Canton Creek Snorkel Surveys (2011-2019)

Authored by Dr. Charley Dewberry, Ph.D.
Prepared by Pacific Rivers, a 501(c)(3) organization

Executive Summary

During eight of the last nine summers, a snorkel survey of Canton Creek (North Umpqua basin) has been completed. During 2019, the survey was completed by Pacific Rivers (Charley and Andrew Dewberry, Alexandria Brereton, and Alan Bunce) and by Phoenix School students. Thomas McGregor, Director of Work Experience at the Phoenix School, coordinated the student participation. The survey included all of the mainstem of Canton Creek to the fourth bridge, Pass Creek, and Mellow Moon Creeks.

The snorkel surveys enable us to construct a snapshot of summer rearing of salmonids in Canton Creek. This snapshot of the abundance and distribution of steelhead (the dominant salmonid) in the basin and the evaluation of the stream habitat and landscape processes provide basic information to identify restoration opportunities within the basin. With each additional year of survey, the trends in the population of each salmonid and age class of steelhead become clearer. It also allows us to greater understand the factors affecting the abundance and distribution of the salmonids in the basin.

A number of trends are observed in the trajectory of steelhead within the basin. The population of age-0 steelhead in the basin has ranged from 16,000 to 40,000 during the previous period of sampling. During 2019, the number of age-0 steelhead was by far the lowest that we have seen, only 7,302 fish. That is less than 50% of the previous low count. The population of age-1 steelhead in the basin has ranged from 1,400 to 5,100 fish. During 2019, the number of age-1 steelhead was 2,213 fish, which is average for the period of sampling. A disproportional number of age-one fish were observed in Pass Creek and the right fork of Pass Creek. The population of age-2 steelhead in the basin has ranged between 260 and 950 fish during the period of sampling. During 2019, 733 age-two steelhead were observed in the basin. This is a higher than average number of fish.

The cutthroat population estimates in 2019 were the highest observed during the eight years of sampling. The previous year also had the highest number of cutthroat trout observed to that date. Over the period of sampling, the population estimates for age-two steelhead and cutthroat trout have similar trends, suggesting that similar factors were controlling both of these populations.

During 2019, coho were observed in the lower reaches of the mainstem of Canton Creek; however, not enough were observed to calculate a reliable estimate of the population.

We began a life-history analysis of the steelhead in the Canton Creek basin. The number of age-0 steelhead in previous years has ranged from 16,000 to over 40,000 fish during the previous seven years. In 2019, our population estimate was only 7,302 fish, which is the lowest observed.

The number of age-1 steelhead has ranged from 1,460 to 5,082 fish during the previous seven years. During the current year, there were 2,213 fish estimated to be in the basin. The correlation between the number of age-0 fish and the number of age-1 fish the following year is -0.09. This indicates that the number of age-0 fish has little to do with the number of age-1 fish observed in the following year. This suggests that spawning is not limiting to steelhead in Canton Creek. Even the 2014 age-0 steelhead (the lowest number of age-0 steelhead observed) resulted in 2,820 age-1 steelhead the next year. This is a survival rate of 17%. In 2015, only 1,514 age-1 steelhead were estimated to be in Canton Creek. They originated from one of the largest age-0 cohort of fish (2014). Their survival was only 4%. The high temperatures combined with low base flows undoubtedly contributed to the low survival rates. It is clear that the number of age-0 fish does not determine the number of age-1 fish that survive in each subsequent year. During 2018, the survival from age-0 to age-1 steelhead was 8%, which is about average for the period of record. During 2019, the survival of age-0 to age-1 steelhead was 0.08, which is average.

During 2019, the survival of age-1 to age-2 steelhead was about 28%. This is an above average survival rate. In most years, survival from age-1 to age-2 has been between 10% and 20%.

The results of the life-history analysis indicate that the severe high temperature conditions during the summer of 2015 significantly reduced the survival of age-1 and age-2 steelhead within the basin. The number of age-0 steelhead that survived to age-1 was only four percent, the lowest observed during the entire survey. The year 2018 was also a high temperature year, however, it does not appear that it led to a significant decrease in the survival rates of juvenile steelhead in Canton Creek. Subsequent surveys and life-history analysis will greatly increase our understanding of steelhead population dynamics in Canton Creek and their response to restoration efforts.

In 2019, the age-0 steelhead were likely decimated by a large storm in May (Fig. 5); however, the age-1 and age-2 steelhead were less affected by the storm.

Introduction

Overview

In 2011, a partnership was formed among Pacific Rivers, the Phoenix School in Roseburg, Oregon, the Cow Creek Tribe, and the BLM to begin collecting baseline information prior to designing a restoration project within the Canton Creek Drainage basin. The Canton Creek Drainage was of interest because it is partially within the Oregon and California Railroad Lands (O&C) as well as being strategically located within the North Umpqua basin. This project provides an opportunity to collect background information for designing an effective restoration project within the context of the North Umpqua drainage.

During eight summers (2011-2019 minus 2012), a snorkel survey for juvenile salmonids was conducted in Canton Creek (North Umpqua basin) was completed by the Phoenix School students and Pacific Rivers. Thomas McGregor, Director of Work Experience at the Phoenix School, coordinated the student participation. During the current year, the snorkel divers for Pacific Rivers were: Charley and Andrew Dewberry, Alexandria Brereton, and Alan Bunce. A list of the students that participated in the 2019 survey is found in the Appendix. The survey included all of the mainstem Canton Creek to the fourth bridge, Pass Creek, and Mellow Moon Creeks. During 2018, all the standard survey reaches were completed.

Study Area

Canton Creek is a major tributary of Steamboat Creek in the North Umpqua River basin (Fig. 1). The drainage area is approximately 60 square miles. Canton Creek is a strategically important producer of steelhead trout, coho salmon, chinook salmon and cutthroat trout within the North Umpqua drainage. Most of the western two-thirds of the basin are BLM-private land checkerboard (O&C lands). The remaining one-third of the basin is managed by the USFS.

The basin is entirely within the Western Cascades. The geology is dominated by weathered Tertiary volcanic rocks. The dominant forest community is western Hemlock- Douglas fir.

Methods

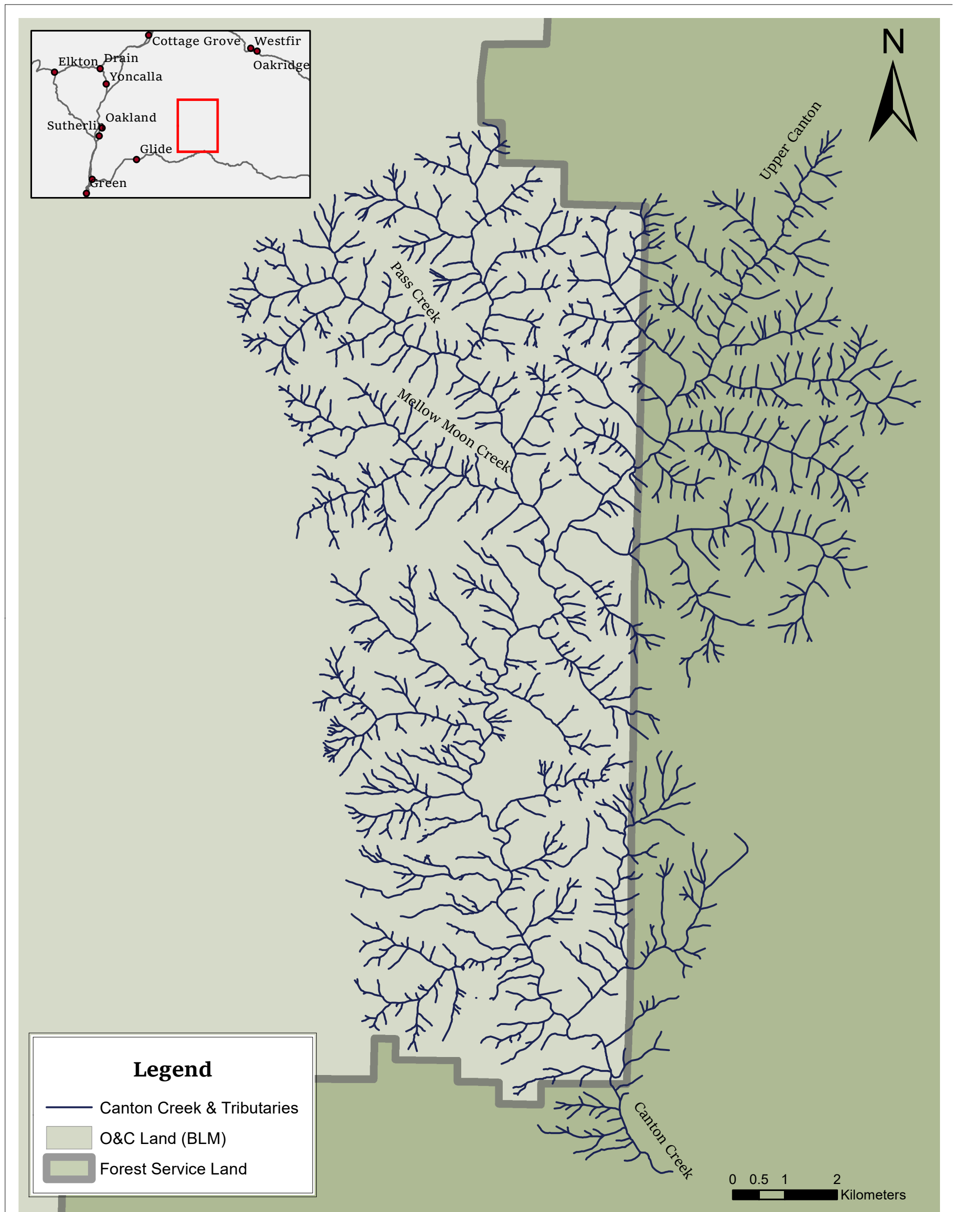

Fig. 1. Map detailing extent of research (i.e. Canton Creek Watershed). Of note are the delineations of land ownership within the watershed, with over 50% designated as O&C lands (owned by the Bureau of Land Management) with the remaining lands falling under the management of the United States Forest Service (USFS).

The snorkel surveys were conducted during August and September each year using the Hankin-Reeves method (Hankin and Reeves 1990). A dive crew consisting of two or more people work their way upstream through their designated stream reach. The stream channel was divided into three habitat types: riffles, pools, and glides. For each habitat unit, the length and width was estimated. The frequency of the surveyed units was: 1:10 riffles; 1:8 glides; and 1:5 pools. All salmonids were counted in each surveyed stream habitat. In the habitat units that were snorkeled, the length and width were measured.

The Phoenix students participated in a day of training prior to conducting the surveys. The topics emphasized during the training were safety, identifying the three habitat types in Canton Creek, how to identify the species and age of the salmonids found in the basin, and how to approach counting the fish in a habitat unit. During training, the students spent a total of four hours in the stream conducting actual counts in habitat units. All students could identify coho, steelhead, and cutthroat trout. The Phoenix School students divided into two teams. One team snorkeled Pass Creek, the major left fork of Canton Creek, while the second team snorkeled upper Canton Creek. Charley Dewberry alternately worked with each crew to verify their counts. In addition, he snorkeled a reach of Mellow Moon Creek, upper Canton Creek, and Pass Creek to verify the student counts.

Andrew Dewberry and Alexandria Brereton snorkeled the majority of the mainstem of Canton Creek. The mainstem of Canton Creek consists of the lower ten miles of Canton Creek up to the confluence of Pass and Upper Canton Creeks. We completed the standard dive survey for Canton Creek (Fig. 1). The same reaches were dove in 2019 as in 2013.

For these surveys, age-0 and 1 trout include both steelhead and cutthroat trout. While some individuals are easy to identify into their respective species, others are very difficult. As a result, we elected to combine both species into these age categories. Age-2 steelhead were differentiated from age-2 cutthroat trout. While a few adult salmonids were observed in the surveys, they are not included in this discussion.

The densities of each age class of steelhead were calculated in each habitat unit that was dove. In the reaches dove by the students, habitat units that were dove also had the length and width measured by a measuring tape. This increased the accuracy of the area estimates. In the Canton mainstem, only a portion of the habitat units dove were also measured. For example, long pools in the mainstem were not measured as age-0 fish were always at low densities in these units.

A map of the densities of each age of steelhead was constructed by the following method. First the cumulated length of all the habitat units was calculated. That total was compared to the map length in the routed stream layer. A calibration factor was determined to line up the estimated location of each habitat unit with the map. The densities of each age of steelhead were placed in at least four classes from not present to high densities. The definition of each class is given in the legend of each of the constructed maps. The stream is mapped according to the density class. For example, if the density of age-0 steelhead in the first dove habitat unit was medium, then all habitat units from the first habitat unit to the dove unit would be designated as having a medium density. The medium designation would continue upstream until a habitat unit had a different density class. At that point, if the density class increased to a higher class the change would be immediately implemented. The end point of the medium class would end half way between the last medium habitat unit and the new higher density habitat unit. If the next dove habitat unit had a density class lower than the current class, it takes two lower units to reduce the current density designation. This step is taken to smooth the distribution of density classes.

Results and Discussion

Surveyed Reaches
During the eight years, the following reaches of Canton Creek were snorkeled each year: the mainstem up to the confluence with Pass Creek, Pass Creek (including both forks), Upper Canton to the first bridge, and Mellow Moon Creek. During 2011, not all of Pass Creek and Upper Canton Creek were finished by the students. In some years selected reaches of the following creeks were surveyed: No Man Creek, Francis Creek, Chilcote Creek, and an unnamed tributary in upper Canton Creek.

Salmonid Population Estimates
The results of the eight years of snorkel surveys are summarized in Fig. 2-6. Steelhead trout, and cutthroat trout were observed and their populations estimated in the basin. In addition, a few adult steelhead and Chinook salmon were observed in the mainstem of Canton Creek, but their numbers were low and were not estimated. In previous years, population estimates were made of coho salmon, but in 2018 and 2019, coho were observed in the mainstem, but an accurate population estimate could not be created.

Below are listed results of population estimates of steelhead trout of ages 0, 1, and 2 surveyed between 2011 and 2013. Additional tables detail this study's population estimates of cutthroat trout and life history analysis of steelhead trout in Canton Creek between the years of 2011 and 2019.

Table 1: Population Estimates of Steelhead trout age 0 in Canton Creek. Data based on snorkel surveys from 2011-2019 with the exception of 2012.

Reach	2011	2013	2014	2015	2016	2017	2018	2019
Mainstem	32,968	15,430	7,433	23,180	11,537	20,768	13,780	3,902
Upper Canton	3,888	5,948	3,247	4,901	1,372	4,929	6,274	822
Pass Creek	3,138	9,523	5,089	5,491	4,784	6,279	6,652	1,911
RF Pass Creek		200	131	462	572	386	12	245
LF Pass Creek		165	216	716	498	410	458	116
Mellow Moon	135	233	165	529	207	582	165	306
Total	40,129	31,499	16,281	35,279	18,970	33,354	27,341	7,302

Table 2: Population Estimates of Steelhead trout age 1 in Canton Creek. Data based on snorkel surveys from 2011-2019 with the exception of 2012.

Reach	2011	2013	2014	2015	2016	2017	2018	2019
Mainstem	3,615	892	1,512	1,585	796	745	1,385	1,232
Upper Canton	1,059	644	444	685	134	357	945	194
Pass Creek	211	937	518	287	264	278	284	425
RF Pass Creek		6	0	4	118	0	0	186
LF Pass Creek		35	37	31	48	58	13	34
Mellow Moon	197	53	12	228	154	22	16	142
Total	5,082	2,567	2,523	2,820	1,514	1,460	2,643	2,213

Table 3: Population Estimates of Steelhead trout age 2 in Canton Creek. Data based on snorkel surveys from 2011-2019 with the exception of 2012.

Reach	2011	2013	2014	2015	2016	2017	2018	2019
Mainstem	673	113	432	301	96	188	728	546
Upper Canton	173	36	102	146	28	80	116	23
Pass Creek	29	124	84	25	26	8	13	148
RF Pass Creek		0	0	4	50	0	0	11
LF Pass Creek		0	0	0	5	5	4	0
Mellow Moon	69	58	6	10	63	0	0	5
Total	944	331	624	486	268	281	861	733

Table 4: Population Estimates of Cutthroat trout age 2 in Canton Creek. Data based on snorkel surveys from 2011-2019 with the exception of 2012.

Reach	2011	2013	2014	2015	2016	2017	2018	2019
Mainstem	167	42	165	154	32	36	328	246
Upper Canton	31	35	6	0	0	11	14	48
Pass Creek	107	13	15	0	0	16	0	29
RF Pass Creek		0	0	0	20	0	0	28
LF Pass Creek		0	0	0	0	0	0	6
Mellow Moon		0	6	0	0	0	0	64
Total	305	90	192	154	52	63	342	421

Table 5: Life History Analysis of Cutthroat trout age 2 in Canton Creek. Data based on snorkel surveys from 2011-2019 with the exception of 2012.

	2013	2014	2015	2016	2017	2018	2019
Age-0	31,499	16,281	35,279	18,970	33,354	27,341	7,302
Age-1	2,523	2,820	1,514	1,460	2,643	2,213	
Age2	486	268	281	861	733		

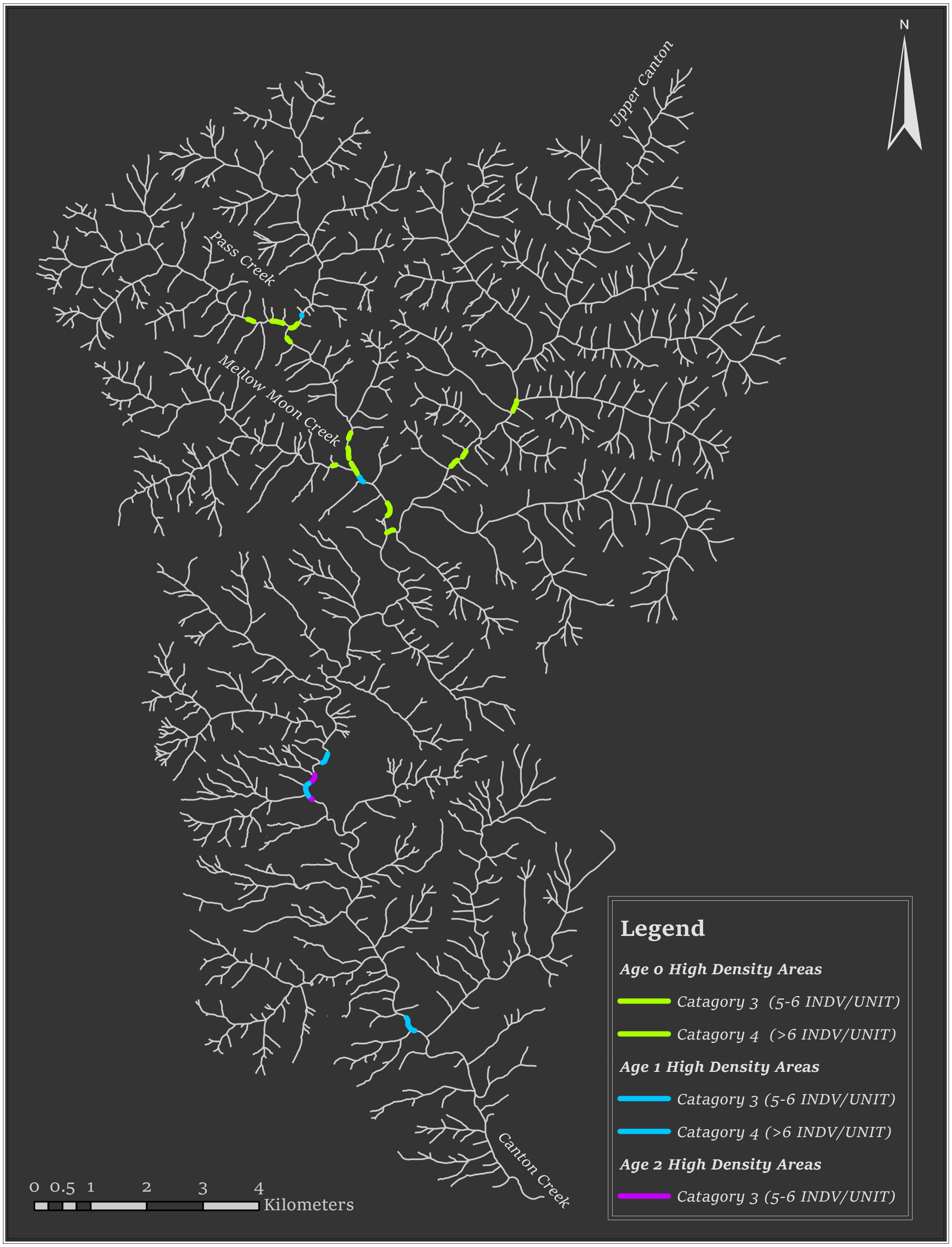

Fig.2. Density analysis of all ages of steelhead trout. The highest two categories of densities are displayed for each age group, with Category 0, 1, and 2 (low densities) being excluded.

Age-0 Steelhead

Steelhead trout were the most abundant salmonid within the basin. All three ages of steelhead were observed. As expected, age-0 fish dominated the survey. During the eight years of survey, between 16,000 - 40,000 age-0 steelhead were usually observed in the major surveyed reaches. The 2011 survey estimate of 40,129 age-0 steelhead (the highest observed during the survey period) is underestimated because only about 75% of Pass Creek was completed by the students. In 2014 and 2016, the estimate of age-0 steelhead was only about one-half of the usual number. During 2018, over 27,341 age-0 steelhead were estimated to be rearing in the Canton Creek watershed. During 2019, only 7,302 age-0 steelhead were observed, which is only about 50% of the previous low population estimate.

The number of age-0 steelhead was examined by reach. In the mainstem (the lower approximately 10 miles) of Canton Creek, the number of age-0 steelhead has varied between about 7,500 and 33,000 fish. In 2011, the highest year with the highest number of age-0 steelhead in the basin, over 33,000, or over 80% of the age-0 fish, were located in the mainstem of Canton Creek. By contrast, in 2014, the year with the lowest observed number of age-0 steelhead in the basin, only 7,500, or 46%, of the age-0 steelhead were in the lower mainstem reach. During the current year, the number of age-0 steelhead observed was about 50% of the previously lowest count in the lower mainstem; however, more than 50% of the age-0 steelhead found in the basin were in lower Canton Creek. It appears that in years with a high population of age-0 steelhead, the mainstem reach of Canton Creek is producing a greater percentage of the fish than in years with a lower number of fish observed in the basin.

In Pass Creek, the population estimates of age-0 steelhead in previous years were between 3,138 and 9,523 fish during the seven years of survey (Table 1). The 2019 population estimate of age-0 steelhead in Pass Creek is 1,911 fish. That is significantly below average.

In upper Canton Creek, the population estimates of age-0 steelhead in previous years were between 1,300 and 6,274 for the eight years of survey (Table 1). In 2019, this was a little more than 50% of the lowest estimate. The population of age-0 steelhead in Pass Creek and Upper Canton Creek were by far the lowest observed during the surveys.

In Mellow Moon Creek, a tributary of Pass Creek, the population estimates for age-0 steelhead in previous counts were between 130 and 582 fish. The number age-0 steelhead in Mellow Moon Creek in 2019 was about average. The seven-year pattern in Mellow Moon Creek generally tracks the estimates seen in Pass Creek. This is expected, as Mellow Moon is a tributary of Pass Creek. However, in 2019, only Mellow Moon Creek was average for the period of survey. The other reaches were significantly lower than average. When the total number of age-0 steelhead in the basin is high, the mainstem of Canton Creek usually account for about three-quarters of the age-0 steelhead in the basin. When the number of age-0 Steelhead was low in the basin (2014), only about 45% of the age-0 steelhead were found in the mainstem of Canton Creek. This suggests that the preferred habitat for age-0 steelhead is in Pass, upper Canton, and the tributaries and not the mainstem of Canton Creek. The mainstem is not the center of age-0 rearing, except in high production years. This trend was observed in 2019. This year was by far the lowest recorded during the survey.

In a year with the lowest number of age-0 steelhead observed during the nine years of surveying Canton Creek, it comes as no surprise that in the mainstem of Canton Creek all of the observed densities were in the low or medium class. During years with low total numbers of age-0 in the basin, the lower mainstem has even lower than expected numbers. Steelhead prefer the upper basin over the mainstem. In Pass Creek the majority of reaches had low or medium densities of fish, but there were a number of reaches where high densities of fish were observed. One surveyed unit was in the very high density category. No pattern was evident within Pass Creek. Upper Canton Creek had a similar pattern to Pass Creek with the exception there were more low category reaches high in Upper Canton than in Pass Creek. Mellow Moon, a tributary of Pass Creek, consisted of all low or medium density class reaches.

To summarize, the total number of age-0 steelhead observed in 2019 in the Canton Creek drainage was by far the lowest average for the period of survey. The mainstem population estimate was a little less than 50% as is predicted for low population A-0 steelhead had higher densities in Pass and Upper Canton Creek than they did in lower Canton mainstem. This is a pattern that we have seen in years with a low total number of age-0 steelhead in the basin.

Age-1 Steelhead

The population estimates of age-1 steelhead were between 1,460 and 5,000 fish for the previous period of sampling (Table 2). The largest population was observed in 2011, even though the survey underestimated the number of fish in that year because only about three-quarters of Pass Creek and Upper Canton Creeks were completed. The lowest number of age-1 steelhead was observed in 2017. The population of age-1 steelhead was slightly below the average for the period of sampling.

The population estimates were also calculated by reach. In the mainstem of Canton Creek, the population estimates of age-1 steelhead were between 745 and 3,600 fish. In 2011, a high population year, the mainstem accounted for about 70% of the total age-1 steelhead in the basin; while 2013, in an average population year, the mainstem accounted for only 35% of the age-1 steelhead in the basin. In 2019, the lowest basin total was observed. However, the percentage of age-1 steelhead in the mainstem was 51%. We currently do not have a good explanation for the percentage pattern in the mainstem.

The population estimates for the age-1 steelhead in Pass Creek in previous surveys were between 200 and 950 fish. A slightly below average number of age-1 steelhead were observed in Pass Creek in 2019. The number of fish in Pass Creek does not correlate well with the total number of fish observed in the Canton Creek basin as a whole.

The population estimates for age-1 steelhead in upper Canton Creek have been between 130 and 1,060 fish. In 2019, the population estimate was 194 fish, which is significantly lower than the average.

The population estimates of age-1 steelhead in Mellow Moon Creek were between 12 and 200 fish. During 2019, an above average number of age-1 steelhead were observed (142) in Mellow Moon Creek. This is one of only a couple sites with an average number of fish during this year's survey.

Age-1 steelhead densities are distributed pretty uniformly throughout the basin. In the mainstem, low densities predominated but there were a number of medium and high category habitat units. One unit had a very high density. Curiously the upper portion of the mainstem was predominantly low density. We currently have no explanation for that absence. Most of Pass and Upper Canton Creeks are dominated by the not present or low density classes. Two areas stood out. Mellow Moon had a significant number of reaches that had medium densities of age-1 steelhead. The other site was on the right fork of Pass Creek. There were a significant number of age-1 steelhead in the plunge pool of an impassable falls.

In summary, the abundance of age-1 steelhead in the basin as a whole averaged about 2,600 fish in the eight years of surveying. In the first year of the survey (2011), over 5,000 fish were observed in the basin. In 2016 and 2017, below average numbers of age-1 steelhead were observed in the surveys. During 2019, a slightly below average number of age-1 steelhead were observed in the basin.

Age-2 Steelhead

The population estimates for age-2 steelhead were between 268 and 950 fish (Table 4). The largest number of fish was observed in 2011, while the lowest number of fish were observed in 2016 and 2017. During 2019, a total of 733 age-2 steelhead were estimated for the basin as a whole, which was the third highest estimate recorded during the period of sampling. The factors affecting the number of age-2 fish will be discussed in greater detail in the life history analysis section.

The population estimates of age-2 steelhead were also calculated by stream reach. In the mainstem of Canton Creek, the population estimates tracked those of the basin as a whole because the mainstem is the largest and usually dominant section for age-2 steelhead. In fact, the number of age-2 steelhead observed in the mainstem was the third largest observed during the eight years of sampling. The population estimates for age-2 steelhead in upper Canton Creek was the lowest observed during the period of survey. The population estimate of age-2 steelhead in Pass Creek during 2019 was the highest observed.

Age-2 steelhead have the largest number of not present reaches than either age-0 or age-1 steelhead. Age-2 steelhead are a little more common in lower Canton than the upper tributaries (Fig. 2). This is not a surprise as they prefer the larger riffles and heads of pools in the larger water. Surprisingly, they occurred in most all snorkeled unit in the upper reaches of the Canton mainstem. This was the reach that did not have age-1 steelhead present in. Again, we have no explanation for the pattern. We will examine this in earlier years and in the coming year to see if this pattern reoccurs. There were significantly more dive units in Pass Creek and upper Canton Creek and their tributaries that we did not see any age-2 fish. Most of the densities were in the low category. No other patterns were evident in the analysis.

In summary, the trajectory of age-2 steelhead in the eight years of surveys was highest in 2011, lowest in 2016. The number of age-2 steelhead in the basin was the third highest recorded in the eight years of sampling.

Cutthroat Trout

The majority of the cutthroat trout observed in the Canton Creek basin were in the mainstem reach. They were highest in the current year of survey (421) and lowest in the 2016 survey (52). During 2019, cutthroat numbers were significantly higher in the tributaries than we have observed in previous years. The trajectory of Cutthroat trout in the Canton Creek watershed was similar to the age-2 steelhead in the basin.

Coho and Chinook Salmon

In each survey year, some coho salmon juveniles were observed in the lower reaches of Canton Creek. During 2019, we observed coho juveniles in the lower mainstem of Canton Creek. There were not enough observed to calculate an accurate population estimate. Almost all of the coho were observed inside channels connected to pools and away from the major swimming areas. All coho were observed below the falls, just below the first bridge crossing over Canton Creek.

Chinook salmon juveniles were observed in very low numbers in lower Canton Creek in each of the surveys. Their numbers were so low that reliable population estimates could not be made. No more than 10 juveniles were observed in any one year. All observed chinook were below the first series of falls.

Overview of the salmonids in the basin

The lower ten miles of the mainstem of Canton Creek are the most important reaches for adult cutthroat trout and juvenile coho and chinook salmon. No juvenile coho or chinook salmon juveniles were observed above the third falls, just below the first bridge. Steelhead trout of all ages are distributed throughout the Canton Creek basin. Age-1 steelhead and cutthroat trout were distributed higher in the basin than we have seen them previously.

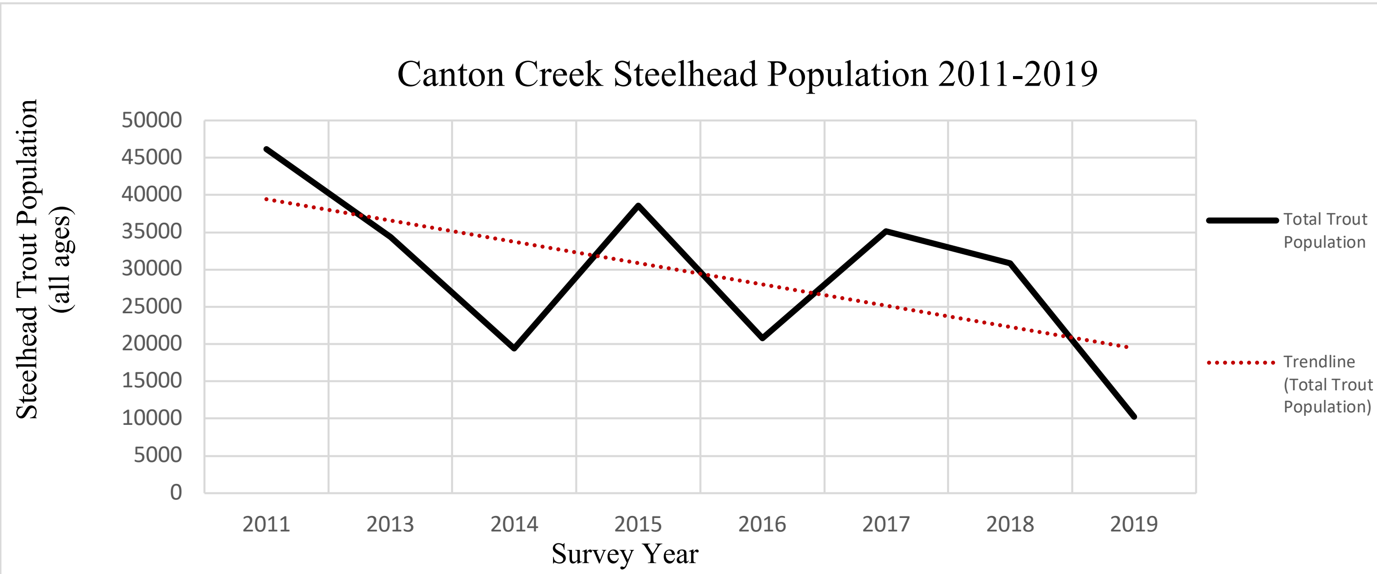

Fig. 3. Findings of total Steelhead trout population (ages 0, 1, and 2) observed plotted over time. 2011-2019 Pacific Rivers.

Life-History Analysis

A life-history analysis is a powerful tool to evaluate the survival of each year of residence of steelhead in freshwater. In the analysis, each year class of juvenile steelhead is followed through their three years of life in freshwater. For example, steelhead that were age-0 in 2013 were age-1 in 2014 and age-2 in 2015 (see Table 5). A life-history analysis looks at the percent survival of each age of steelhead to the next year. As additional year classes are followed through their freshwater cycle, the analysis detects differences in survival in either age-0 to age-1 or from age-1 to age-2. These survival rates can then be compared with differences in environmental factors such as annual peak flows or low-flows. Over a period of time, the life-history analysis combined with adult steelhead counts and streamflow information becomes a powerful tool for determining the trajectory of health of the stream habitat.

The first step in the life-history analysis is to examine the number of age-0 fish in each year (Table 5). The table is constructed vertically. For example, in 2013 there were 31,499 age-0 steelhead in the basin. The next year there were 2,523 age-1 steelhead in the basin. And finally there were 486 age-2 steelhead in the basin in 2015. During the seven years of surveys, the number of age-0 fish in the basin has ranged between 7,300 to over 40,000 age-0 steelhead. The survival rates from age-0 to age-1 have ranged from 4 percent to 17 percent. The highest survival rate was observed in the lowest population estimate for age-0 fish (2014), but the lowest survival rate was found in a year with an average number of age-0 steelhead. During the current survey, the survival of age-0 to age-1 steelhead was average (8%). On the whole, the number of age-1 steelhead is not determined by the number of age-0 fish observed in the previous year. The correlation is -0.09 between them. This suggests that the number of spawning fish and hence the number of age-0 fish does not determine the number of age-1 fish the following year. Other factors have more determinative value.

The survival rates for age-1 steelhead to age-2 steelhead ranged from ten percent to sixty percent. This is significantly higher than the survival from age-0 to age-1. It is true that the lowest number of age-1 steelhead (1,460 fish) had the highest survival rate (fifty-nine percent) and the highest number of age-1 steelhead (2,820 fish) had the lowest survival rate (ten percent). The survival rate for these fish was average for the period of survey. This suggests that the amount of good habitat is limiting survival of these fish. However, in the other years with a more average number of fish, the number of age-1 steelhead does not correlate well with the survival rates.

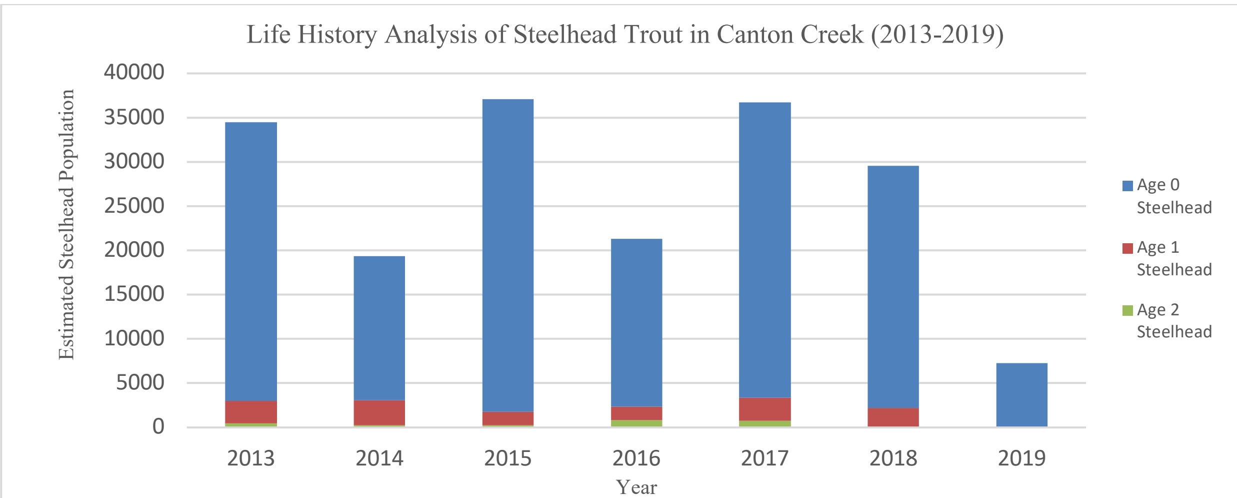

Fig. 4. Findings of total life history analysis survey. Of note are the significant changes between age 0 and age 1 population sizes, indicating low survival rates for age 0 steelhead trout. 2013-2019 Pacific Rivers.

Next, we will examine the annual stream hydrographs for the water years between 2011 and 2019 to see if there are patterns that correspond to the abundances of steelhead age-0's in the basin. We have previously discussed that 2014 was an unusual year.

Having watched steelhead spawn in Oregon streams for over 30 years, I have observed that steelhead spawning is most successful in years when the highest flow of the year occurs around January 1 and is large enough to move gravel-sized sediment in the spawning areas, and subsequent storms are not large enough to move significant sediment. The spawning strategy of steelhead appears to be that they move upstream as far as possible during the peak storm of the year. They spawn on new gravel that has just moved and been deposited. When steelhead spawn, they are "betting" that each subsequent storm event and peak flow will be lower than the one that they spawned on. If the storm they move upstream on is not large enough to move significant gravel and clear the fines out of it, survival of the eggs is low. If subsequent storms are large and subsequent stream flows are as high, or higher, than the storm they spawned on, the gravel will be moved, which causes the eggs to be scoured out of the gravel.

In reviewing the Steamboat gaging station for the period 1956 to the present, most peak-flow events occur between November and February. In fact, only 5 peak-flows were observed in other months of the year. In three years, the peak event occurred in March and in two of the years it occurred in May -- the current year being one of those years (Fig. 5).

In addition, this May 2019 storm was particularly large. The flows exceeded 19,000 cfs. The highest observed flow for the period of record (1956-present) was Dec 1964 when flows exceeded 51,000 cfs. The next highest was in November 1996 when flows exceeded 31,400 cfs. Of the sixty-one years of record, the May 2019 storm was the fifteenth highest.

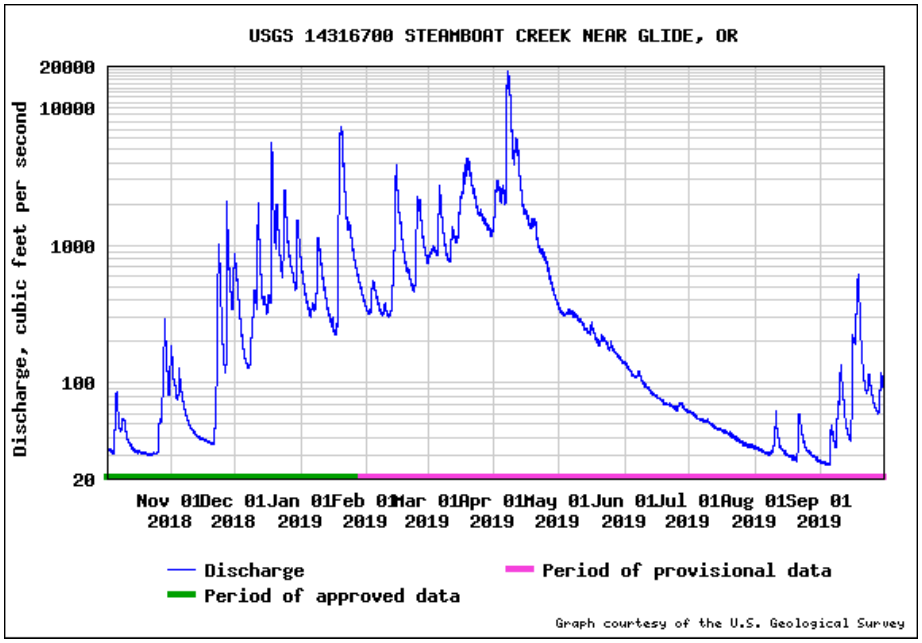

Fig. 5. Peak flow and discharge of Steamboat Creek over seven months between Nov. 2018 and Sept. 2019 as measured in ft.^{3}/s. USGS 2019.

The annual hydrographs of the water years suggests that the above narrative of steelhead spawning success is correct for Canton Creek. When the stream discharge at the Steamboat Creek gaging station exceeds approximately 10,000 cfs, major movement of gravel will occur in Canton Creek. In 2011, the year with the second highest age-0 population in the Canton Creek, the peak flows occurred in January 2011 and exceeded 18,000 cfs. Subsequent storms during the winter never exceeded 5,000 cfs. In 2017, a year with an average age-0 population of steelhead there was a similar stream flow pattern.

The age-0 population in Canton Creek in 2014 was about one-half of that observed in the other surveys. The analysis of the peak flow and subsequent flows were different than those of the high population years for age-0 fish. First, no storm approaching 10,000 cfs occurred in January. There was one storm with a peak discharge of 3,000 cfs in January and one of 4,000 cfs in early February. Then there were three storms in late February through April of 11,000 cfs, and two of 8,000 cfs. There was no large storm that allowed steelhead to move far upstream into small tributary streams with freshly deposited clean gravel in early January. Second, subsequent storms in late February through April were larger than the storm the steelhead spawned on. The first storm was large enough to move gravel-sized sediment. It undoubtedly scoured out many redds. The second two storms moved some gravel but deposited considerable fine sediment in the redds, reducing survival of the fry. As a result, it is likely that the effect of these storms was to significantly reduce the survival of the eggs, either by scouring them out or by suffocating them with fine sediment. The result was that there were about half of the number of age-0 steelhead as observed in the other surveys.

In 2016, like 2014, only about one-half of the average number of age-0 steelhead were observed in the basin. Analysis of the stream flow did not fit the expected pattern. The peak flow was approximately 15,000 cfs in December. In early January, a peak of about 7,000 cfs was experienced in the basin. After that, the next few peaks declined from 4,000 to 2,000 cfs. Then in mid-March 2016, there was a peak of approximately 4,000 cfs. It is possible that this higher peak resulted in the scouring of a significant number of redds in the basin.

During the current water year, a major storm of approximately 19,000 cfs occurred in May. In mid-January, a storm raised the streamflow in Steamboat Creek to about 4,000 cfs. This is an adequate flow for the fish to move up and spawn. About a month later, there was a storm of about 6,000 cfs. This would have removed some of the redds, but it is still within the range of an above average year. The May storm likely heavily scoured redds and destroyed many age-0 fish. It resulted in the lowest number of age-0 steelhead observed during the eight years of record. It is also significant that the survival of the age-1 to age-2 steelhead do not appear to have been impacted by the May storm to the same degree as the younger fish.

The magnitude of the effects of these hydrologic events depends on the health of the stream habitat. In the best habitats, sediment movement and storage (fines and gravel) are very patchy. Even with poor hydrologic conditions for spawning, there are patches of clean gravel. Also, in years with very high flows, protected areas create stable clean gravel beds for spawning. (Additional discussion of the health of the stream habitat occurs in the restoration section.)

The survival rate of each of these populations of age-0 fish to age-1 fish gives us information on the status of the set of stream habitat features that these age-0 to age-1 fish utilize as they grow. There are now six year classes that we can compare the survival rates of age-0 to age-1 steelhead in Canton Creek (2013-2018). In 2013, there were 31,500 age-0 steelhead estimated in Canton Creek. The following year, there were 2,523 age-1 steelhead in the basin. This is a survival rate of about 8%. In the following year, there were only 16,281 age-0 steelhead in Canton Creek, but there were 2,820 age-1 steelhead the next year. That is a survival rate of about 17%, which is double that of the previous year. In 2015, there were 35,279 age-0 steelhead and in 2016 there were 1,514 age-1 steelhead. This is a survival rate of 4%, much lower than the survival rate of the two earlier year classes. This is likely the result of the high stream temperatures in 2015. In 2016, there were 18,970 age-0 steelhead and in 2017 there were 1,460 age-1 steelhead. This is a survival rate of 8%, which is about average. In 2019, the survival rate was again .08. This is a typical pattern for steelhead in the Pacific Northwest.

The number of age-0 fish highly fluctuates from year to year; in this case from 7,300 to 40,000 fish(Table 1). However, the number of age-1 fish has been between 1,460-2,800 in eight survey years. This suggests that the habitat for age-1 fish in its current state is about 2,800 fish. In 2016, only about one-half of the normal population number of age-1 steelhead was observed because of the high stream temperatures. Additional healthy habitat would provide greater habitat for age-1 fish and increase the carrying capacity for steelhead in the basin.

We have six years of analysis that we can examine for the survival of steelhead from age-1 to age-2. The year class 2012 (when they were age-0) resulted in 2,526 age-1 fish in 2013 and 624 age-2 fish in 2014. This is a survival rate of 25% between age-1 and age-2. The year class 2013 had 2,523 age-1 fish in 2014 and 486 age-2 fish in 2015. This is a survival rate of 19%. During last year, the survival rate of age-1 to age-2 steelhead was about twice the previously recorded highest survival rate. During 2019, the survival rate of age-1 to age-2 fish was 28%, which is the second highest. These fish appear to not be greatly affected by the May storm. It is interesting to note that although there was not a survey in 2012, the 2011 year class was the largest age-0 population that we have observed during the survey period and it resulted in the lowest population of age-2 fish observed during the surveys two years later. In 2016, the survival from age-1 to age-2 steelhead was only 9.5%. In 2017, the survival rate from age-1 to age-2 steelhead was 19%, about average. With additional surveys, the analysis of survival rates combined with streamflow data should lead to a greater understanding of the dynamics of steelhead in Canton creek.

Restoration

In its natural state, Canton Creek would have a number of large trees and jams that controlled the long profile of the stream. Energy would have been dissipated as it spilled over the trees or jams. Reaches above the jams would have a lower gradient and gravel and fine sediment would have been sorted in the low gradient area.

By contrast, when we started, the surveys there was only one tree or jam that controlled the gradient in all of the mainstem of Canton Creek and in Pass and Upper Canton Creek. The one long-profile controlling jam is just below the bridge on upper Canton Creek.

During the last two years, the BLM has tipped some existing mature conifers into Pass Creek and the West Fork of Pass Creek to serve as the key pieces that will form these long-profile controlling jams. While the results of this work will take years to set up and create the stair step long-profile, we will have the before and after fish counts for these developing reaches.

Conclusion

The storm that occurred in May decimated the age-0 steelhead in the basin. The age-1 and age-2 steelhead and cutthroat trout were far less impacted by the storm. Their survival rates were about average for the period. Also, age-1 steelhead and cutthroat trout were distributed higher in the basin than we have previously seen. It may be the case that they moved upstream during the high water period in May.