Canton Creek Snorkel Surveys (2011-2020)

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Executive Summary

During nine of the last ten summers, a snorkel survey of Canton Creek (North Umpqua basin) has been completed. During 2020, the survey was completed by Andrew Dewberry, Emma Latendresse, Rhiana Pritchett, and Nick Chambers. Normally students of the Phoenix Charter School in Roseburg participate in the survey but because of COVID-19, they were not able to participate this year. The survey included all of the mainstem of Canton Creek to the fourth bridge, Pass Creek, Upper Canton Creek, East and West Pass Creek, and Mellow Moon Creek.

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 2020, the number of age-0 steelhead was 38,885. This is the second highest number of age-0 steelhead since the surveys began. The population of age-1 steelhead in the basin has ranged from 1,400 to 5,100 fish. During 2020, the number of age-1 steelhead was 1,934 fish, which is lower than average for the period of sampling, but not as low as it might have been. Last year was by far the lowest number of age-0 steelhead we have observed. The population of age-2 steelhead in the basin has ranged between 260 and 950 fish during the period of sampling. During 2020, 902 age-two steelhead were observed in the basin. This is the second highest count of age-2 steelhead during the nine years of sampling.

The 2020 cutthroat trout population estimates were the highest observed during the nine years of sampling and the previous year also saw the second highest number of cutthroat trout. 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 2020, coho were observed in the lower reaches of the mainstem of Canton Creek. The population was estimated to be around 220 fish. These estimates are poor with so few fish.

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. In 2020, our population estimate was 38,885 fish, which is the second highest observed.

The number of age-1 steelhead has ranged from 1,460 to 5,082 fish. During the current year there were 1,934 fish estimated to be in the basin. The survival rate from age-0 to age-1 had previously been between 4% and 17%. Survival this year was 26%, which is by far the highest during the surveys. This is not a big surprise, as the number of age-0 fish was by far the lowest observed. Also, it was a year when the peak flow occurred in late January and it was under 9,000 cfs. The few fish were able to occupy good habitat and there was not a high magnitude flood. 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, and 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%. Only 1,514 age-1 steelhead were estimated to be in Canton Creek in 2016. They originated from one of the largest age-0 cohort of fish. 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 7% which is about average for the period of record. During 2019, the survival of age-0 to age-1 steelhead was 8% which is average.

During 2020, the survival of age-1 to age-2 steelhead was about 41%. This is the second highest 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 2020 was a very good year for juvenile steelhead of all ages. The peak flow occurred in January and it was under 9,000 cfs.

Introduction

In 2011, a partnership was formed among the Pacific Rivers Council, Phoenix School in Roseburg, Oregon, the Cow Creek Tribe, and the Bureau of Land Management (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.

Over the course of eight summers (2011-2019 minus 2012), a snorkel survey for juvenile salmonids in Canton Creek (North Umpqua basin) was completed by students of the Phoenix Charter School in Roseburg OR under the supervision of Pacific Rivers. Thomas McGregor, director of work experience at the Phoenix Charter School, coordinated the student participation. During the current year, all of the snorkel divers were from Pacific Rivers: Andrew Dewberry, Emma Latendresse, Rhiana Pritchett, and Nick Chambers. No students from the Phoenix School were allowed to participate this year due to COVID-19. The survey included all of the mainstem Canton Creek to the fourth bridge, Pass Creek, East and West Pass Creek, Upper Canton Creek, and Mellow Moon Creek. These are all the areas of our standard survey.

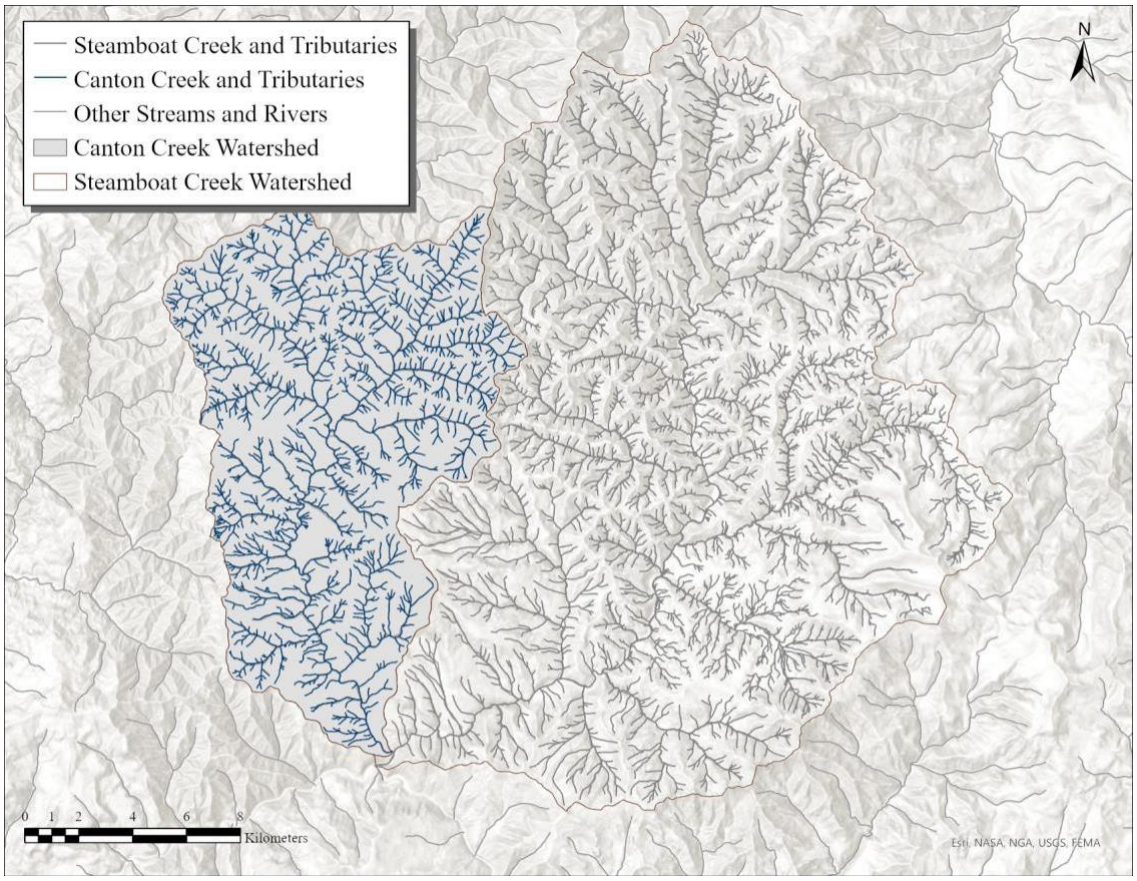

Fig. 1: Canton Creek and its tributaries, situated within the N. Umpqua basin.

Study Area

Canton Creek is a major tributary of Steamboat Creek in the North Umpqua River basin (Figure 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

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 were 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.

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.

Results and Discussion

Surveyed Reaches

During the nine 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.

In previous years, the mainstem of Canton Creek was primarily snorkeled by Charley and Andrew Dewberry. During this year the mainstem of Canton Creek was primarily snorkeled by Rhiana Pritchett and Nick Chambers.

Salmonid Population Estimates

The results of the nine years of snorkel surveys are summarized in Tables 1-5 and Figures 2-4. 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. During the current year an estimate of the coho salmon was made.

Reach	2011	2013	2014	2015	2016	2017	2018	2019	2020
Mainstem	32,968	15,430	7,433	23,180	11,537	20,768	13,780	3,902	29,755
Upper Canton	3,888	5,948	3,247	4,901	1,372	4,929	6,274	822	3,431
Pass Creek	3,138	9,523	5,089	5,491	4,784	6,279	6,652	1,911	4,689
RF Pass Creek		200	131	462	572	386	12	245	373
LF Pass Creek		165	216	716	498	410	458	116	291
Mellow Moon	135	233	165	529	207	582	165	306	346
Total	40,129	31,499	16,281	35,279	18,970	33,354	27,341	7,302	38,885

Table 1: Population estimate of Steelhead Age 0 in Canton Creek (2011,2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020).

Reach	2011	2013	2014	2015	2016	2017	2018	2019	2020
Mainstem	3,615	892	1,512	1,585	796	745	1,385	1,232	1,549
Upper Canton	1,059	644	444	685	134	357	945	194	53
Pass Creek	211	937	518	287	264	278	284	425	148
RF Pass Creek		6	0	4	118	0	0	186	81
LF Pass Creek		35	37	31	48	58	13	34	86
Mellow Moon	197	53	12	228	154	22	16	142	17
Total	5,082	2,567	2,523	2,820	1,514	1,460	2,643	2,213	1,934

Table 2: Population estimate of Steelhead Age 1 in Canton Creek (2011,2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020).

Reach	2011	2013	2014	2015	2016	2017	2018	2019	2020
Mainstem	673	113	432	301	96	188	728	546	844
Upper Canton	173	36	102	146	28	80	116	23	9
Pass Creek	29	124	84	25	26	8	13	148	0
RF Pass Creek		0	0	4	50	0	0	11	38
LF Pass Creek		0	0	0	5	5	4	0	11
Mellow Moon	69	58	6	10	63	0	0	5	0
Total	944	331	624	486	268	281	861	733	902

Table 3: Population estimate of Steelhead Age 2 in Canton Creek (2011,2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020).

Reach	2011	2013	2014	2015	2016	2017	2018	2019	2020
Mainstem	167	42	165	154	32	36	328	246	563
Upper Canton	31	35	6	0	0	11	14	48	62
Pass Creek	107	13	15	0	0	16	0	29	102
RF Pass Creek		0	0	0	20	0	0	28	8
LF Pass Creek		0	0	0	0	0	0	6	0
Mellow Moon		0	6	0	0	0	0	64	0
Total	305	90	192	154	52	63	342	421	735

Table 4: Population estimate of Cutthroat Trout in Canton Creek (2011,2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020).

	2013	2014	2015	2016	2017	2018	2019	2020
Age-0	31,499	16,281	35,279	18,970	33,354	27,341	7,302	38,885
Age-1	2,523	2,820	1,514	1,460	2,643	2,213	1,934	
Age2	486	268	281	861	733	902		

Table 5: Life History Analysis of Steelhead Trout in Canton Creek (2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020).

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 nine years of survey, between 16,000 - 40,000 age-0 steelhead were usually observed in the major surveyed reaches. During 2020, 38,885 age-0 steelhead were observed which is the second highest population estimate during the period of the surveys. This is significantly higher than the 7,302 steelhead observed during 2019, which is the lowest recorded to date. The 2011 survey estimate of 40,129 age-0 steelhead (the highest observed during the survey period) is low because only about 75% of Pass Creek was completed by the students. In 2014 and 2016, the estimate of age-0 steelhead wasonly about one-half of the usual number.

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 2019, the year with the lowest observed number of age-0 steelhead in the basin, only 3,902 or 53% of the age-0 steelhead were in the lower mainstem reach. During the current year there were 29,755 age-0 steelhead in the mainstem, the second highest observed during the period of survey. The number of age-0 steelhead observed in mainstem Canton Creek was 76% of the total observed in the basin. 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 1,911 and 9,523 fish during the nine years of survey (Table 1). The 2020 population estimate of age-0 steelhead in Pass Creek is 4,689 fish. That is slightly below average.

In Upper Canton Creek, the population estimates of age-0 steelhead in previous years were between 822 and 6,274 for the nine years of survey (Table 1). In 2020, there were 3,431 fish, which is about average for 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 2020 was 346, which is 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.

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 and 2019), only about 45-55% 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 2020. This year was the second highest number of age-0 steelhead observed in the basin during years of survey.

To summarize, the total number of age-0 steelhead observed in 2020 in the Canton Creek drainage was the second highest for the period of survey. The mainstem population estimate was 77% of the total which is the typical pattern we have observed in high production years.

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 during 2020 was 1,934 fish, which is below the average for the period of sampling; however, since last year the number of age-0 steelhead was by far the lowest we have observed during the period of survey, that suggests survival of this cohort was high (We will discuss this in greater detail in the life-history section.).

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. During the current year, there were 1,549 fish in the lower mainstem, an average year, which was 80% of the basin total. In 2011, a high population year, the main stem accounted for about 70% of the total age-1 steelhead in the basin; while in 2013, an average population year, the mainstem accounted for only 35% of the age-1 steelhead in the basin. 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. During 2020, only 148 age-1 steelhead were observed. This is the lowest number observed during the years of survey. The number of age-1 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 2020, the population estimate was 53 fish, which is significantly lower than the previous low count during the surveys.

The population estimates of age-1 steelhead in Mellow Moon Creek were between 12 and 200 fish. During 2020, 17 fish were observed which also is very low. We will discuss this in greater detail in the life-history section.

In summary, the abundance of age-1 steelhead in the basin as a whole averaged about 2,600 fish in the nine years of surveying. In 2020, there were 1,934 fish which is below average.

Age-2 Steelhead

The population estimates for age-2 steelhead were between 268 and 950 fish (Table 3). The largest number of fish was observed in 2011 while the lowest number of fish were observed in 2016 and 2017. During 2020, a total of 902 age-2 steelhead were estimated for the basin as a whole, the second 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 highest observed during the nine 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 zero.

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 in 2020 was the second highest recorded in the nine 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 (735) compared with the previous high (421). They were lowest in the 2016 survey (52). During 2020, for the second year in a row, 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 2020, we observed an estimate of 220 coho juveniles in the lower mainstem of Canton Creek. Almost all of the coho were observed in side 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.

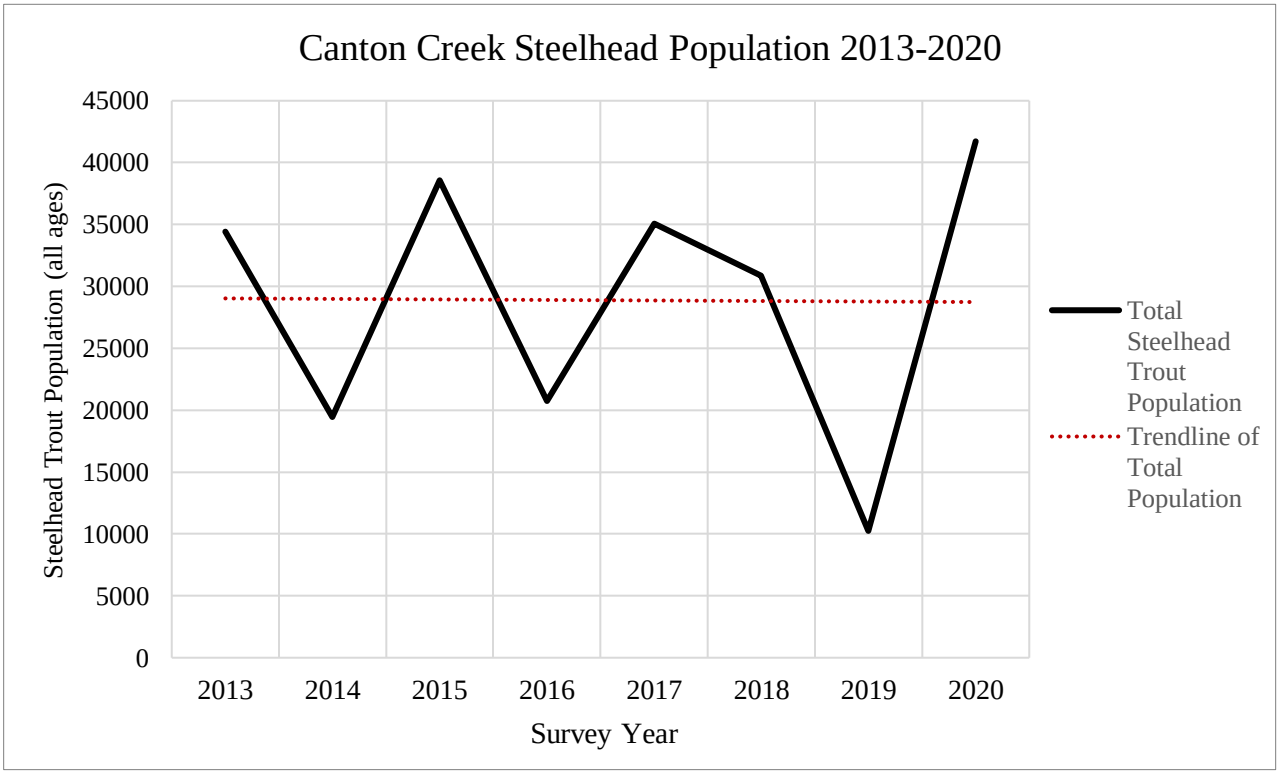

Figure 2: Findings of total Steelhead trout population (ages 0, 1, and 2) observed plotted over time. 2013-2019 Pacific Rivers.

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. 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, one year later there were 486 age-2 steelhead in the basin. During the seven years life-history 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 previously ranged from 4 percent to 17 percent. The highest previous 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 year, the survival of age-0 to age-1 steelhead was by far higher than any previous year (24%). The number of age-0 steelhead last year was the lowest we recorded. 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 number of age-1 steelhead was average last year, but the survival rate for 2020 was 41%, which is quite high. 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.

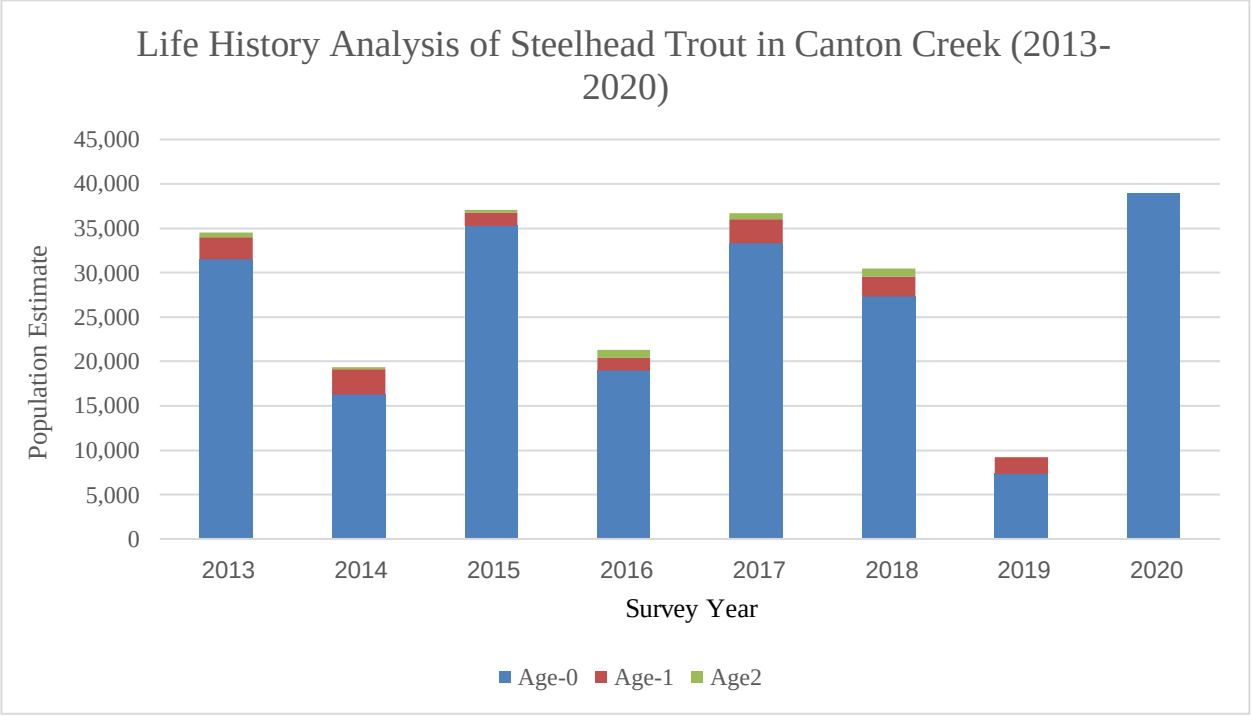

Figure 3: Population estimate of Steelhead Age 0 in Canton Creek (2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020).

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 and the eggs scoured out with 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 one of the years it occurred in May. Last year the peak flow occurred in April.

Last year's April storm was particularly large. The flows exceeded 19,000 cfs. The highest observed flow for the period of record (1956-present) was December 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 April storm was the fifteenth highest.

The annual hydrographs of the water years suggest 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 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 had 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 a small tributary stream 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 a significant reduction in 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, the peak flow occurred in late January and it was only about 9,000 cfs. As a result, one would expect survival rates of steelhead of all ages to be higher than normal. This was the case in 2020.

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 next 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% -- 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%, about average. In 2019, the survival rate was again 8%. This is a typical pattern for steelhead in the Pacific Northwest. From 2019 to 2020 the survival rate was 26%. This is substantially higher than any reported survival rates in our survey.

The number of age-0 fish highly fluctuates from year to year -- in this case from 7,300-40,000 fish (Table 1). However, the number of age-1 fish has been between 1,460-2,800 in eight survey years (Table 2). 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) had 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 2523 age-1 fish in 2014 and 486 age-2 fish in 2015. This is a survival rate of 19% (Table 5). From 2019 to 2020, the survival rate of age-1 to age-2 steelhead was the second highest survival rate (41%) observed during the period of surveys. 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. 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. 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 2019-2020 water year was a typical year timing wise, with the peak flow during the year occurring in late January. The peak flow was under 9,000 cfs. These conditions resulted in some of the highest numbers of age-0 steelhead during the period of surveys. Also, the survival rates of the existing steelhead in the basin were either the highest on record or the second highest.