Juvenile Coho Salmon Population Size and Rescue in Pond 1 on Towhee Creek, a Small Tributary of the Tsolum River, BC

By

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For the

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Introduction

Towhee Creek (also known as "Vanier Creek") is a small second order tributary that flows into the lowermost reach of the Tsolum River near Courtenay, BC. It is the type of small stream that juvenile coho salmon (*Oncorhynchus kisutch*) frequently overwinter in, either as juveniles that are the progeny of adult fish that spawn in Towhee Creek, or juveniles that migrate up into Towhee Creek from the Tsolum River in the fall. The problem with Towhee Creek is that the lower end of the stream currently goes subsurface for much of the year, trapping fish in Towhee Creek and preventing them from leaving in the spring.

There are at least six ponds on Towhee Creek that were excavated to increase the amount of fish habitat available for fish. Ranging from approximately 50 to 500 m^2 in area, these ponds may collectively harbour as many as 5,000 juvenile coho salmon during the winter. Unfortunately, with no access downstream to the Tsolum River, fish trapped in the ponds have perished in the past when water levels declined and water temperatures increased from April to May and dissolved oxygen levels fell to levels too low for coho salmon juveniles to survive in.

This report is a summary of a juvenile coho salmon rescue project that was undertaken in the isolated downstream-most pond (Pond 1) of Towhee Creek from March 20 to May 10, 2020. One day prior to the rescue operation commencing, a mark-recapture experiment was initiated where a number of coho salmon juveniles were marked and immediately returned to the pond. During the subsequent rescue operation the number of marked and unmarked coho salmon captured were recorded to estimate how many juvenile coho salmon were originally present in Pond 1, and by inference how many juvenile coho salmon were still left to be caught each day.

Lower Towhee Creek Pond 1

Towhee Creek was the focus of a stream rehabilitation project in 2005 (Minard 2004)[1]. There are currently six distinct pools and ponds in Towhee Creek, numbered 1 to 6 going upstream from the Tsolum River (Figure 1). On March 21, 2020, Pond 1 had a total wetted length of 80 m with an average

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[1] Minard, J. 2004. Fish Habitat Rehabilitation Plan for Towhee Creek. A submission to DFO and MOELP for approvals to proceed. Tsolum River Restoration Society report. 24 p.

wetted width of approximately 5 m, for a total wetted area of 400 m^2 (Figure 2). There was a dry channel 120 m long between Pond 1 and Pond 2 upstream, and a dry channel 110 m long between Pond 1 and the mouth of Towhee Creek at the Tsolum River. Water levels fluctuated in Pond 1 in response to several rain events, but never close enough to change the wetted length of the pond appreciably, or its connectivity upstream to Pond 2 or downstream to the Tsolum River.

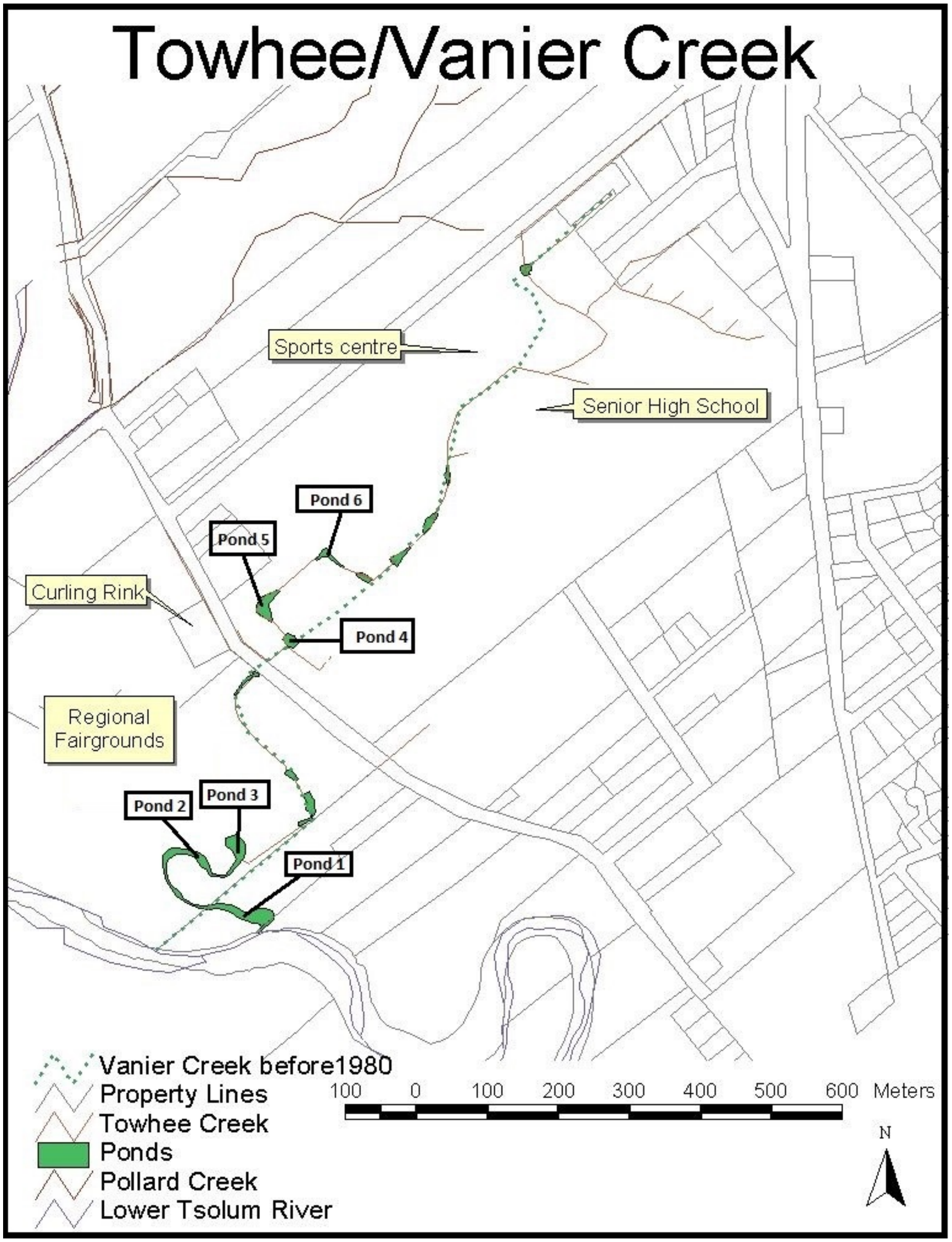

Figure 1. Towhee Creek showing the location of Pond 1 (approximate).

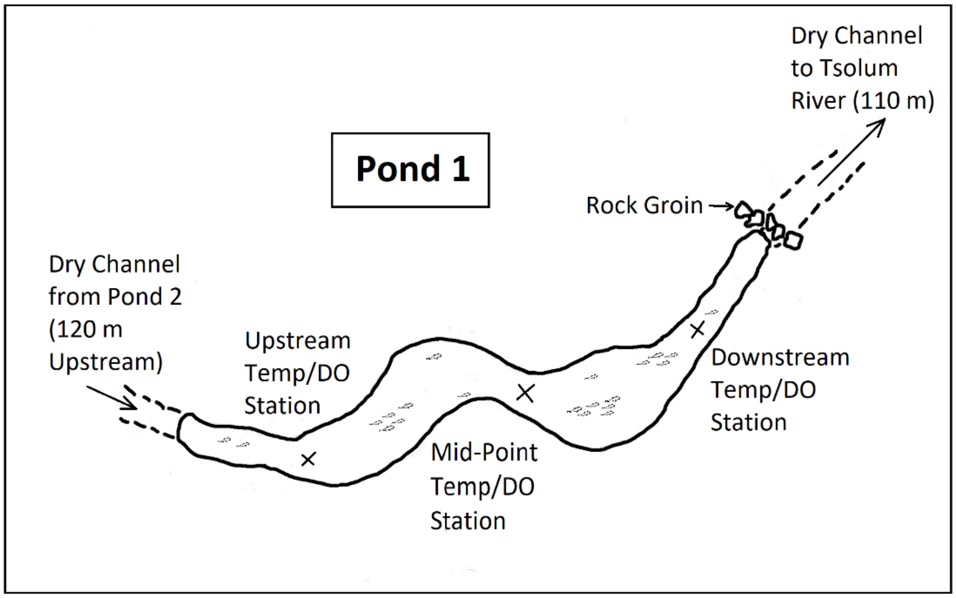

Figure 2. Sketch of Pond 1 showing the dry channels above and below the pond, plus the location of routine water temperature and dissolved oxygen measurements. A rock groin marked the downstream end of Pond 1.

Pond 1 has a deep, organic substrate composed mainly of fine silts and decomposing vegetation, with an abundance of floating and sunken small and large woody debris throughout. During the study period water depth averaged roughly 0.8 m, ranging from 0.3 to 1.5 m. The banks are steeply angled to vertical, approximately 1 m high, and thickly vegetated with trees, shrubs and sedges (Figures 3 and 4).

Figure 3. Pond 1 looking downstream from the upstream end.
Flagging marks the location of G-minnow traps.

Figure 4. Pond 1 looking upstream from the downstream end.

Methods

Water Quality

Water temperatures (C) and dissolved oxygen levels (mg/L, % saturation) were monitored at various sites and times in Pond 1 with an OxyGuard Handy Polaris portable DO meter (Point Four Systems Inc., Coquitlam, BC). This helped determine not only the need for salvaging coho salmon in Pond 1, but also which areas in Pond 1 were likely to be avoided by juvenile coho, and which areas would be preferred. Chronic and acute incipient lethal DO levels for salmonids are widely considered to be 4.0 mg/L and 2.0 mg/L, respectively.

Fish Rescue

All fish in Pond 1 were captured with a combination of 1/8" and 1/4" galvanized steel mesh Gee-Minnow traps (Cuba Manufacturing Ltd, NY, Figure 5). Comparison of catches between the traps did not indicate any mesh size was better at catching juvenile coho. Each trap was baited with approximately 4-8 ml of pickled salmon roe that was wrapped in a small plastic baggy and placed inside the trap. Just before closing and setting each trap, the bag of roe was snagged a few times on the wire mesh at the inside end of the trap funnel (Figure 6) to expose the roe to the water and spread its scent.

Figure 5. The Gee-Minnow Trap, Cuba Manufacturing Inc.

Figure 6. Small plastic bags containing bait (salmon roe) were placed in each trap, snagging the bags on the wire mesh to expose the roe to the water and spread its scent.

Traps were usually set in late morning at depths of 0.3 to 1.0 m and retrieved the next morning after soaking overnight for 20-24 hours. Traps were placed around the pond and tied off to a branch or stick on the edge of the pond. Initially traps were located to cover as much of the pond area as possible. As time went by, site location became more strategic when it became clear that fish were avoiding areas with the lowest (<2.0 mg/L) dissolved oxygen levels.

All juvenile coho salmon captured on the first day were counted and measured to the nearest mm fork length. They were then marked with an adipose fin clip (Figure 7) and released back into the pond, scattering them around the pond in random fashion. On every fish trapping day after that, all captured fish were individually counted and examined for an adipose fin clip, recording how many fish were marked (Figure 8) and how many fish were unmarked (Figure 9).

Figure 7. Clipping the adipose fin on a juvenile coho for mark-recapture estimates.

Figure 8. A marked (adipose fin clip) juvenile coho salmon in Pond 1.

Figure 9. An unmarked (no adipose clip) juvenile coho salmon in Pond 1.

When retrieving each trap, fish in the traps were held in the water as long as possible before they were quickly tipped into a bucket of aerated water for later processing. This was invariably a two-person job, with one person retrieving and opening the traps, and the second person carefully carrying the bucket of fish from trap to trap. When all traps were checked, all captured fish were taken to a central staging area and placed in a larger aerated tub for processing (Figure 10). This involved lifting or dip netting each fish into a clear plastic viewer so that it could be measured to the nearest mm fork length, or examined for fin clips. For this project, water used to hold fish in the buckets when the traps were checked and in the tub(s) when fish were counted and checked for marks was typically a 50:50 mixture of water from Pond 1 and the Tsolum River.

Figure 10. Checking and counting the number of marked and unmarked coho juveniles captured in the G Minnow traps.

The number of marked and unmarked coho salmon juveniles captured during each trapping session were recorded separately. The number of fish that were present the first day was then estimated with the following simple formula:

$$N = (M+1)(C+1)/(R+1), \text{ where}$$

N is the size of the population;
M is the number of fish marked;
C is the number of fish caught and checked for marks;
R is the number of fish caught that were marked (i.e. “Recaptures”).

Each additional day of trapping provided increasingly more accurate information on how many juvenile coho salmon were originally present in the Pond when the project started. Because Pond 1 was a closed system with no fish immigration or emigration, the data also provided an estimate of how many fish were left to be caught after each day, assuming there was no mortality.

Results

Water Quality

Water quality was poor throughout the rescue, but especially so from April 20 to May 12 when temperatures increased to 10-14 C and dissolved oxygen levels fell to 0.6-2.3 mg/L. Water temperature during the project ranged from 3.7 – 14.0 C while the dissolved oxygen concentration and % saturation level ranged from 0.6 – 5.4 mg/L and 5.2 – 43.4%, respectively (Table 1). There was a distinct oxygen gradient in Pond 1 with the lowest values (0.6-4.5 mg/L) typically at the upstream end and the highest (1.2-5.4 mg/L) at the downstream end. In the deeper areas of Pond 1, values were also lower compared to surface values, though not as distinctly so as the longitudinal gradient between sites.

Fish Rescue and Catches per Trap

The highest catches for coho salmon juveniles per trap (Figure 11) was on Day 2 of the rescue project when an average of 13.5 coho/trap were captured with 12 traps. The second highest catch per trap was on Day 1 when 11.7 coho per trap were captured for the initial adipose fin clipping. One of the lowest catches per trap was on April 1 when only 2.1 coho/trap were captured with 30 traps. However, the second highest catch/trap (7.4) was just the day before on March 31 when 30 traps were also used. This resulted in the single largest catch in one day, a total of 221 coho juveniles, 14 of which were marked.

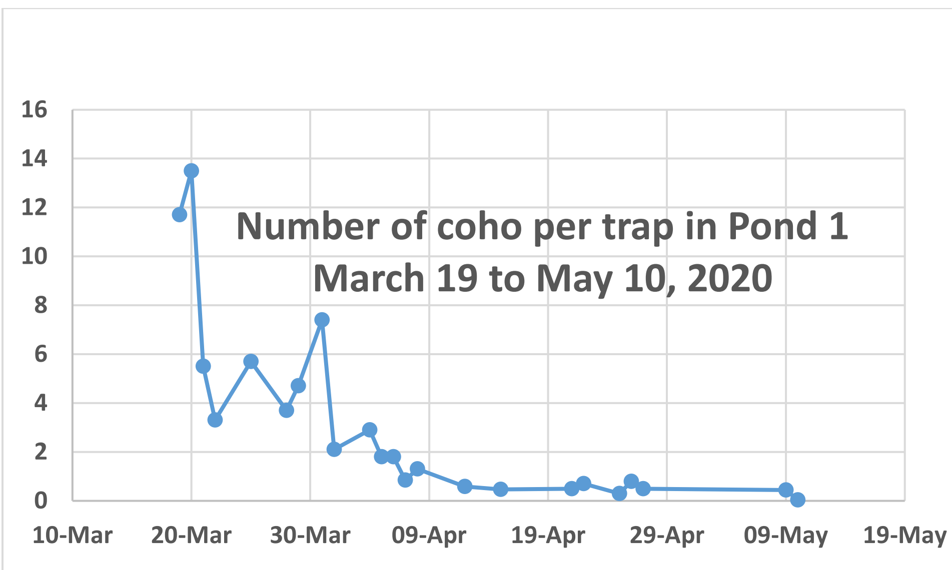

Figure 11. Number of juvenile coho salmon per G-trap set in Pond 1, March 19 to May 10, 2020.

The number of coho juveniles captured per trap each trapping day declined from a high of 13.5 to 1.0 in the first 17 days, and then typically remained at <1 coho per trap for the next 34 days. By April 6, 86% of all the coho eventually captured had been caught. The remaining 14% were captured over the following 34 days.

On the last day of the rescue operation (May 10), only one coho juvenile was captured in 25 traps. Because so few fish were being caught at this time, and those that were had often suffocated in the trap, the rescue operation was terminated. In view of the low DO levels at this time, fish that the mark-recapture data indicated were still present in Pond 1were deemed either uncatchable or dead.

Table 1. Water temperature and dissolved oxygen levels in Pond 1, March 19 to May 12, 2020.

Date	Site No.	Water Temp (C)	DO (mg/L)	% Saturation
March 19, 2020	Mid-point	5.0	2.8	21.7
March 20, 2020	u/s end	4.4	1.6	12.4
"	Mid-point	4.4	2.3	17.7
"	d/s end	4.5	3.3	25.3
March 24, 2020	Mid-point	6.8	3.5	28.9
"	d/s end	7.0	3.9	33.6
March 25, 2020	u/s end	3.7	4.5	34.7
"	Mid-point	4.1	4.1	31.6
"	d/s end	4.1	5.4	41.5
March 27, 2020	u/s end	6.9	1.7	14.2
"	Mid-point	6.5	2.8	22.5
"	d/s end	7.2	5.2	43.4
March 29, 2020	Mid-point	7.5	1.5	12.9
"	d/s end	9.4	4.6	41.0
April 3, 2020	u/s end	6.3	3.2	26.1
"	Mid-point	6.6	3.4	27.5
"	d/s end	7.1	4.1	34.0
April 5, 2020	u/s end	5.5	3.3	26.8
"	Mid-point	5.7	3.4	26.9
"	d/s end	6.2	3.6	29.3
April 15, 2020	u/s end	9.3	1.1	9.7
'	d/s end	8.9	2.4	20.5
April 20, 2020	Mid-point	11.7	1.1	10.4
'	d/s end	11.1	2.3	20.4
May 4, 2020	u/s end	8.1	1.9	16.0
'	d/s end	8.8	1.2	10.9
May 10, 2020	Mid-point	10.4	1.4	12.6
May 12, 2020	u/s end	10.1	0.6	5.2
'	d/s end	14.0	1.2	10.9

Juvenile Coho Population Size

Mark-recapture data for each trapping session are summarized in Table 2, while the population estimates generated based on the ratio of marked to unmarked fish captured each session are shown in both Table 2 and Figure 12. The initial estimates for coho juveniles in Pond 1 were high, ranging from 1,490 to 1,650 fish over the first few days. Thereafter, numbers dropped to between 1,140 and 1,340 fish over the next 48 days. The most consistent mark-recapture estimates of the number of coho salmon juveniles originally present in Pond 1 on March 19 were the last four estimates April 26-May 10. These data indicate that the initial total number of juvenile coho salmon present in Pond 1 on March 19 was most likely 1,275 to 1,300 fish. Of these, 1,131 fish were rescued, which represents approximately 88% of all the fish originally present. The combined estimate for "uncatchable fish" and natural mortality in Pond 1 was by inference 12% of the initial population.

Table 2. Number of marked/unmarked juvenile coho salmon captured in Pond 1 and estimated initial population size, March 20 to May 10, 2020.

Date	No. traps used	Daily catch	Cumulative catch	No. marks available to catch	No. marks recaptured	Cumulative No. marks recaptured	Catch per trap	Estimated No. coho originally in pond	No. left to catch
March 19	6	70	0	70	0	0	11.7	-	-
March 20	12	162	162	70	6	6	13.5	1,653	1,491
March 21	20	110	272	64	6	12	5.5	1,491	1,219
March 22	20	67	339	58	2	14	3.3	1,609	1,270
March 25	12	68	407	56	7	21	5.7	1,317	910
March 28	20	75	482	49	8	29	3.7	1,143	661
March 29	20	94	576	41	3	32	4.7	1,241	665
March 31	30	221	797	38	14	46	7.4	1,205	408
April 1	30	62	859	24	3	49	2.1	1,221	362
April 4	22	63	922	21	3	52	2.9	1,236	314
April 5	24	47	969	18	2	54	1.9	1,252	283
April 6	26	47	1,016	16	1	55	1.8	1,289	273
April 7	26	22	1,038	15	1	56	0.8	1,294	256
April 8	26	34	1,072	14	1	57	1.3	1,314	242
April 12	12	7	1,079	13	0	57	0.6	1,322	243
April 15	28	13	1,092	13	1	58	0.5	1,315	223
April 21	10	5	1,097	12	0	58	0.5	1,321	224
April 22	10	7	1,104	12	0	58	0.7	1,330	226
April 25	10	3	1,107	12	0	58	0.3	1,333	226
April 26	10	8	1,115	12	2	60	0.8	1,299	184
April 27	8	4	1,119	10	1	61	0.5	1,283	164
May 9	25	11	1,130	9	1	62	0.4	1,275	145
May 10	25	1	1,131	8	0	62	0.0	1,276	145

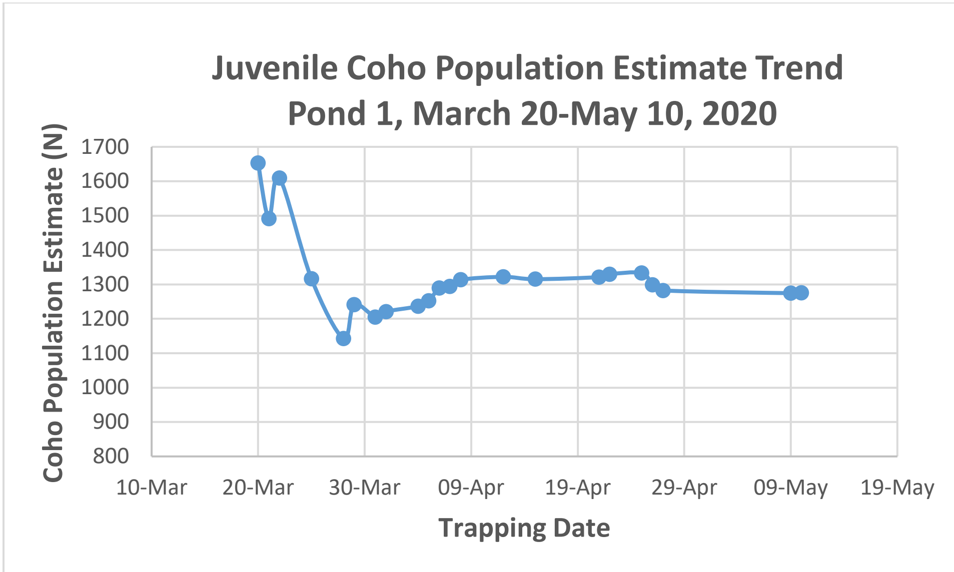

Figure 12. Sequential mark-recapture population estimates for juvenile coho salmon in Pond 1, March 20 to May 10, 2020.

After marking and releasing 70 adipose clipped coho juveniles back into Pond 1 on March 19, a total of 1,131 coho juveniles were eventually captured from March 20 to May 10. Of these 1,113 were transferred to the Tsolum River and released. This included 62 of the original 70 coho juveniles that were marked with an adipose fin clip, indicating that most (89%) of the juvenile coho originally present in Pond 1 had been captured. The eight marked fish not recaptured represent the proportion of fish (11%) in the Pond 1 that were either "uncatchable" or mortalities.

Coho Length Frequency Distribution and Age Composition

Juvenile coho salmon in Pond 1 ranged from 57 to 115 mm in fork length. The magnitude of the size range (58 mm) and the polymodal nature of the distribution (Figure 13) suggested that these fish might be composed of more than one broadly overlapping age class. However, examination of a limited sample (n=18) of scales and otoliths from fish that had suffocated in the traps on March 31 indicates that most of the fish were one year old fish that had spent only one summer and one winter in freshwater.

Fourteen coho ranging from 65-101 mm in fork length showed only one distinct annulus, either a clear band on the otoliths or a region of dense circuli on the scales, followed by a region of rapid growth which we interpreted as growth in the late winter/spring of 2020. Four fish 101-115 mm fork length showed two annuli. Coho salmon juveniles 57 to 100 mm in fork length represented 95% of the fish sampled for fork length measurements in March. Average fork length of coho salmon juveniles sampled on March 19 was 82.1 ± 11.0 mm (1SD, n=70). Average fork length of coho juveniles sampled May 9 was 98.4 ± 12.7 mm (1SD, n=11). None of the captured coho were weighed, but all appeared to be in good condition with a healthy weight.

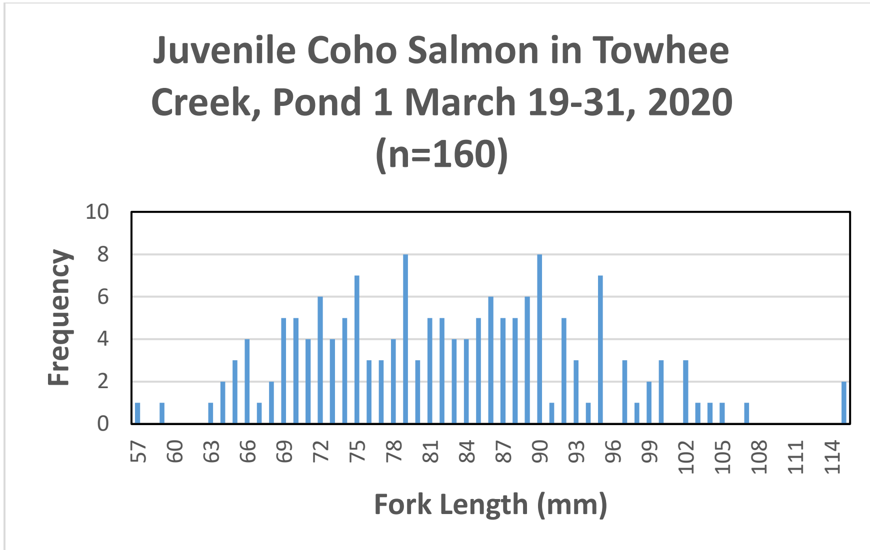

Figure 13. Fork length frequency distribution of juvenile coho salmon in Pond 1, March 19-30, 2020.

Other Species

Immature and mature three spine sticklebacks (*Gasterosteus aculeatus*) were as abundant in Pond 1 as juvenile coho salmon. Together with coho salmon these two fish species represented virtually all the fish present in Pond 1. One prickly sculpin (*Cottus asper*) one chinook salmon juvenile (*Oncorhynchus tshawwytscha*) and one larval western brook lamprey (*Lampetra richardsoni*) were three other fish species captured. Non-fish species captured included less than 10 American bullfrog (*Lithobates catesbeianus*) larvae in total, and typically 2-6 terrestrial adult Northwestern salamanders (*Ambystoma gracile*) in each trapping session. Northwestern salamander paedomorphic adults (adults with legs and gills) were also captured, along with a few rough skinned newts (*Taricha granulosa*). One adult red-legged frog (*Rana aurora*) was observed.

Discussion and Recommendations

Coho juveniles in Towhee Creek could be the progeny of adults that spawn in Towhee Creek, adults that spawn elsewhere but whose young migrate into Towhee Creek, or some combination of the two. Since no coho fry were captured in G-traps set at four sites this year on May 18 upstream of Headquarters Road, it appears that no coho spawned in Towhee Creek last year. While past records indicate sometimes substantial numbers of adult coho spawning in Towhee Creek (up to 20 pairs, D. Swift, DFO, pers.com.), regular foot surveys and trapping in lower and upper Towhee and Towhee Tributary is recommended over the next two years to substantiate the presence/absence of coho spawning or coho fry in Towhee Creek. Regular trapping in all the ponds over the next fall and winter periods is also recommended to determine when coho juveniles move into the ponds.

The ponds that were constructed in 2005 on Towhee Creek presently appear to be “fish traps”, where juvenile coho are unable to swim down to the Tsolum River in spring as they develop into smolts and try to migrate to sea. It is not known if this is the case every year, or if it only occurs in some years. It is also not known how much both immigration into Towhee or emigration out of Towhee Creek depends on flows in Towhee Creek, and how much is determined by water levels in the Tsolum River. It is likely that local rainfall in the Towhee Creek basin and rainfall plus snowmelt in the upper Tsolum River both need to be adequate to ensure a successful outmigration; however, the relative importance of the two factors is unknown. This should be assessed before steps to mitigate fish being stranded in Towhee Creek are undertaken. Water levels in Pond 1 fluctuated in tandem with water levels in the Tsolum River, indicating good underground connectivity, and understanding this dynamic is important for future pond renovations.

There are no flow data for Towhee Creek, however rainfall may be a useful proxy for flows inasmuch as all of Towhee Creek lies within an area where virtually all precipitation is rainfall. Monthly rainfall records for March, April and May over the past 23 years suggest that both March and April in 2020 were considerably drier than normal, while May was close to normal. In 2018 and 2019, March and May were both drier than normal while April was close to normal. In this report "drier" means the monthly rainfall was lower than the first quartile values shown in Table 3, while "normal" was a value between the first and third quartile values. Figure 14 shows the range and median values for March, April and May rainfall near Towhee Creek for the period 1998-2020 (rainfall data from Environment Canada Station Courtenay Puntledge). Similar data for the 1981-2000 period indicates that rainfall then in March was effectively the same (132 mm) as the last 20 years, wetter in April (91 mm) and slightly wetter in May (53 mm).

Table 3. Monthly rainfall statistics for March, April and May near Towhee Creek, 1998-2020.

Statistic	March (47.0 mm in 2020)	April (26.6 mm in 2020)	May (48.2 mm in 2020)
Mean (1998-2020)	130.29	72.413	45.283
N	22	23	23
SD	77.741	56.071	26.956
Minimum	2.8000	21.400	0.0000
1st Quartile	83.600	27.500	26.000
Median	113.50	47.800	42.600
3rd Quartile	173.78	109.60	55.800

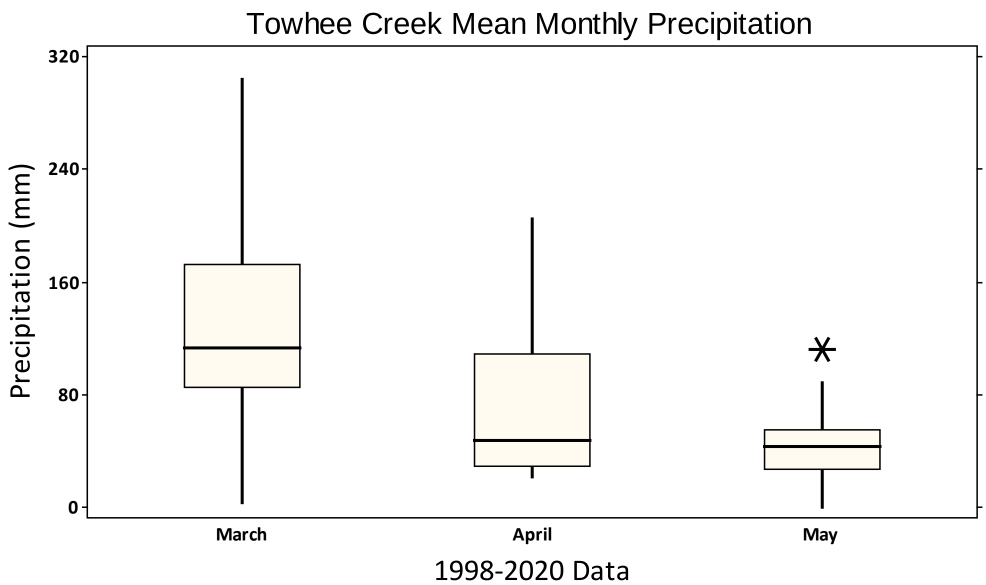

Figure 14. Box and whisker plots for 1998-2020 monthly rainfall data near Towhee Creek. The box encloses the middle half of the data, bounded by the lower and upper quartiles. The box is bisected by a line at the value for the median. The vertical lines at the top and bottom of the box indicate the range of “typical” data values. The star is a possible outlier value.

We are not aware of any “as-builts” for the rehabilitation work undertaken on Towhee Creek in 2005, nor any post-construction assessments of their effectiveness. During the course of our rescue efforts in Pond 1, we observed only a small portion of all the work that was planned. However, we felt some of the structures were of questionable value, and so we therefore recommend an assessment of all the work undertaken, to see what work was completed, and which structures appear to be functioning as planned and which are not. The main goal would be to improve access out of Towhee Creek by juvenile coho salmon without the need of annual rescue operations.

Constructed ponds like Pond 1 are common on many properties in the Tsolum River watershed. It is unlikely that all these ponds attract and trap coho salmon juveniles like the ponds on Towhee Creek, but this should be assessed. If a portion of such ponds do trap fish then the potential reduction in returns or the lost opportunities for enhanced returns could be significant. It is therefore worthwhile to count the number of constructed ponds/dug outs and their physical characteristics in the Tsolum watershed, determine how many are used by coho for overwintering, how many may be trapping coho, and what the potential gains/losses may be to the coho stocks generally in the watershed. Inasmuch as the growth and condition of coho attracted to and trapped in constructed ponds could also be quite variable, it may also be worthwhile to assess the relative survival of the coho smolts produced in different ponds, including natural wetlands and other off-channel areas besides constructed ponds.

As indicated, the number of coho juveniles trapped in ponds like Pond 1 on Towhee Creek can be substantial. With a wetted area of 400m^2, the number of coho juveniles in Pond 1 on March 19 averaged 3.2 fish/m^2, almost all of which were of good size and condition. More detailed assessments of smolt production in Towhee Creek and 4-5 other ephemeral streams with natural and constructed wetland/pond habitats are warranted. Combined with a PIT tagging program and similar studies of fish that overwinter in the mainstem streams, the data would provide valuable information on differences in coho salmon smolt survival rates to the ocean, ocean survivals, contributions to the ocean fisheries, and returns to the Tsolum River.

With enough traps and trapping every other day, results of the G-trapping mark-recapture data indicate that over 85% of juvenile coho trapped in a pond like Pond 1 on Towhee Creek can be safely rescued and relocated. The data also indicate that it could take over twice the effort to catch the remaining 15% of the fish. If significant rescue operations are to continue in Towhee Creek, and the Tsolum watershed generally, we recommend always including a mark-recapture component so that the number of fish remaining can be assessed based on the mark-recapture data. To reduce the amount of time needed to rescue fish, other capture methods such as fine mesh seines or other types of fish traps (e.g. large "Clover-leaf" type traps) should also be used or tested. In addition to increasing the number of fish that can be captured in a limited period of time, the use of other capture methods helps to remove the bias associated with single sample methods when doing mark-recapture estimates.

Acknowledgements

A sincere thanks to Kerri Brownie, and Vitya and Bella Hermanek. They regularly and diligently helped us rescue the coho salmon juveniles trapped in Pond 1 and take them to the Tsolum River where they could continue their journey in life, wherever that may take them.

Kerri Brownie

Bella and Vitya Hermanek