City of Bend Bridge Creek Water System
2020 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 or harm to fish, which is can occur in electrofishing surveys. The difficulty 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 unfeasible 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 can occur 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:

Site location map is located on page 13.

Site 32 (Control): This site is characterized by a relatively high gradient (2.74%) channel with cobble and small boulder substrate, bankfull widths of 25 to 30 feet, no side channels, and low amounts of large woody material (LWM). 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 density 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 density. 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 density, 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.

2020 Results: During 2020, all five planned monitoring sites were surveyed by night snorkeling between the dates of 8/06/20 and 10/8/20.

Table 1 displays the data collected in 2020, along with results from 2011 and 2016, 2017, and 2018. 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, 2020

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**
32	Control	8/11/20	N44.03180 W121.56524	16.1	2.74	9.0	NS	200	1	18	52	8	0	**79**	0	10	13	0	0	**23**	0	0	0	0	0	0	**0**	**102**
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	A1-RR (upper)	8/11/20	N44.0298 W121.555739	15.5	1.67	8.0	NS	160	19	74	37	4	0	**134**	2	44	28	0	0	**74**	0	0	0	0	0	0	**0**	**208**
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**
22 SC	A1-RR (upper)	10/8/20	N44.0298 W121.555739	15.5	1.14	7.0	NS	160	0	0	0	0	0	**0**	9	41	55	0	0	**105**	0	0	0	0	0	0	**0**	**105**
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**
23	A1-RR (lower)	8/6/20	N44.042842 W121.478581	10.5	2.06	10.0	NS	200	4	30	33	1	0	**65**	4	18	23	2	0	**47**	2	2	1	0	0	0	**5**	**117**
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**
18	A1-B	8/12/20	N44.04303 W121.464698	9.6	3.24	11.0	NS	200	2	78	75	2	0	**157**	0	5	8	1	0	**14**	0	0	0	0	0	0	**0**	**171**
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**
29	A1-B	8/25/20	N44.052291 W121.41028	6.5	1.16	12.9	NS	200	28	32	59	24	0	**143**	0	0	9	1	0	**10**	0	0	1	0	0	0	**1**	**154**

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

Monitoring Site Data:

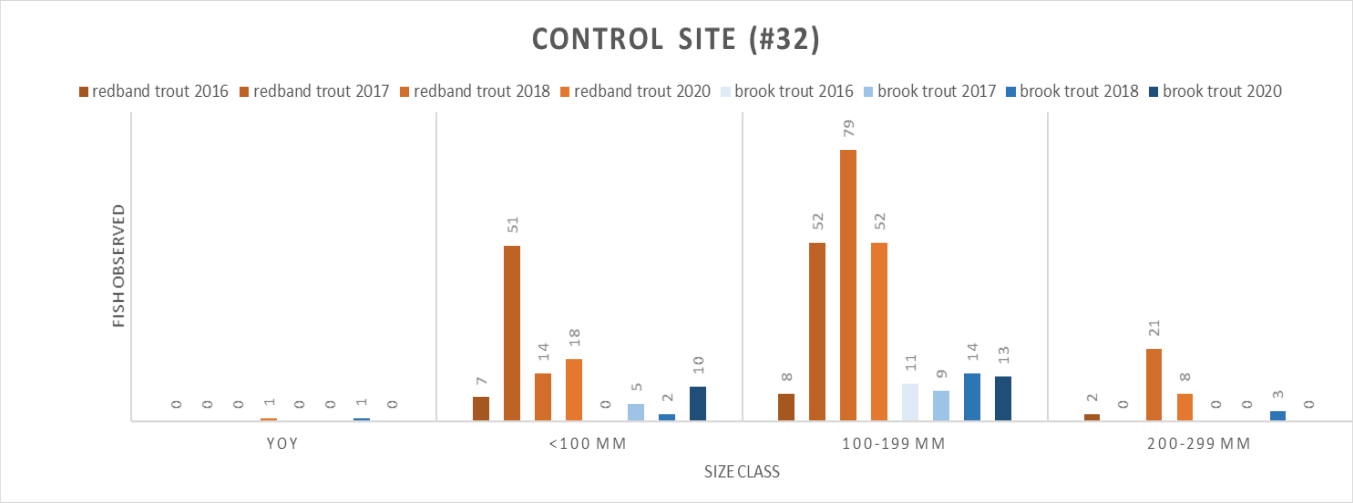

Figure 1. Control Site Data 2016-2020

The Control Site was established in 2016 and surveys were repeated in 2017, 2018, and 2020. The numbers of redband trout were significantly larger in all subsequent survey years compared to 2016 (Figure 1). Several large redband trout (>200 mm) were observed in 2018 and fewer in 2020, but both years were an increase over numbers observed in the previous two surveys. Brook trout numbers had little change between 2016 and 2020, increasing slightly from 11 to 14 total fish. The largest increase in brook trout numbers were observed in the <100mm size class, with 10 observed in 2020.

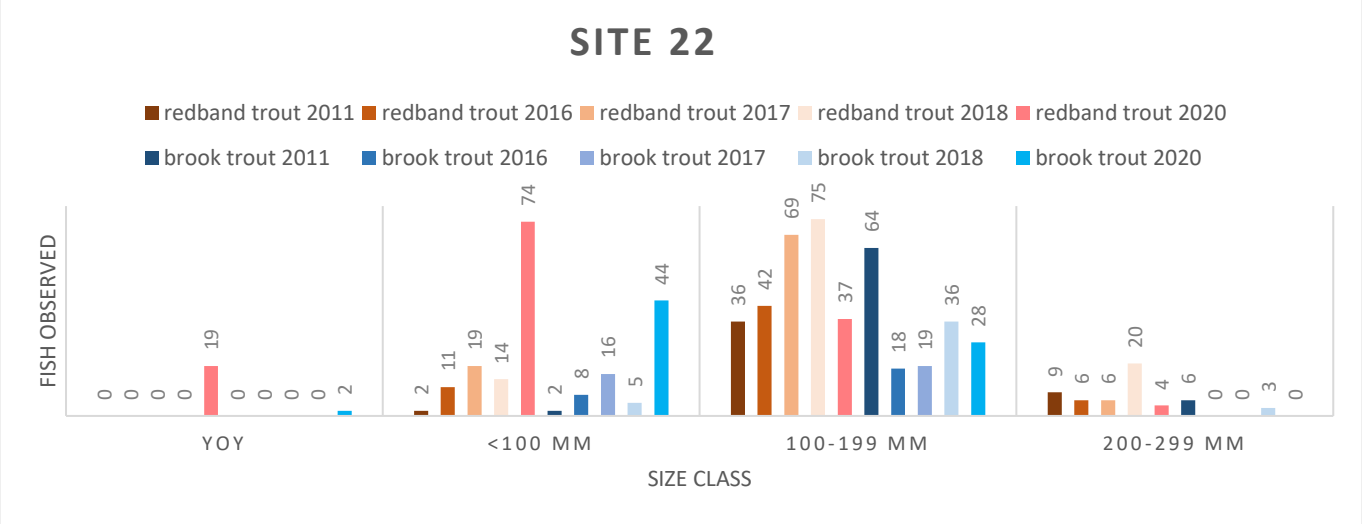

Figure 2. Site 22 Data 2011, 2016-2020

Site 22 experienced a marked increase in redband trout in 2020 in the <100 mm size category, relative to prior years (Figure 2). This increase may be partially explained by potential snorkeler bias to identify fish as being within this smaller size class. This seems plausible, noting the significant decrease in the 100-199 mm size category in redband trout in 2020. Large redband trout numbers remained similar. Overall, the redband trout numbers increased in this reach, from 59 to 134, from 2016-2020. Brook trout numbers nearly tripled between 2016 and 2020, from 26 to 74. 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 brook trout numbers observed within this reach, including notable YOY (young of year) observation in 2020.

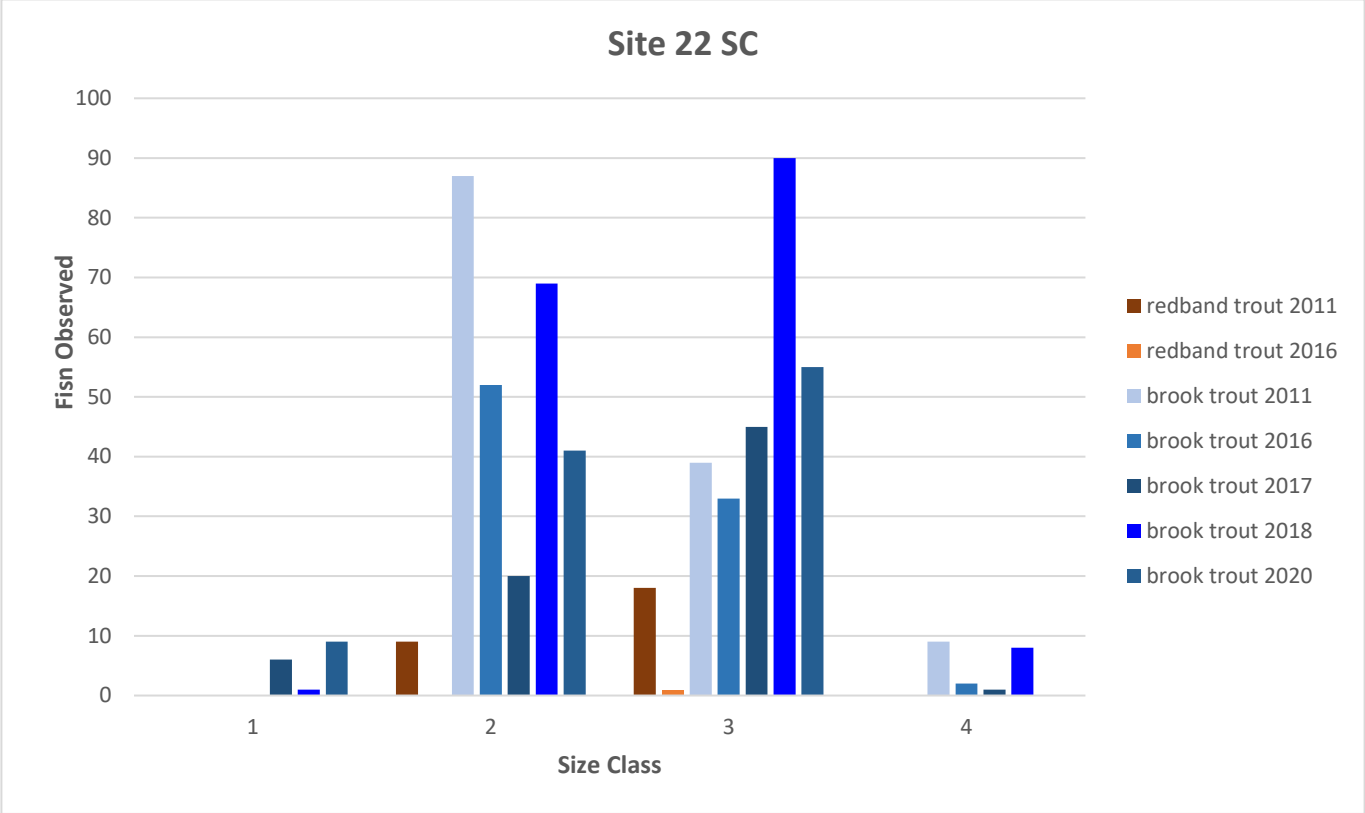

Figure 3. Site 22SC Data 2011, 2016-2020

Within the side channel, no redband trout were observed in 2017, 2018, or 2020. Only one was observed in 2016 (Figure 3). In 2020 105 Brook trout were counted, up from the 2017 low of 72 but down from the 2018 survey of 168. The side channel is filling in with silt and is difficult to snorkel because of significant shallow depths, easily disturbed silty bottoms with long clearing times, and heavy brush. In the future, in may be acceptable to electrofish the side channel rather than snorkel. Shallow, silty, low velocity habitat is not preferred by redband trout and may explain their absence.

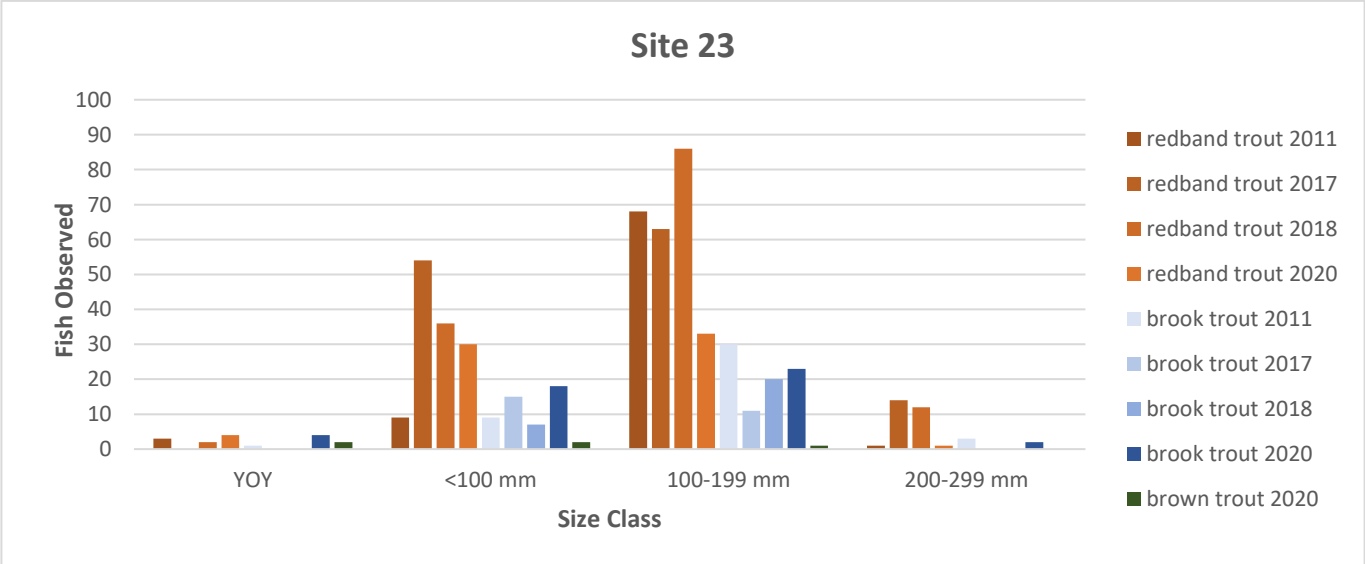

Figure 4. Site 23 Data 2011, 2017, 2018, 2020

Site 23 was not monitored in 2016. A comparison between the 2011, 2017, 2018 and 2020 data is displayed above. The redband trout population showed an overall decrease from 2011 to 2020 (Figure 4). Decreases in the 100-199 mm and 200-299 mm size classes in 2020 were also observed. Overall, an increase in brook trout was observed, especially in the <100 mm size class. Brown trout were observed in 2020, the first time in this reach since monitoring began, including 2 young of the year and 2 in the less than 100mm size class, and 1 in the 100-199mm size class. Brown trout appear to be increasing in abundance and distribution.

Figure 5. Site 18 Data 2011, 2017, 2018, 2020

Site 18 was not monitored in 2016. A comparison between the 2011 and 2017, 2018, and 2020 data is displayed above in Figure 5. Trends for redband trout numbers are currently variable, with the <100 mm size class nearly doubling from 2018 to 2020, whereas a declining trend exists in the 100-199 mm and 200-299 mm size classes. Brook trout remain at static low numbers. No large redband trout were observed in 2017.

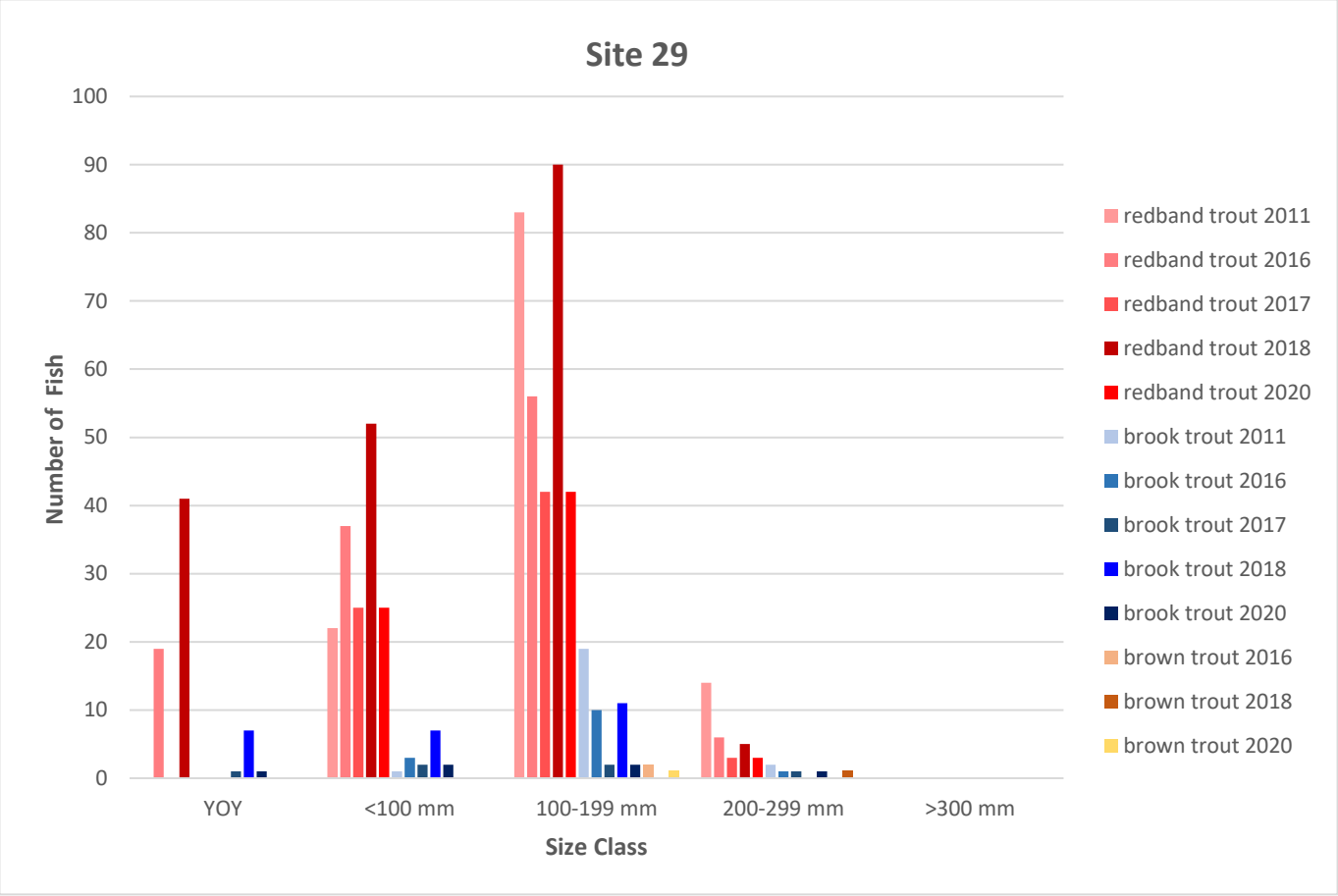

Figure 6. Site 29 Data from 2011, 2016, 2017, 2018, 2020

Site 29 was monitored in 2016, 2017, and 2018, and again in 2020. Data from 2011 is also presented. Between 2016 and 2017, redband trout numbers decreased across all age classes, rebounded to 2016 numbers in 2018, and fell back to 2017 levels in 2020 (Figure 6). Trends in brook trout numbers essentially mirrored redband trout numbers in the reach across survey years. Two brown trout were observed in 2016, none were observed in 2017, one was observed in 2018, and one was observed in 2020.

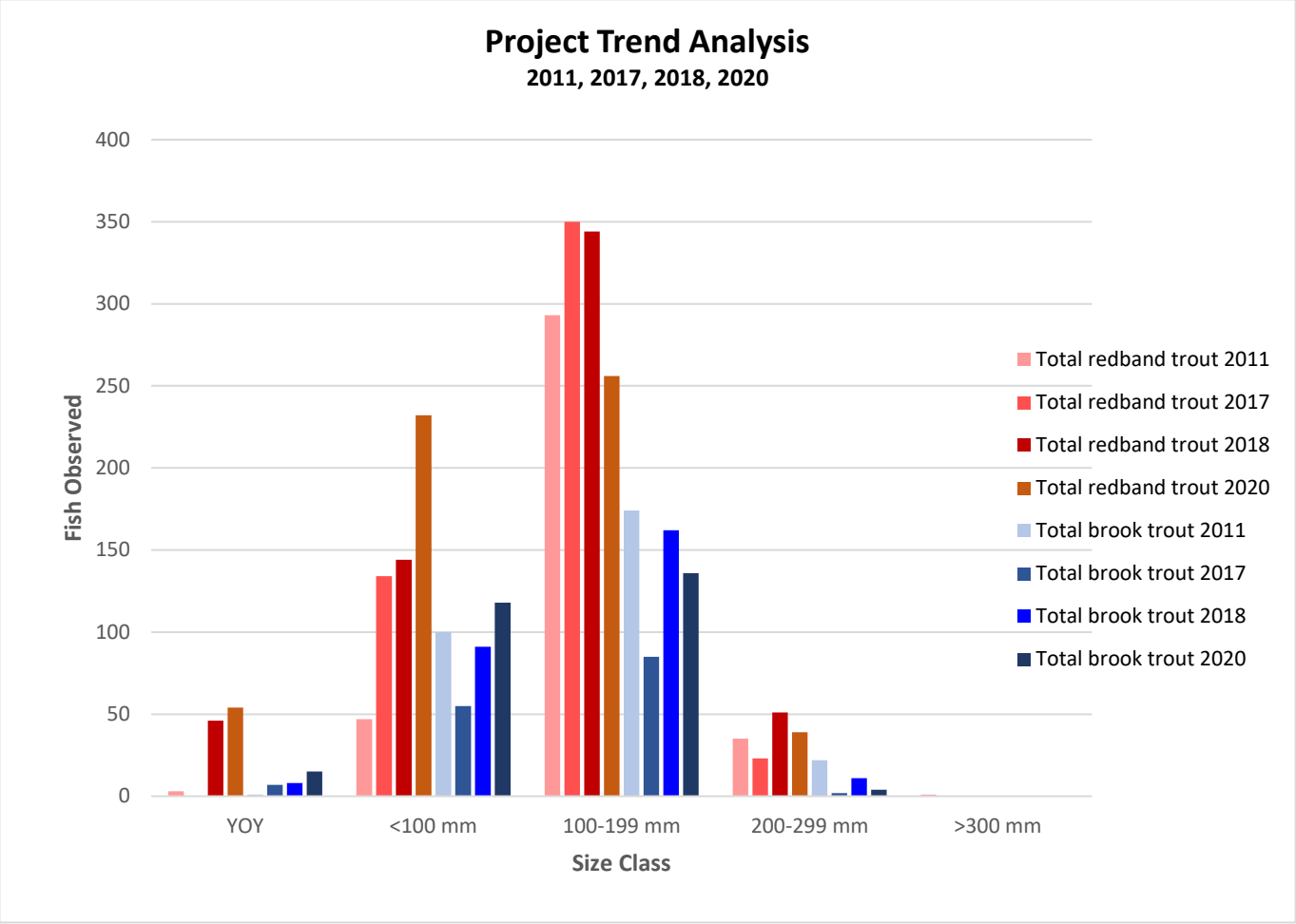

Figure 7. Population Trend Within the Project Area

Figure 7 demonstrates the trends in fish assemblage and size class structure for the project area comparing 2011 across surveys from 2017, 2018, and 2020. 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 overall trend is an increase in redband trout in the YOY and <100 mm size classes, a decrease in redband trout ≥100 mm, with a static total population from 2018 to 2020, but an overall increase between 2011 and 2020. Brook trout size class trends have followed a similar pattern, except their total population numbers have declined between 2011 and 2020.

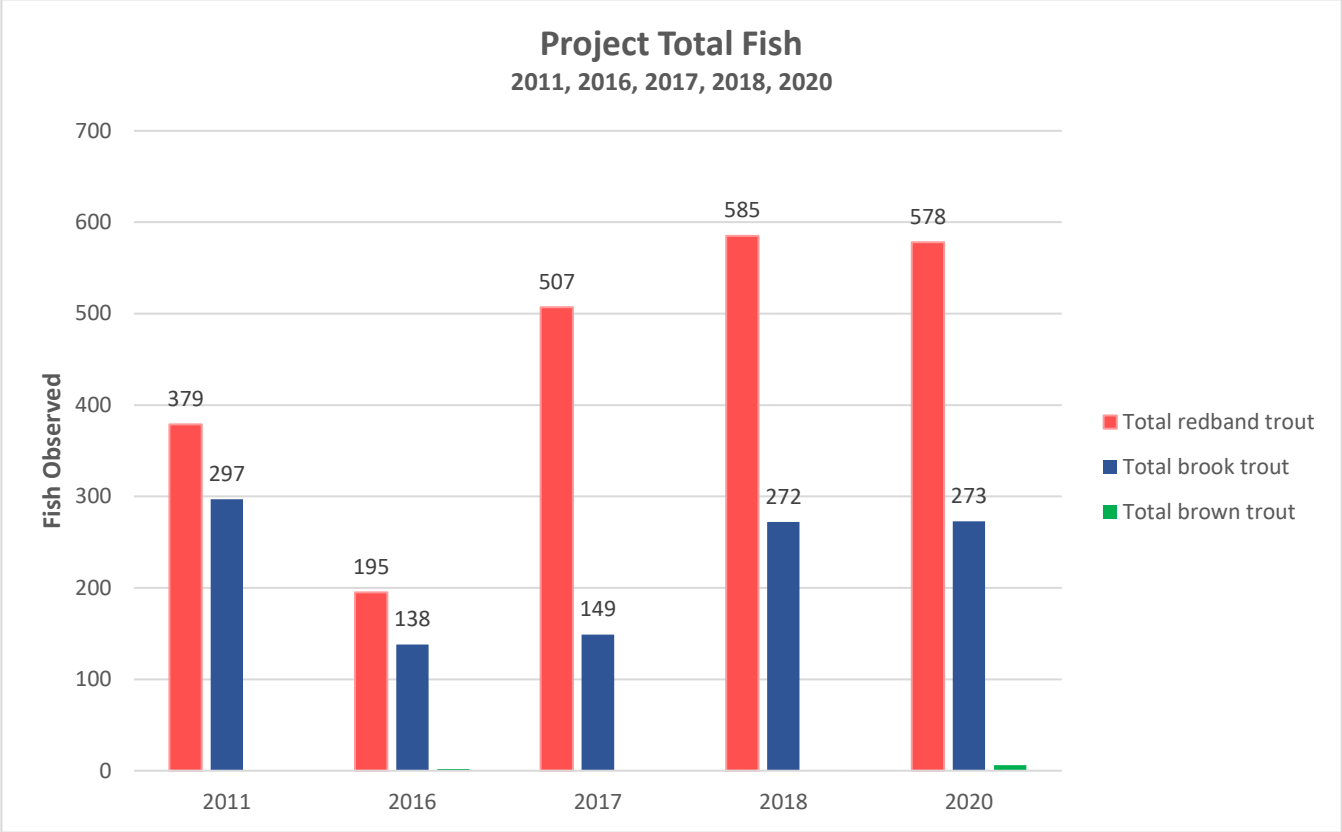

Figure 8. Total Fish Observed Within Project Area 2011, 2016, 2017, 2018, 2020. Data from 2016 did not have surveys conducted in Reaches 18 and 23.

Figure 8 demonstrates the trend between 2011 and 2020 of an overall increase in redband trout and overall decrease in brook trout observed within the project area (same sites as listed above). The most brown trout were observed in 2020 but this species still only represents a small portion of the overall trout population at this time.

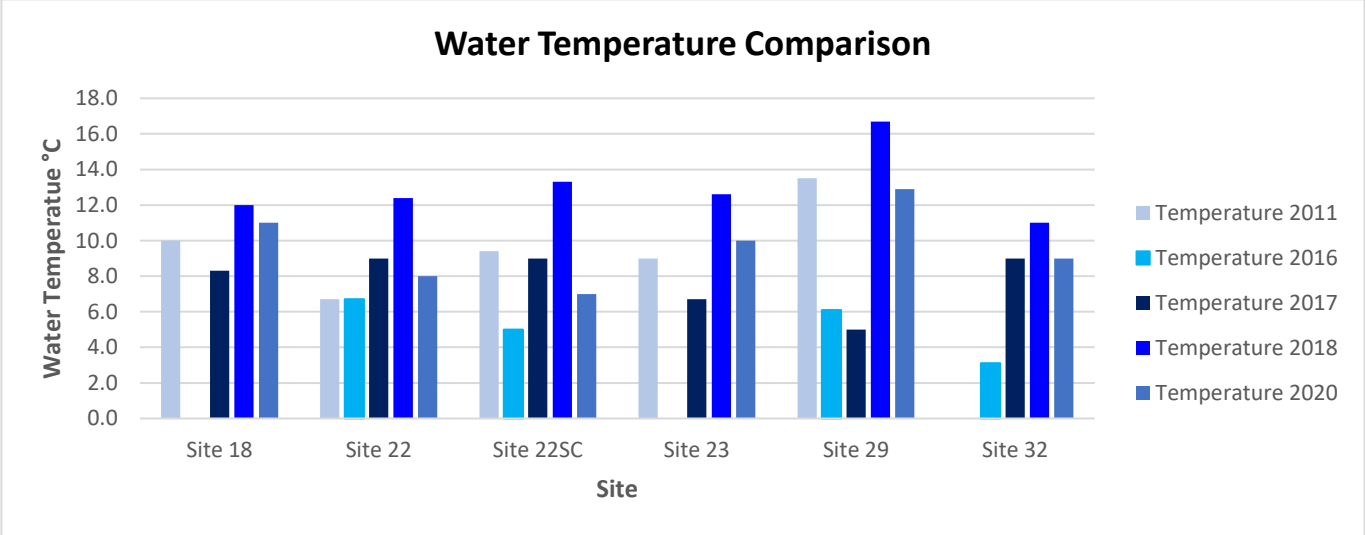

Figure 9. Water Temperatures at Time of Survey 2011, 2016, 2017, 2018, 2020

Figure 9 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.

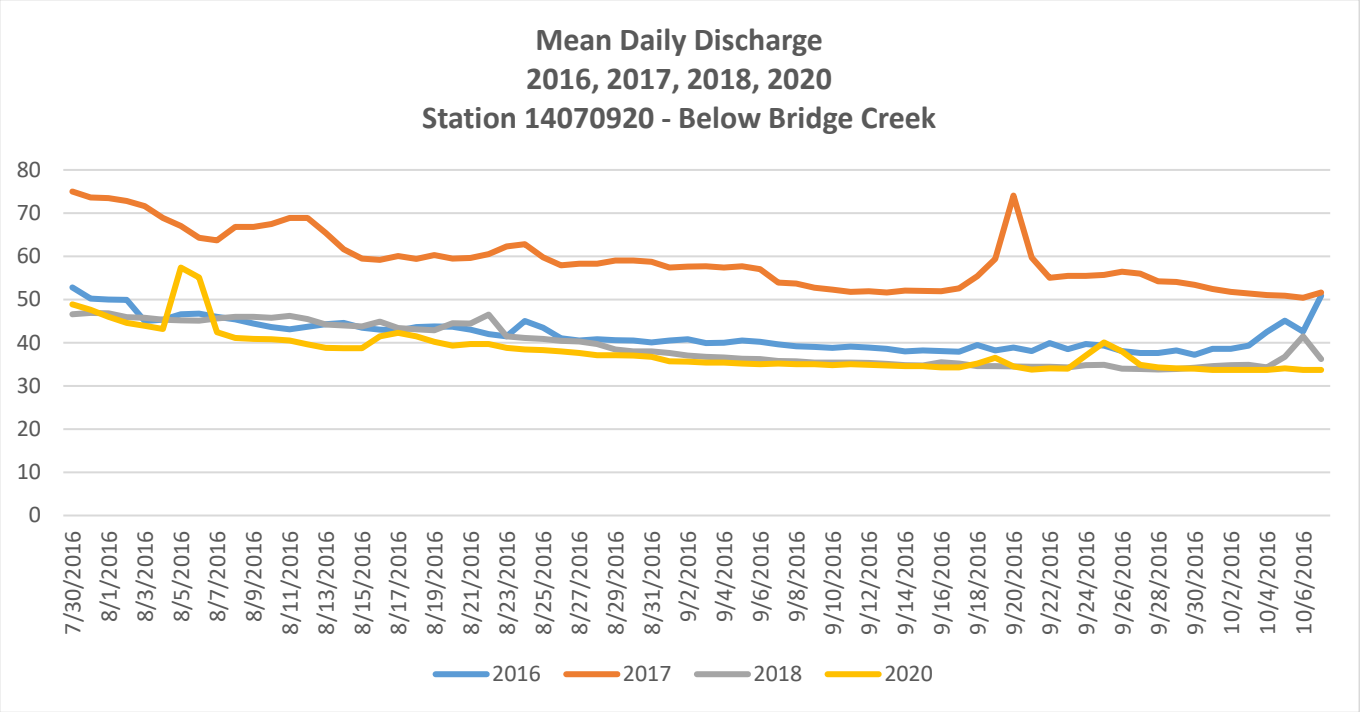

Figure 10. Mean Daily Discharge Comparison 2016-2020 Station 14070920

Figure 10 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. Discharges between survey years were fairly similar with the exception of 2017 which had substantially more discharge.

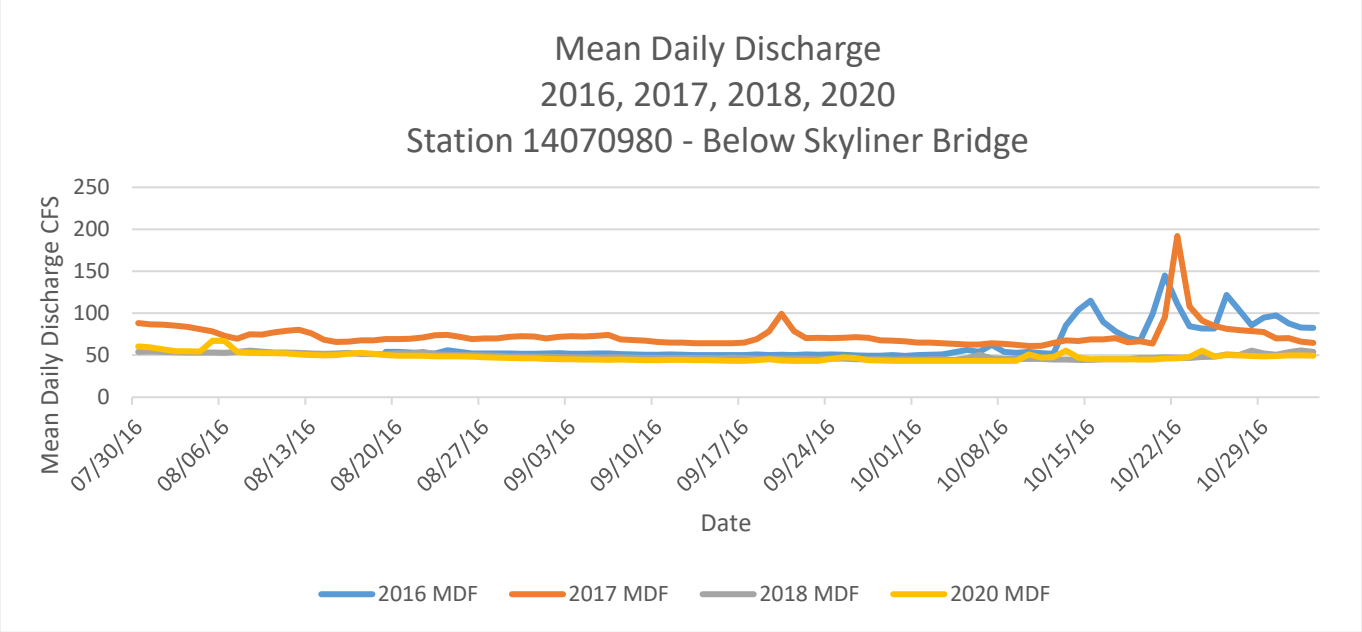

Figure 11. Mean Daily Discharge Comparison 2016-2020 Station 14070980

Figure 11 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
32	7/31/2018	44.4	14070920	Provisional	11.0
32	8/11/2020	40.5	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
22	8/9/2018	42.5	14070920	Provisional	12.4
22	8/11/2020	40.5	14070920	Provisional	8.0
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
22SC	7/31/2018	NA	NA	NA	13.3
22SC	10/8/2020	NA	NA	NA	7.0
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
23	8/6/2020	67.0	14070980	Provisional	10.0
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
18	8/12/2020	51.1	14070980	Provisional	11.0
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
29	8/25/2020	48.5	14070980	Provisional	12.9

Table 2 displays the water temperatures and discharge at the time snorkel surveys were conducted during 2011, 2016, 2017, 2018, and 2020. 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 be lower, as Station 14070920 was not yet established, and the displayed discharge includes the accretion zone contribution.

Discussion:

Compared to the 2011 data, surveyed prior to the new water system operations and considered the baseline, there continues to be an overall trend of an increase in the relative abundance of redband trout populations and a small decrease in the relative abundance of the non-native brook trout (Figures 7 and 8), except in the Side Channel of Site 22, which has become wholly populated by brook trout. It appears from the 2020 results that brown trout are expanding their distribution up Tumalo Creek. When trout populations are sympatric, variability

in populations is typical and one species may not be able to monopolize the other. The two dominant species, redband and brook trout, have co-existed in Tumalo Creek for nearly 100 years. They 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 at the heads of pools and behind boulders mid-stream in riffles.

The trend of decreasing numbers of fish observed within the side channel (Site 22SC) in 2017 reversed in the 2018 survey, and only decreased slightly from those higher numbers in 2020. Habitat within this site appears to be increasingly less available as pools fill in with silt and potentially has 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, 2018, and 2020 (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, and subsequent surveys indicate the population is likely stable here. Higher flows may have increased suitable habitat for redband trout but decreased suitable habitat for brook trout.

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 further upstream since 2011. Brown trout were again observed in Site 29 in 2020, and in Site 23 during the 2020 survey, indicating an expansion of their distribution up Tumalo Creek. The increasing velocities and cooler temperatures may be serving as a barrier to further upstream distribution of brown trout, since they have not been observed in sites farther upstream.

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 2020 Flow and Temperature Monitoring Report for Tumalo Creek by K. Wright and J. Gritzner.

Tumalo Creek Fish Monitoring Sites