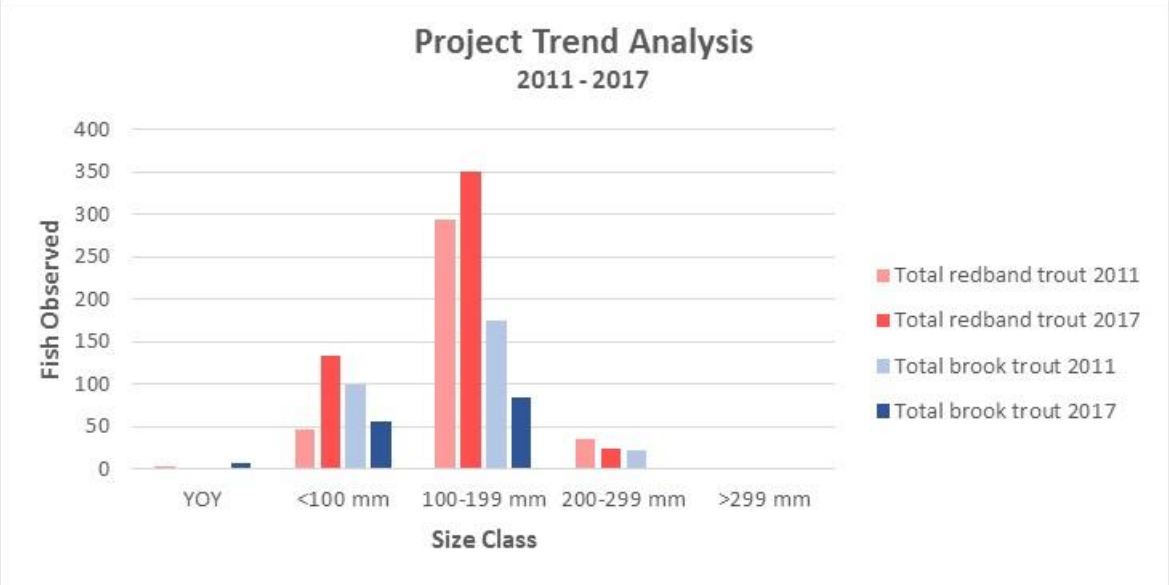
Figure 4. Site 18 Data 2011, 2017

Site 18 was not monitored in 2016. A comparison between the 2011 and 2017 data is displayed above. The trend in fish populations was a very large increase in redband trout numbers, rising to a total of 212 from 104, due to increases in the small and medium sizes. Brook trout numbers dropped from 25 total to 10. No large redband trout were observed in 2017.

Figure 5. Site 29 Data from 2011, 2016, 2017

Site 29 was monitored in 2016 and 2017. Data from 2011 is also presented. Fish observed in 2011 were very similar to what was observed in 2016, other than redband trout observed were smaller overall. Between 2016 and 2017, redband trout numbers decreased across all age classes, with total numbers dropping to 70 from 118. Brook trout numbers also decreased, from a total of 14 to 6. While two brown trout were observed in 2016, none were observed in 2017.

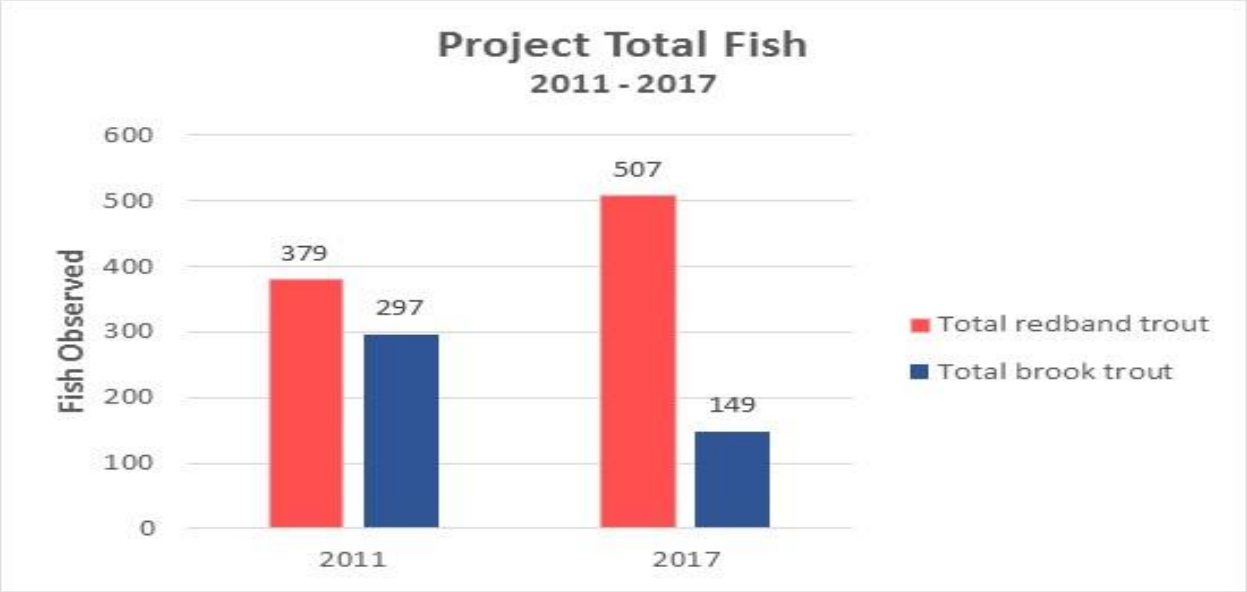
Figure 6. Population Trend Within the Project Area



The figure above demonstrates the trends in fish assemblage and size class structure for the project area comparing 2011 with 2017. Data from Sites 18, 22, 22SC, 23, and 29 were totaled and compared. Site 32 is not

included as this established in 2016 as the control site. Data from 2016 is not included as not all reaches were completed that year. Project wide, the trend is an increase in redband trout in the small and medium size classes, with a simultaneous decrease in the brook trout within all age classes other than YOY.

Figure 7. Total Fish Observed Within Project Area 2011, 2017



Similar to Figure 6 above, Figure 7 demonstrates the trend between 2011 and 2017 of an overall increase in redband trout and overall decrease in brook trout observed within the project area (same sites as listed above).

Figure 8. Water Temperatures at Time of Survey 2011, 2016, 2017

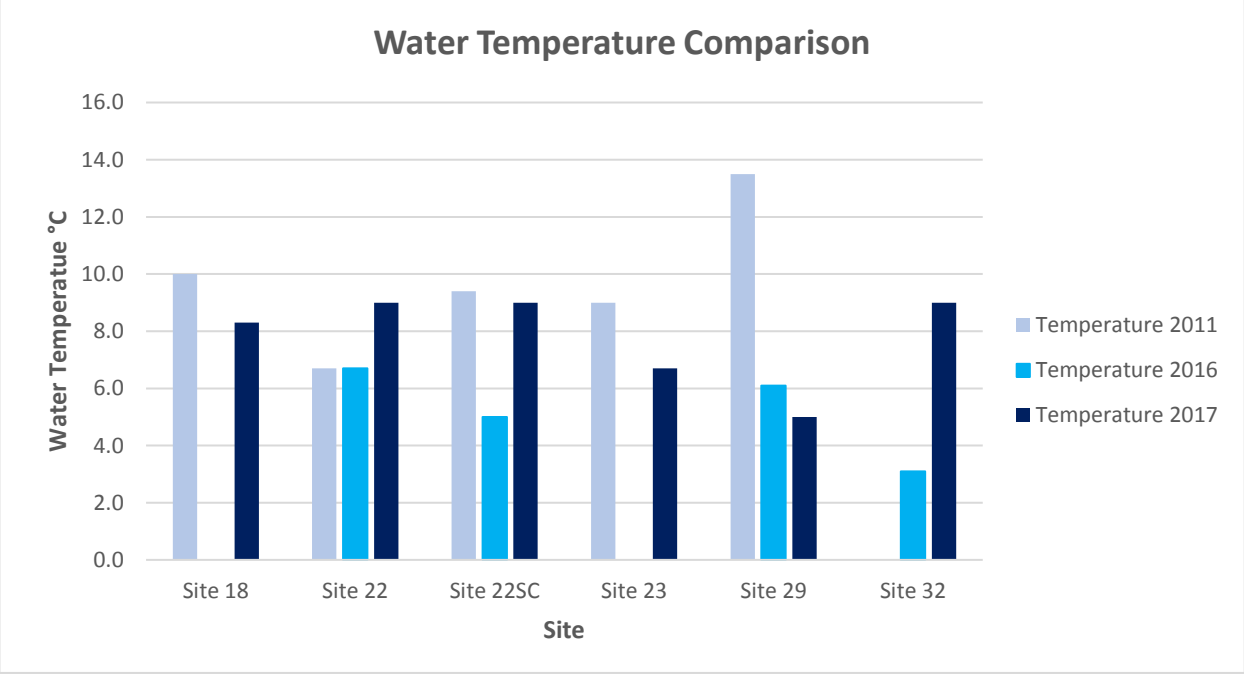


Figure 8 compares water temperatures by year, collected at the time of snorkel surveys for each of the sites. Water temperature can affect fish behavior and the ability to observe them during snorkel surveys.

Figure 9. Mean Daily Discharge Comparison 2016-2017 Station 14070920

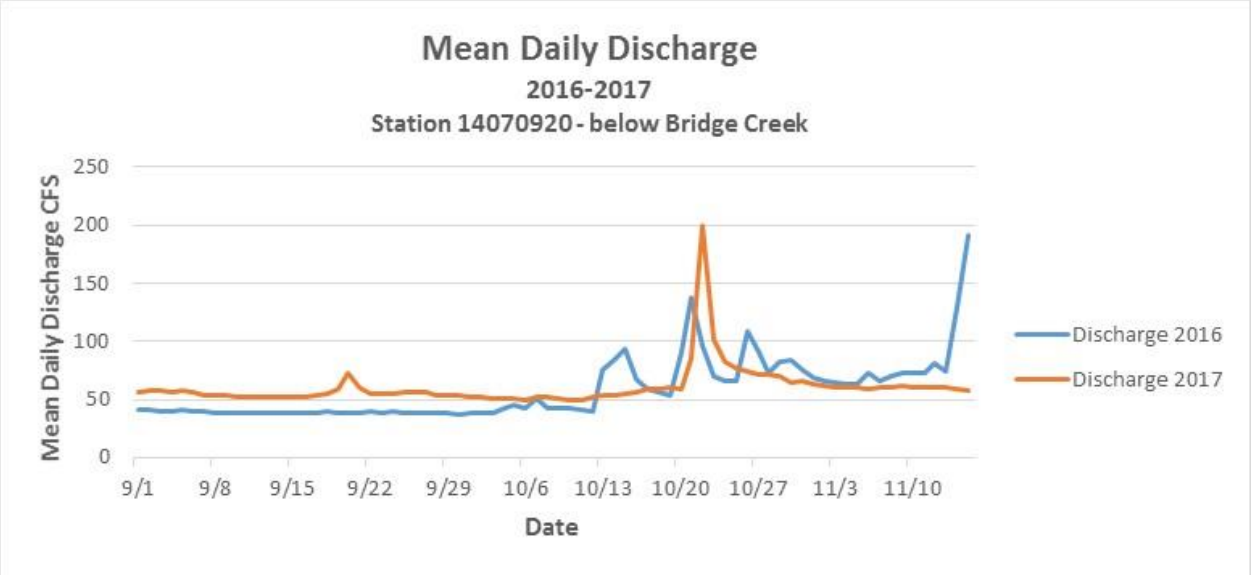


Figure 9 displays the discharge at the newly established gaging station immediately below the junction of Bridge Creek and Tumalo Creek during the fall when snorkel surveys were conducted. Discharge can influence fish behavior and movement, and the ability to observe them.

Figure 10. Mean Daily Discharge Comparison 2016-2017 Station 14070980

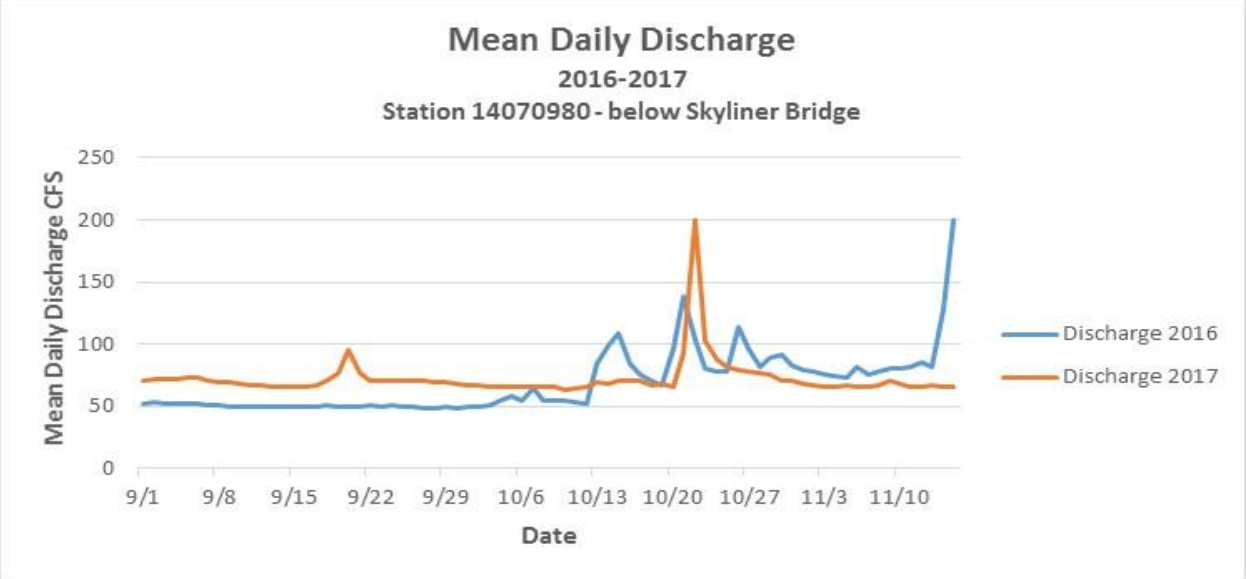


Figure 10 displays the discharge at the newly established gaging station at Skyliners Bridge during the fall when snorkel surveys were conducted. Data includes the contribution of the accretion zone, which includes several springs, South Fork of Tumalo Creek, and Tumalo Lake Creek.

Table 2. Temperature and Discharge during Snorkel Surveys

Site	Date	Mean Daily Q - CFS	Discharge Station	Status	Temp °C
32	11/1/2016	69	14070920	Provisional	3.1
32	9/6/2017	57	14070920	Provisional	9.0
22	9/2/2011	61.3	14073520 & 14073500	Published	6.7
22	9/19/2016	38	14070920	Provisional	6.7
22	9/6/2017	57	14070920	Provisional	9.0
22SC	9/2/2011	NA	NA	NA	9.4
22SC	9/19/2016	NA	NA	NA	5.0
22SC	9/8/2017	NA	NA	NA	9.0
23	9/2/2011	61.3	14073520 & 14073500	Published	9.0
23	9/26/2017	71	14070980	Provisional	6.7
18	9/14/2011	57.3	14073520 & 14073500	Published	10.0
18	9/28/2017	69	14070980	Provisional	8.3
29	8/30/2011	67	14073520 & 14073500	Published	13.5
29	10/12/2016	52	14070980	Provisional	6.1
29	10/6/2017	65	14070980	Provisional	5.0

Table 2 above displays the water temperatures and discharge at the time snorkel surveys were conducted during 2011, 2016, and 2017. The actual discharge for Site 32 is likely 10-15 cfs lower as this site is above the junction with Bridge Creek. The actual discharge for Site 22 in 2011 would actually be lower as Station 14070920 was not yet established, and the displayed discharge includes the accretion zone contribution, which is downstream of Site 22.

Discussion:

Compared to the 2011 data, surveyed prior to the new water system operations and considered the baseline, there has been an overall trend of an increase in the relative abundance of redband trout populations and a decrease in the relative abundance of the non-native brook trout (Figures 6 and 7). When trout population are sympatric, variability in populations is typical and one species may not be able to monopolize the other. These two species have co-existed in Tumalo Creek for nearly 100 years. The two species are often spatially segregated to an extent, based on a combination of velocity, depth, cover types, and food availability. In Tumalo Creek, brook trout are generally observed in the lower velocity stream margins and other slow water habitats, with redband trout typically in faster water areas and behind boulders mid-stream. Currently, redband trout have gained the upper hand.

Assessing project operation effects since operations began in April 2016 is not possible at this time due to two sites (18 &23) not being surveyed in 2016. Personnel shortages and numerous high precipitation events during the fall precluded finishing the surveys. Therefore, the only sites comparable between 2016 and 2017 are the Control (Site 32) and Sites 22 (including the side channel – Site 22SC) and 29. An increase in redband trout and brook trout was observed in Site 22 while a decrease in both species was observed in Site 29 (Figures 2 and 5). Similar numbers of fish were observed comparing 2011 with 2016 within Site 29, despite a considerable

difference in water temperatures at the time of the surveys, 13.5°C in 2011, compared to 6.1°C in 2016. Water temperature was slightly reduced (by 1.1°C) in 2017 compared to 2016 (Figure 8). The trend of decreasing numbers of fish observed within the side channel (Site 22SC) continued in 2017. Habitat within this site is becoming less available as pools fill in with silt and potentially less flow, as this site has no upstream surface connection to Tumalo Creek, but is fed by groundwater from further upstream. The slow velocities are favored by brook trout, which composed the entire population in 2017 (Table 1).

The establishment of the Control site in 2016 gives insight to how environmental variables might influence the fish population. Redband trout numbers were significantly higher in 2017 compared to 2016, an increase of a multiple of 6 (Figure 1). Likely the largest factor was the considerable water temperature differences between the two years, just 3.1°C in 2016 but 9.0°C during the 2017 survey (Table 2). With the onset of winter, fish may move into different habitats or become concealed in the substrate, making observation during surveys difficult, and biasing the data. Other potential contributing factors include: (1) the winter of 2016-2017 experienced a good snowpack and resultant run-off, a "good" water year, which may have increased available habitat and food supply (Figures 9 and 10); (2) the Bridge Creek diversion at the headwaters was closed during the winter months of 2016-2017 (unplanned anomaly), resulting in additional discharge through the Control site, potentially benefiting wintering habitat; and (3) an increased population of redband within the project area resulting in individuals moving upstream into the Control site. Interestingly, the brook trout numbers only slightly increased (Figure 1) within the Control site.

In 2016 two brown trout were observed at Site 29 for the first time, which is the most downstream site, suggesting brown trout may have increased their distribution farther upstream since 2011. No brown trout were observed at Site 29 in 2017, and no brown trout have been observed above Site 29 during any of the surveys. The increasing velocities and cooler temperatures may be serving as a barrier to upstream distribution of brown trout.

YOY are difficult to observe while snorkeling due to their propensity to occupy very shallow stream margins, less than the minimum depth for which a mask can be submerged. The snorkel surveys are most likely undercounting this size class. During the current monitoring efforts, fish <50 mm total length are considered YOY. Due to an apparent lengthened spawning season in Tumalo Creek, perhaps late March to early July, many YOY are likely >50 mm total length. Therefore, when analyzing the data, YOY and <100 mm size classes should be combined.

For more information on stream flow and temperature data, see the 2017 Flow and Temperature Monitoring Report for Tumalo Creek.

Tumalo Creek Fish Monitoring Sites