City of Bend Bridge Creek Water System
2018 Tumalo Creek Fish Monitoring Report

Tom Walker, Bend/Ft. Ranger District Fisheries Biologist
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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.

2018 Results: During 2018, all five planned monitoring sites were surveyed by night snorkeling between the dates of 07/31/18 and 08/9/18.

Table 1 below displays the data collected in 2018, along with results from 2011, 2016, and 2017. 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, 2018

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**
32	Control	7/31/18	N44.03180 W121.56523	16.1	2.74	11.0	NS	200	0	14	79	21	0	**114**	1	2	14	3	0	**20**	0	0	0	0	0	0	**0**	**134**
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	A1-RR (upper)	8/9/18	N44.0298 W121.555739	15.5	1.67	12.4	NS	200	0	14	75	20	0	**109**	0	5	36	3	0	**44**	0	0	0	0	0	0	**0**	**153**
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**
22 SC	A1-RR (upper)	7/31/18	N44.0298 W121.555739	15.5	1.14	13.3	NS	160	0	0	0	0	0	**0**	1	69	90	8	0	**168**	0	0	0	0	0	0	**0**	**168**
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**
23	A1-RR (lower)	8/2/18	N44.042842 W121.478581	10.5	2.06	12.6	NS	200	2	36	86	12	0	**136**	0	7	20	0	0	**27**	0	0	0	0	0	0	**0**	**163**
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**
18	A1-B	8/2/18	N44.04303 W121.464698	9.6	3.24	12.0	NS	200	3	42	93	14	0	**152**	0	3	5	0	0	**8**	0	0	0	0	0	0	**0**	**160**
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**
29	A1-B	8/9/18	N44.052291 W121.41028	6.5	1.16	16.7	NS	200	41	52	90	5	0	**188**	7	7	11	0	0	**25**	0	0	0	0	1	0	**1**	**214**

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

Monitoring Site Data:

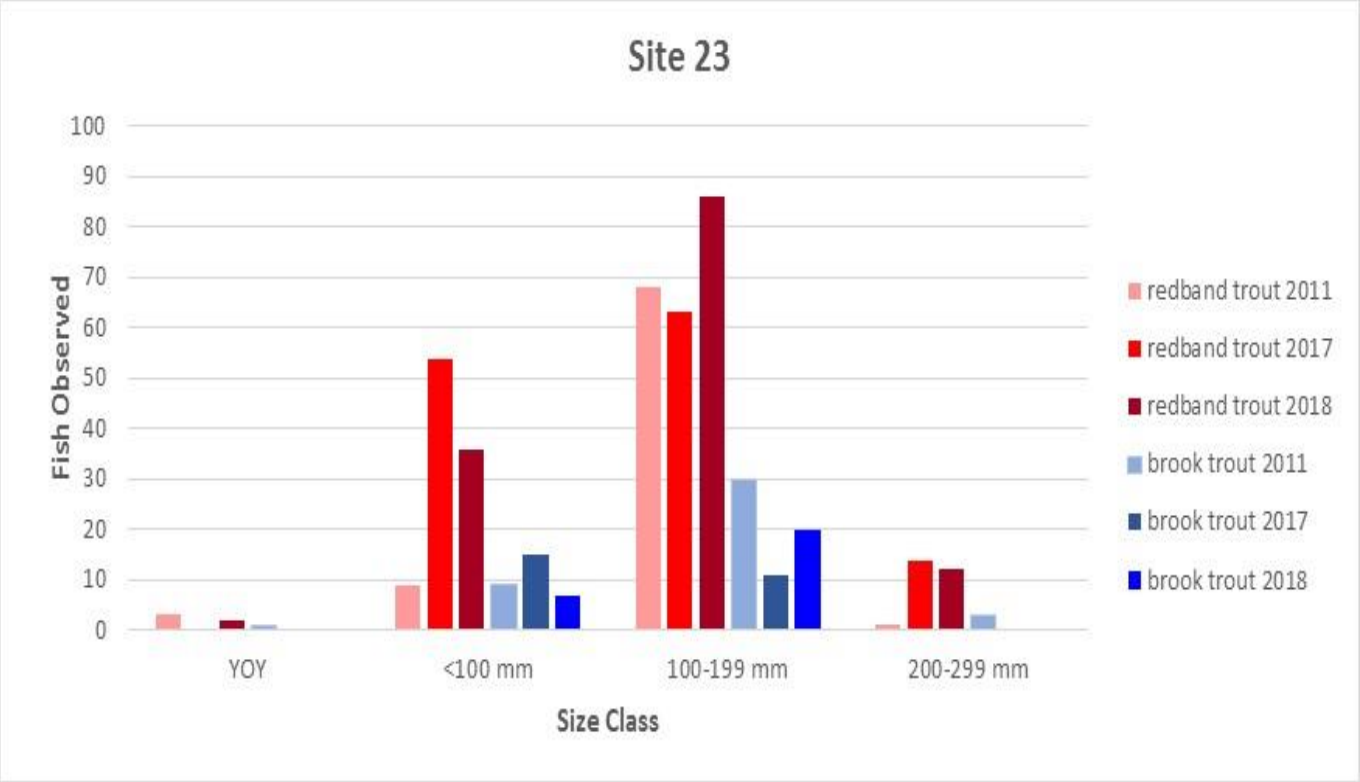
Figure 1. Control Site Data 2016-2018

The Control Site was established in 2016 and repeated in 2017 and 2018. The overall numbers of Redband Trout were slightly greater in 2018 compared to 2017, but there was a shift in numbers toward large size classes, especially in the 200-299 mm range that increased from 0 to 21. Brook trout numbers and average size of fish slightly increased between 2017 and 2018.

Figure 2. Site 22 Data 2011, 2016 - 2018

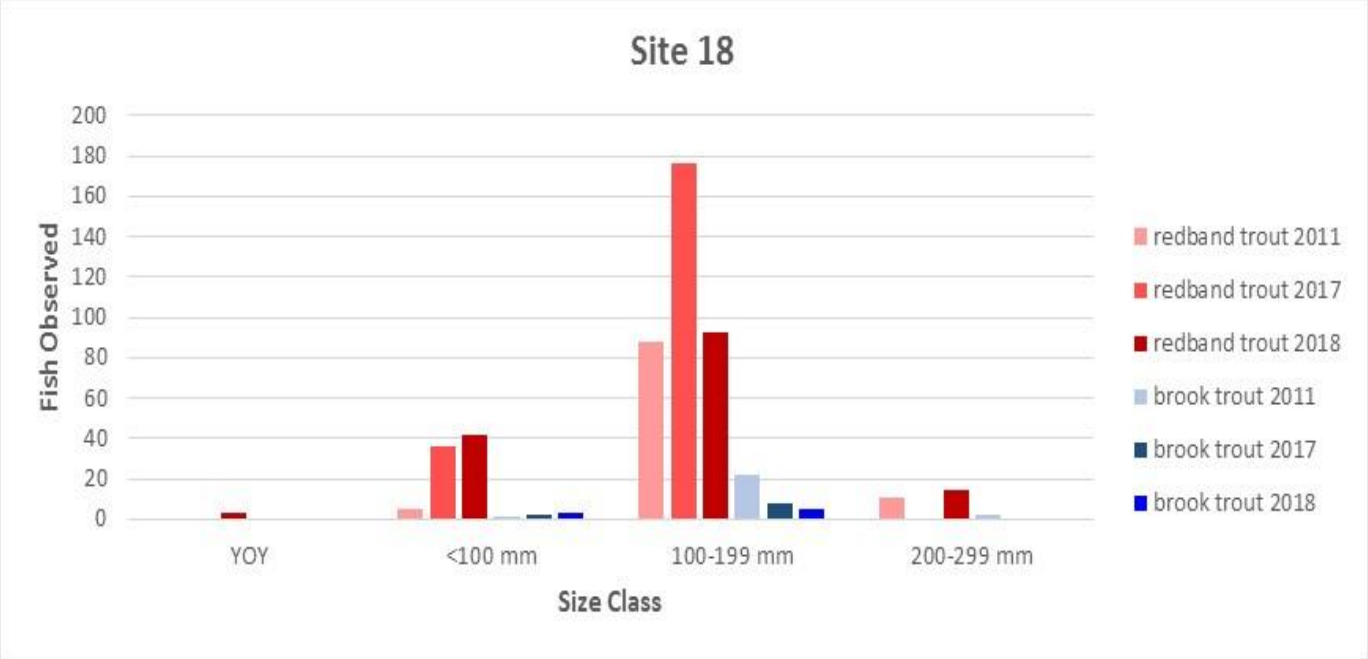
The trend of increasing numbers of redband trout in Site 22 continued in 2018, with more large fish observed as well. The number of redband observed in 2018 was nearly double of what was observed in 2016, 109 total individuals comparted to 59. Brook trout numbers also continued a slight upward trajectory in numbers, as 44 fish were observed compared to 26 in 2016 and 35 in 2017. 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. Although brook trout numbers have increased since 2016, less were observed in 2018 than 2011. Within the side channel, again no redband trout were observed in 2018, compared to 27 in 2011 and 1 in 2016. Brook trout numbers increased in 2018, but accurate counts are difficult because of the environmental conditions. The side channel is filling in with silt and is difficult to snorkel because of significant shallow depths, thick brush, and bottom silts being stirred up during snorkeling reducing visibility.

Figure 3. Site 23 Data 2011, 2017, 2018



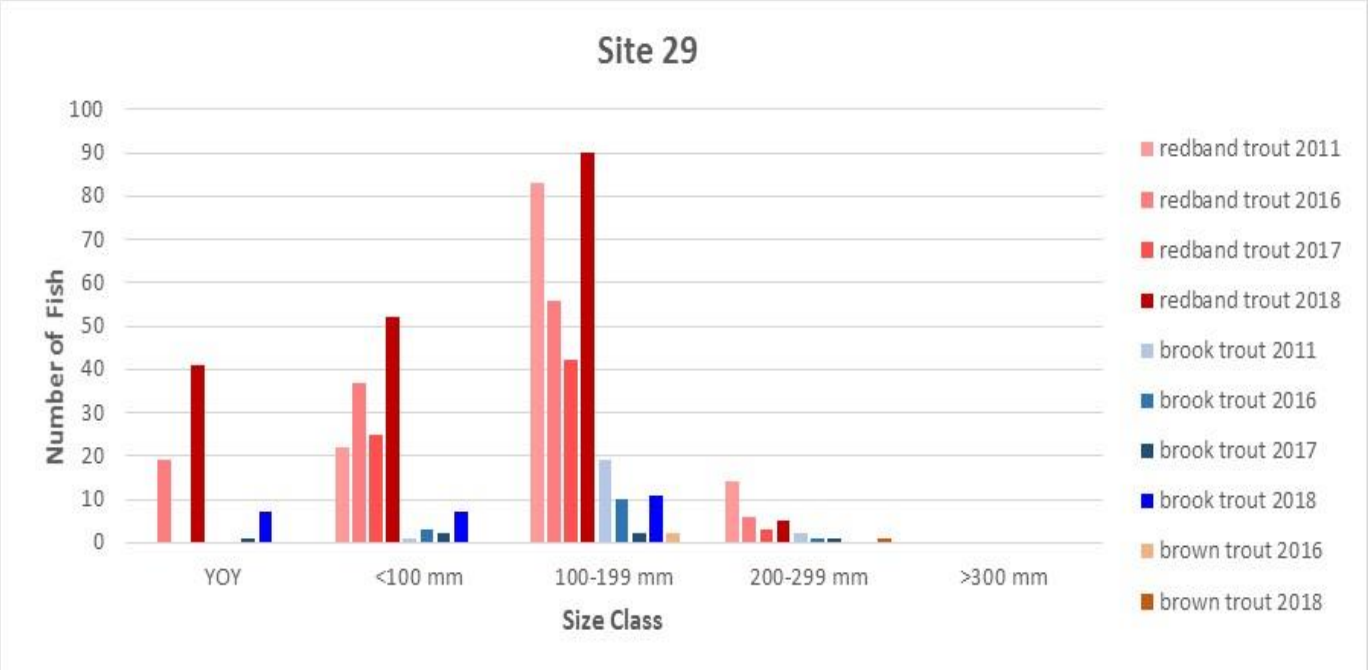
Site 23 was not monitored in 2016. A comparison between the 2011, 2017, and 2018 data is displayed above. The results in 2018 were very similar to 2017 for redband trout in numbers and size class distribution. Brook trout numbers were nearly identical to 2017, with a slight increase in average size observed. The trend in redband populations is an overall increase since 2011. Brook trout numbers, as in 2017, were reduced from 2011.

Figure 4. Site 18 Data 2011, 2017, 2018



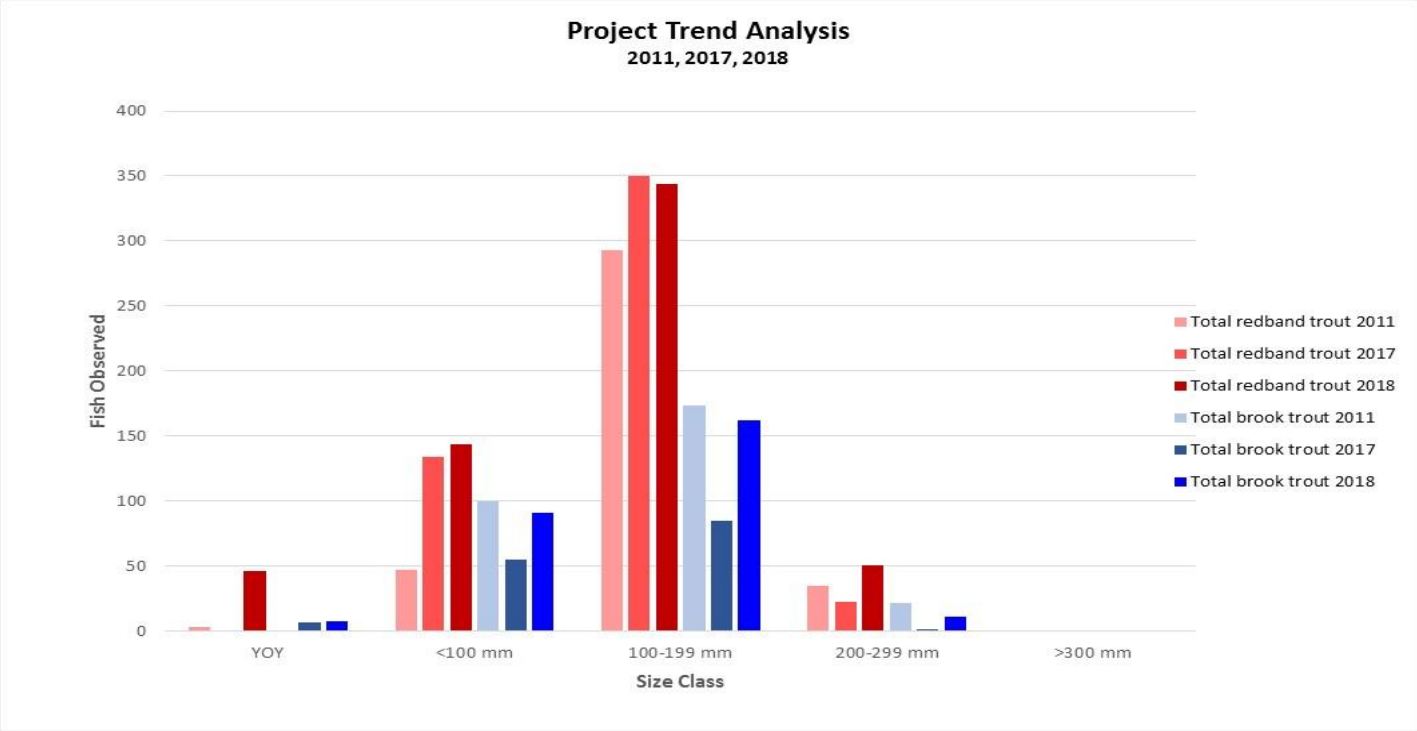
Site 18 was not monitored in 2016. A comparison between the 2011, 2017, and 2018 data is displayed above. Total Redband trout numbers were less than 2017, but still relatively high, and significantly higher than 2011. This reach exhibits the most complex and diverse habitat of all the reaches monitored, so it is not surprising redband numbers are higher here. Some larger fish (>200 mm) were observed in 2018 but none in 2017. Brook trout numbers were again very limited (8 total), nearly the same as 2017

Figure 5. Site 29 Data from 2011, 2016- 2018



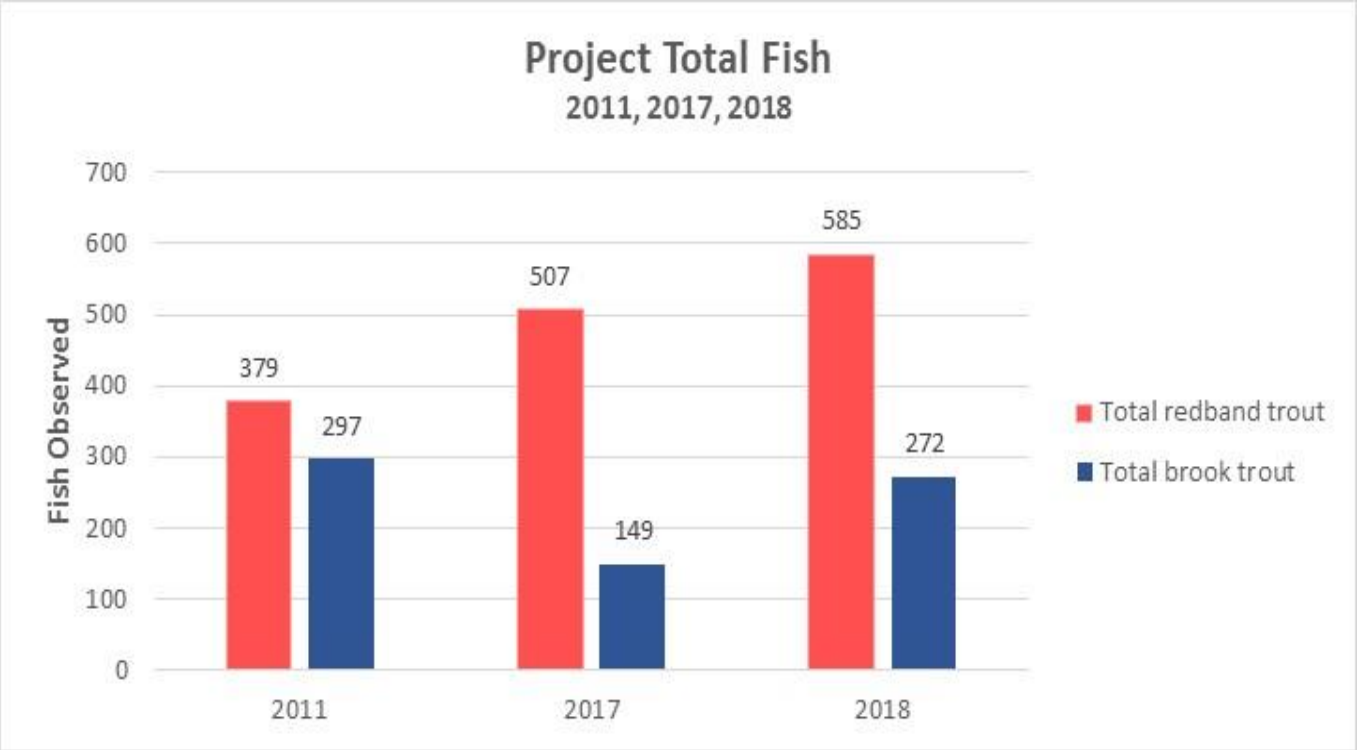
Site 29 was monitored in 2016, 2017, and 2018. Data from 2011 is also presented. Total Redband numbers observed in 2018 were significantly higher in 2018 than 2017 (188 versus 70). The increase was in the Young-of-Year and juvenile size classes. Numbers in 2017 had decreased significantly from what was observed in 2011 and 2016 (118 and 119). Brook trout numbers also increased significantly from 2017, but still made up just 12% of the total fish observed. Brook trout numbers observed in 2018 were similar to what was observed in 2011. One brown trout was observed (>300 mm). This reach appears to be at the edge of the upstream distribution of brown trout in Tumalo Creek.

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, 2017, and 2018. Data from Sites 18, 22, 22SC, 23, and 29 were totaled and compared. Site 32 is not included as this was 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 smaller and larger size classes and relatively stable in the medium size class (100-199 mm). Project wide, there is a trend of increasing numbers of brook trout in all size classes (only two years comparable) but numbers are reduced from 2011 in all size classes with the exception of YOY.

Figure 7. Total Fish Observed Within Project Area 2011, 2017, 2018



Similar to Figure 6 above, Figure 7 demonstrates the trend of increasing numbers of redband trout within the project area. Total brook trout numbers increased in 2018 compared to 2017 but are less, but similar, to numbers observed in 2017.

Figure 8. Water Temperatures at Time of Survey 2011, 2016 - 2018

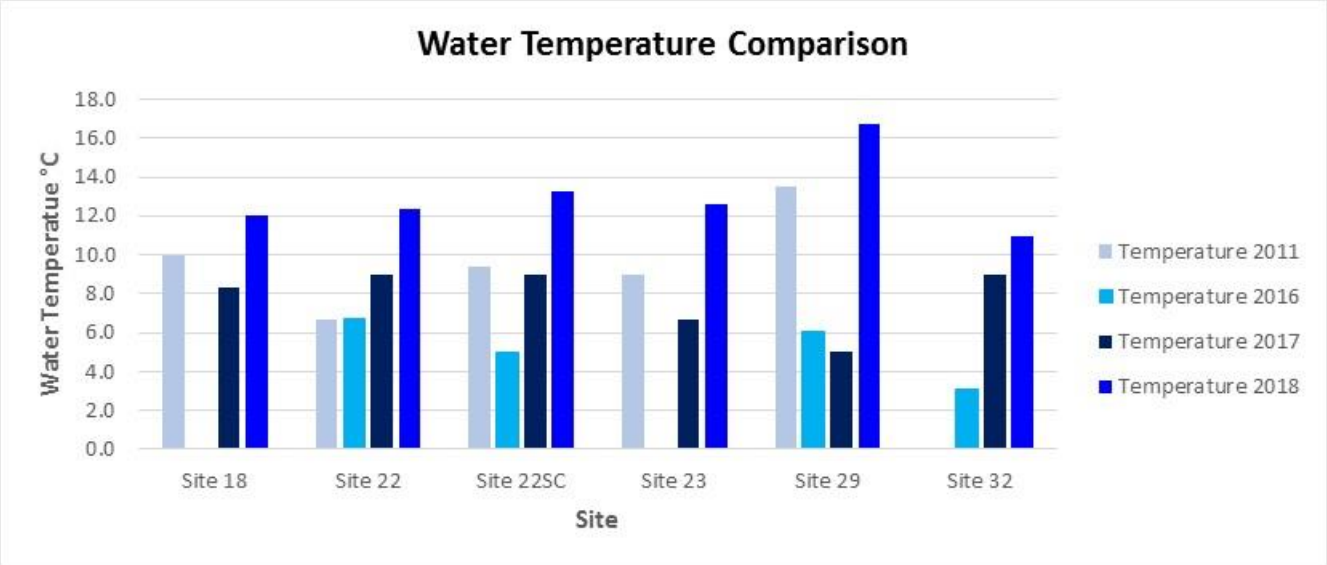


Figure 8 compares water temperatures by year, collected at the time of snorkel surveys for each of the sites. Water temperature can affect fish behavior and the ability to observe them during snorkel surveys. Water temperatures were warmer at all sites in 2018 than previous years.

Figure 9. Mean Daily Discharge Comparison 2016-2018 Station 14070920

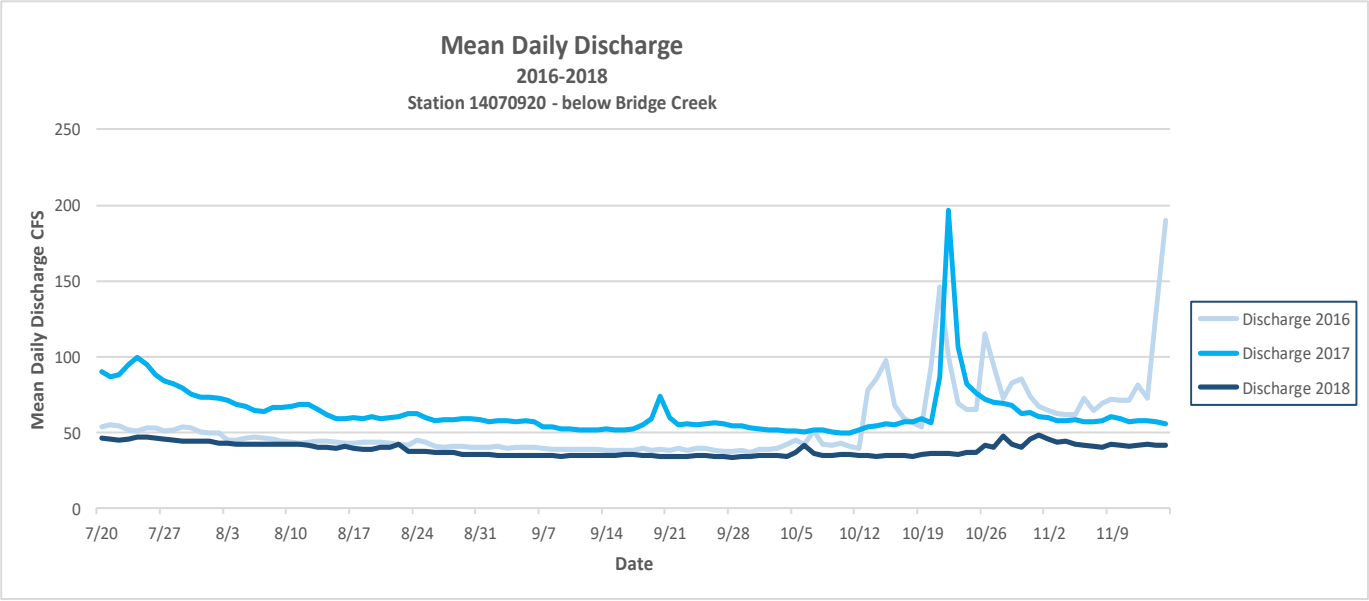


Figure 9 displays the discharge at the gaging station immediately below the junction of Bridge Creek and Tumalo Creek during the summer and fall when snorkel surveys were conducted. Discharge can influence fish behavior and movement, and the ability to observe them. Discharge was less in 2018 than in previous years. Site 22 and 22SC are located below this gaging station and above most of the accretion from the springs and South Fork of Tumalo Creek.

Figure 10. Mean Daily Discharge Comparison 2016-2018 Station 14070980

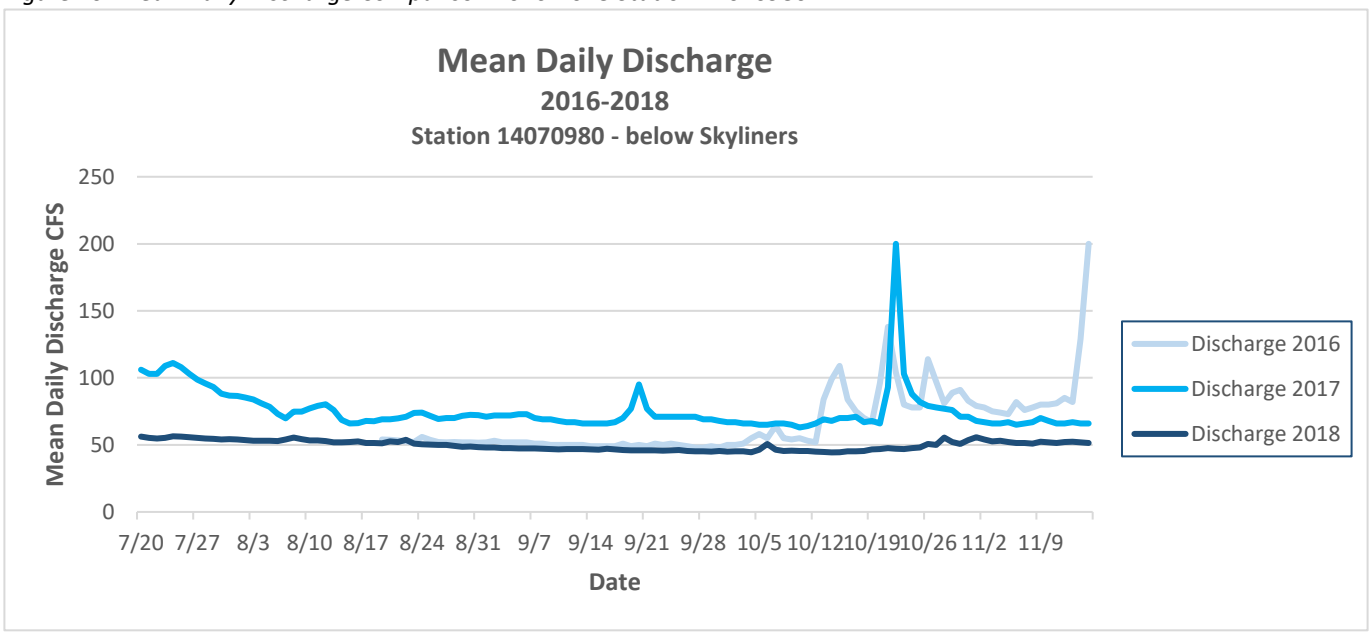


Figure 10 displays the discharge at the newly established gaging station at Skyliners Bridge during the fall when snorkel surveys were conducted. Data includes the contribution of the accretion zone, which includes several springs, South Fork of Tumalo Creek, and Tumalo Lake Creek. Discharge was generally reduced in 2018 compared to previous years. Discharge at this gaging station represents what was experienced at Sites 18, 23, and 29.

Table 2. Temperature and Discharge during Snorkel Surveys 2011, 2016-2018

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
32	7/31/2018	44.4	14070920	Provisional	11.0
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
22	8/9/2018	42.5	14070920	Provisional	12.4
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
22SC	7/31/2018	NA	NA	NA	13.3
23	9/2/2011	61.3	14073520 & 14073500	Published	9.0
23	9/26/2017	71	14070980	Provisional	6.7
23	8/2/2018	53.5	14070980	Provisional	12.6
18	9/14/2011	57.3	14073520 & 14073500	Published	10.0
18	9/28/2017	69	14070980	Provisional	8.3
18	8/2/2018	53.5	14070980	Provisional	12.0
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
29	8/9/2018	54.3	14070980	Provisional	16.7

Table 2 above displays the water temperatures and discharge at the time snorkel surveys were conducted during 2011, 2016 - 2018. 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 (approximately 8-10 cfs) 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, while non-

native brook trout populations have shown more variability. Total numbers in 2018 were similar to what was observed in 2011. A significant number of the brook trout numbers for all years is due to the large numbers found residing in the Site 22 side channel, which is a low velocity series of pools. This area is not utilized by redband trout. In 2018, more than half the brook trout observed came from this one site (168 out of 272 total fish). Brook trout observed at the other sites has either remained steady or has decreased. 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.

Operation of the new Bridge Creek Surface Water System has added more instream flow (flow monitoring reports available on City website). There does not appear, based on the monitoring conducted to date, to be adverse effects to the redband population since operations began. The trend has been an overall increase in redband observed. Many environmental factors can affect fish population density and age structure, and include flow and temperatures. The monitoring period is brief at this point, but subsequent monitoring efforts over the next several more years are planned. The warmer temperatures and earlier monitoring effort in 2018 may have led to fish being more active in the water column, thus increasing the ability to observe fish, potentially resulting in increased numbers of fish observed. The trend of decreasing numbers of fish observed within the side channel (Site 22SC) reversed in 2018 as numbers increased. Accurate observations in this side channel is difficult due to movement of fish and visibility as silt get stirred up from the bottom while snorkeling. 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 and 2018 (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 2018, the temperatures were slightly warmer than 2017 (11.0^{o}C compared to 9.0^{o}C) but the numbers of fish observed for both redband and brook trout were similar, but more larger fish of both species were observed.

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. In 2018, one large brown trout was observed at Site 29. Project operations do not appear to be increasing the upstream distribution of brown trout. Above Site 29, increased velocities and gradient are the likely primary factors serving as a barrier to upstream distribution of brown trout.

Young-of-year 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 for redband trout, perhaps late March to early July, many YOY are likely >50 mm total length. Brook trout are fall spawners, therefore the YOY would be larger than the spring/summer spawning redband at the time monitoring is conducted in late summer or fall. When looking at recruitment into the population, YOY and <100 mm size classes should be combined, for both species.

For more information on stream flow and temperature data, see the 2018 Flow and Temperature Monitoring Report for Tumalo Creek on the City of Bend website.

Tumalo Creek Fish Monitoring Sites