POST PROJECT APPRAISAL FOR STONEY CREEK OFF-CHANNEL HABITAT POND:

HYDROLOGICAL SUITABILITY FOR JUVENILE SALMONIDS

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Stoney creek off-channel habitat pond, "Area A"

Abstract

Habitat restoration is an important process in protecting the iconic salmon in British Columbia. Specific criteria must be met in order to provide a successful salmon habitat. Water quality within the off-channel pond at Stoney Creek was analyzed with data collected from six essential parameters: turbidity, velocity, depth, as well as copper, nitrogen and iron. These were tested over two days under different weather conditions. Turbidity, velocity, iron and nitrates presented preferable conditions while depth could potentially be improved for the salmon's wellbeing. Copper testing was determined to be inconclusive. We conclude that the Stoney Creek off-channel pond is an appropriate water habitat for juvenile salmonids to rest and develop. Possible future management strategies include increasing the overall depth, continued monitoring by the Stoney Creek Environment Committee, future copper testing with more sensitive equipment after a first flush event, and an increase in public outreach and education.

Introduction

Salmon have inhabited the west coast of North America for thousands of years, and have become of major significance to First Nations communities as well as a culturally iconic species in the Pacific Northwest. A keystone species, salmon play an important biological role in the functioning of coastal ecosystems (Garabaldi and Turner 2004). Additionally, the fish have historically been a large part of BC's economy, with stocks reaching their peak between the years of 1882 and 1913 (Lichatowich et al. 1999). The decline that has since occurred is largely attributed to habitat loss due to anthropological activities such as urban development of riparian areas, aquaculture, dam construction, pollution, and flood control (Meehan 1991). Thus, projects to restore the freshwater spawning and rearing habitat have been established.

In 2012, the Stoney Creek Environment Committee completed a project which aimed to improve accessibility for salmon returning to spawn, provide spawning habitat and improve off-channel over wintering habitat for juveniles. Our assessment of the project focuses on the success of this last objective as we examine the suitability of the hydrological conditions of the overwintering pool. Post-project monitoring tests conducted by the Committee include measurements of turbidity, dissolved oxygen, total dissolved solids, pH, water temperature, colour, and water hardness (James, 2013). They do not, however, test for velocity, nitrates, copper or iron. We therefore decided to evaluate the habitat suitability through these parameters. Additionally we decided to evaluate depth and turbidity because our research indicated they are important water quality factors in juvenile salmonid habitat selection.

Methods:

Data was collected on two separate days – field day 1 was a sunny day without precipitation, and field day 2 was an overcast day with light precipitation. This was to capture the varying conditions often present in the area at this time of year. In order to accurately represent conditions, measurements were taken at three different areas within the off-channel pool designated as areas A, B, and C (Figure 1).

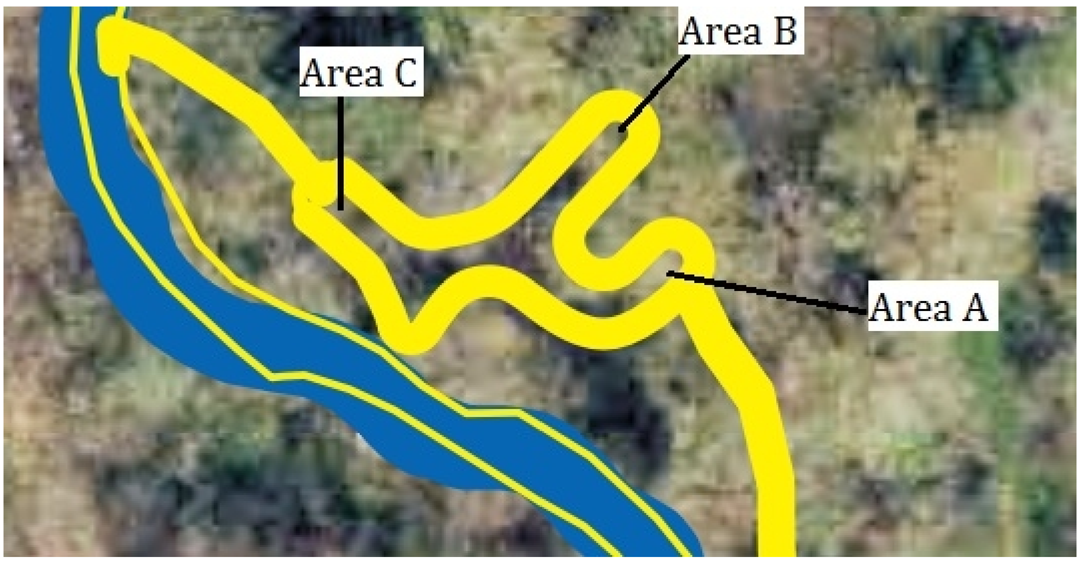

Figure 1. Area designation of off-channel pond

While we describe the important methods used for our testing, we do not discuss in detail the procedure of each test. For detailed procedures, see Appendix B for a list of websites and other informational resources.

Turbidity

Turbidity is the amount of sediment suspended in water. The most precise method of measurement requires a nephelometer, which measures the amount of light scattered by suspended particles and gives results in turbidity units (Effler, 1988). As this equipment was unavailable to us, we used the method of measurement outlined in The Streamkeeper's Handbook: A Practical Guide to Stream and Wetland Care by Fisheries and Oceans Canada. A standard self-retracting, metal measuring tape was used with a piece of bright coloured tape marking the end. The depth at which the brightly coloured tip could no longer be seen was recorded as the turbidity depth. If the tape measure was clearly visible at the stream bed, then the turbidity was recorded as being greater than the depth of the pool (as per the The Streamkeeper's Handbook).

Velocity and Depth

Measurements of velocity were taken using a Global Flow probe, a propeller-type current meter. Depth was measured from the shore using a retractable metal measuring tape and the velocity meter which had cm increments on its side. In order to measure depth in areas of the pool inaccessible by wading, a fishing rod with a weighted end was immersed into the water until the bottom of the pond was reached. Markings were made on the fishing line at 1 ft increments, allowing rough depth estimations. The average of several measurements within each area was then calculated. It is important to note that although we strived to take measurements in the same locations within areas on both days, there is some difference in precise location.

Copper, Iron and Nitrates

The chemical tests for these parameters relied upon treating a water sample and then comparing the resulting solution colour to a standardized chart or vial. When the colour that appeared was in between two chart colour blocks, we recorded the value as halfway in between.

Copper measurements were taken using Sensafe Copper Check II test strips. The length of time the strip was immersed in water was related to water temperature. However, on field day 1 we did not have access to a thermometer, water temperature was therefore estimated to be 10°C and immersion time was based on this estimate. On the second field day, we had access to a digital thermometer and immersion times were therefore more precise.

Samples of nitrogen were tested using a Lamotte test kit, while iron was detected with Aquacheck test strips.

Results and Discussion:

Refer to appendix A for complete results.

Turbidity

On sampling day 1, the turbidity was found to be greater than 1.65m within area A, greater than 0.61m in area B and greater than 0.41m in area C (Table 1). (Recall that when the water was clear of suspended sediment, it was recorded as greater than the depth at that point). On the second sampling day, the recorded turbidity levels were 0.91m, 0.30m and greater than 0.41m in areas A,B and C respectively. This slight increase in turbidity is likely due to recent rainfall, which potentially increased turbidity by stirring up sediments along the stream bed, carrying in sediment from urban runoff, and increasing bank erosion (Lawler et al., 2006). Furthermore, we can attribute this turbidity increase to the rainfall event as the pond had very still water, and therefore wouldn't be capable of stirring up sediment in it's natural flow, as a stream would.

When found above a certain threshold, the amount of turbidity can be just as detrimental to juvenile salmon growth as chemical pollutants. A study by Crouse et al (1981) stated that juveniles in the presence of excess amounts of suspended fine sediment will have limited growth. The level of turbidity in over wintering pools is of specific concern because juvenile salmon may spend quite a bit of time resting and growing within the habitat pond. As the turbidity levels in the Stoney Creek off-channel pool were minimal, it is unlikely that they could negatively impact salmon growth. The habitat is therefore acceptable in this parameter.

Velocity and Depth

The velocity obtained for all areas of the pool was precisely 0.0m/s (Table 1), even in the presence of light precipitation and after a rainfall event. Slow-moving waters provide grounds for juvenile rearing and refuge from high flows during runoff periods. Bisson et al. (1988) found that juvenile salmonoids preferentially occupy aquatic areas with velocities less than 20cm/s. Therefore, our results indicate that the pool area is suitable for salmonoid habitat selection. In particular, the limited velocity of the pool area will benefit coho salmon, which are particularly selective of habitat (especially at age 0+), followed by cutthroat trout and then steelhead (Bisson, 1988).

The average depth for areas A, B, and C were found to be 1.32m, 0.61m and 0.41m, respectively (Table 1). Kruzic et al. (2000) concluded that depth is the most important habitat characteristic for juvenile salmon, with highest survival rates occurring in the deepest habitats (>0.8m). Deep habitats reduce the risk of exposure to predators and offer increased maneuverability, as Kruzic noted, the physiological traits of salmon (large median fins and laterally-condensed bodies) are poorly adapted to shallow riffle areas. Given this evidence, we conclude that the depth in area A is well-suited to juvenile salmon, as it is greater than 0.8m. Areas B and C were found to have depths that fall below the optimal threshold, however, the extent to which this would affect juvenile survival rates is unknown, as the average depth of the three pool areas is very close to optimal, at 0.78m. We therefore conclude that the depth of the pool is, on average, sufficiently deep, but the deepening of individual areas within the pool could be considered with more information.

Copper

Sandahl et al. (2007) found that concentrations as low as 2 µg/L (roughly 2 parts per billion) of dissolved copper begins to significantly impair juvenile coho's olfactory sense. This in turn negatively affects the salmon's ability to avoid predators and to find food. As copper concentration increases, cell death can occur and rapid mortality follows (Linbo et al, 2006).

We had a positive 0.5 ppm copper result for one test, and several tests that were potentially higher than 0.1 ppm, which exceed the lower bound concentrations found by Sandahl et al. While these results may seem alarming, interpretations should be made with caution. The reliability of these measurements is uncertain, and several assumptions were made in order to compare our results to guidelines and others work. Additional opportunities for erroneous results of this test were significant, as discussed in *limitations.*

Maximum total copper for aquatic life, as recommended by the government of BC, is a function of water hardness. If the water hardness levels are very high (over 500 mg/L) then the maximum copper concentration as set by the BC guidelines for aquatic life is 0.05 ppm, detectable by our methods (Government of BC, 1997). However, if water hardness is low, (less than 100 mg/L) then copper toxicity is measured in parts per billion (micrograms/L), much lower than our tests can read. We did not have the tools to read water hardness, but tests in 2004 by the Stoney Creek Environment Committee found the water hardness in a Stoney Creek tributary to be 133 mg/L (Soukhatchev, 2005). If the water hardness in the off-channel creek was of a similar level, then our copper concentrations results are of concern. However, due to the insufficient and unreliable data, we conclude that the evidence for toxic copper levels is insufficient, and more testing is necessary.

Nitrates

The tests conducted showed no sign of nitrates, as we obtained results of 0 ppm. This does not mean there are no nitrates in the water, it simply means our testing methods are not sensitive enough to detect trace amounts. Nitrogen in the form of nitrate is vital for plant growth and reproduction and should be at least 3.0mg/L on average for plant growth (Nordon et al. 2009).

Conversely, large amounts of dissolved nitrate could lead to water quality problems that affect salmon (EPA, 2012). If an excess amount of nitrate were present in a stream, eutrophication may occur. This is when excess nutrients promote algae growth, which may eventually lead to hypoxic levels of dissolved oxygen and salmon suffocation. High levels of nitrate can also compromise the immune system of salmon and should be kept under 32.8mg/L to protect aquatic life (Nordon et al. 2009). In the Stoney Creek area, potential sources of nitrates are fertilized lawns and gardens located upstream. As there were no nitrates detected in the pond, we conclude that the habitat is acceptable in this parameter.

Iron

The Ambient Aquatic Life Guidelines for Iron give a short term maximum concentration of dissolved iron as 0.35 mg/L (Government of BC, 1998). Our results find that the dissolved iron concentrations were within the range for the short term guidelines. When comparing the two field days, day 1 had iron concentrations that were higher than that of day 2. This could be due to the influx of rain water, causing a dilution of the dissolved iron in the pond. The dissolved iron in the pond could originate from natural sources such as iron-enriched rocks that are unearthed via erosion of the bedrock (Vuori, 1995).

Although there is a natural amount of iron found in streams, excessive concentrations can be toxic to fish species related to salmon. Experiments by Peuranen et al (1994) found that increased iron concentrations lead to an increased mortality rate of one-summer-old brown trout (*Salmo trutta*). They suggest that accumulated iron on the gills of the trout fuse together and leads to a decrease in oxygen uptake by the fish. As trout and coho salmon are closely related, the effect would likely be the same. Iron may also precipitate as ferric hydroxide ($Fe(OH)_3$) in the form of a brown slime that could cling onto the gills of the fish (Phippen et al. 2008).

A note on limitations and uncertainty

There are several limitations that we noted during the data collection. For example, we were only able to gather most data from within arm's reach of the pond banks and not from within the centre of the pond or at depths near the bottom of the pond. Therefore we cannot be certain that our results reflect the entire pond ecosystem. The surface waters of the pond are more readily subject to temperature fluctuations and diffusion to the atmosphere than deeper waters. The chemistry of deeper waters could therefore be different than near the banks.

Another major limitation is that most of our data carries some risk of bias, as the test strips and vials were compared to standardized colour charts. The issue here is that when the test result has a colour that falls in-between two colour blocks on the chart, we had to estimate the value based on our collective "best guess". Additionally, there was inconsistency in the colour matching because no single person compared all colour results, tests may have errors due to individual interpretation.

Yet more uncertainty arises when one considers the precision and accuracy of test strips. Although they are stated to be as precise and accurate as chemically possible on the packages, we discovered after our data collection that the copper test strips were three years older than their "use by" date. Therefore, it was possible that the chemicals on the test strips were degraded and gave false hues.

Conclusion:

Based on the hydrological conditions evaluated, we conclude that the off-channel pond of Stoney Creek provides an acceptable over wintering habitat for juvenile salmon. All results fell within ideal limits for salmon, with the exceptions of depth and copper (the results of which must be interpreted with caution). Although we consider the restoration project a success, we acknowledge that our assessment was highly limited by the quality of equipment used and data availability. Thus, future management actions would ideally overcome these obstacles.

As our results in two of the three areas indicate bank depths less than the ideal threshold outlined in literature, we believe fish could potentially benefit from a construction revision of the off-channel pond and a deepening in areas B and C. However, there is much that remains unclear- the average depth for the pool as a whole was very close to the ideal, so would deepening the pool markedly improve juvenile survival rates? Part of the Stoney Creek Environment Committee's outline for this project was continued monitoring and juvenile counts. We suggest that salmon abundance between areas A, B, and C be distinguished in order to further understand how variances in depth within a pool affect distribution. The consultation of literature which explores this question would be imperative before making a decision to deepen certain areas. Furthermore, a detailed depth map of the pool area would be needed. Once this information is obtained, an informed decision should be made, weighing the potential benefits with the time and cost of deepening.

Since the off-channel habitat pond of Stoney Creek is downstream from a major highway, urban runoff may be a future concern. Copper shed from vehicle brakes can accumulate on roads until it is washed into storm drains by rain. Storm drains near Lougheed highway therefore have the potential to introduce copper (and other contaminants) into the Stoney Creek habitat pond.

Although our results are ultimately inconclusive, low water hardness (as found elsewhere in the watershed) coupled with the proximity of the pool to storm drains is a potential threat to juvenile salmon. We believe this merits investigation and monitoring. Future sampling should be done by the Stoney Creek Environment Committee, ideally after a first flush event, with detection methods that are sensitive to µg/mL (ppb) of copper. The water hardness levels should be sampled in conjunction with copper. If potentially high levels of copper are detected, then a 30 day sampling scheme to look for average concentrations would be prudent to discount the possibility of a chance 'one time only' copper influx. If it is determined that there is a consistent inpouring of copper into the Stoney Creek ecosystem, then management actions should include tracing the sources, rerouting/filtering storm drains, or considering the addition of copper complexing agents into the water.

Public education regarding Stoney Creek and salmon's importance to our ecosystems can benefit the stream's long-term success. The Stoney Creek Environment Committee holds events such as the Great Salmon Send-Off to get the community involved and motivated to support. Continued events such as these will help to spread awareness of habitat protection and allow opportunities for the public to become involved via volunteering, donations or home practices. Continued education on the topic of habitat restoration through university classes such as Environmental Science 205, will alert students to the issues facing these delicate salmon ecosystems, and possibly give them the foundation to participate in restoration projects themselves.

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Appendix A

Collected Data

	Field Day 1			Field Day 2		
Area:	A	B	C	A	B	C
Depth[a] (m)	1.65	0.61	0.41	1.69	0.61	0.41
Turbidity[b] (m)	1.65	0.61	0.41	0.91	0.30	0.41
Velocity[c] (m/s)	0.0	0.0	0.0	0.0	0.0	0.0
Copper (ppm)	0 - 0.5	0 - 0.5	0	0 - 0.5	0.5	0
Nitrate (ppm)	0	0	0	0	0	0
Iron (ppm)	0.2	0.2	0.3	0.15	0.1	0.15

[a] Depth data shown is averaged values for the respective area.
[b] Turbidity as a measurement of depth of clarity from water surface down.
[c] Velocity data for day 1 is obtained assuming day 2 data would be larger due to rainfall leading to increased water volume and discharge

Table 1. Data collection results

Appendix B

Turbidity

Using the method outlined in the Streamkeeper's Handbook: A practical Guide to Stream and Wetland care by Fisheries and Oceans Canada. Use a standard self-retracting metal measuring tape and a bright tape marking. Immerse into water and measure depth once tape marking is no longer visible. To obtain a better understanding on how to measure turbidity please visit links below.

http://www.pskf.ca/publications/Module03.pdf

Velocity

Immerse Global Flow probe 60cm into water and measure velocity. For detailed instructions please visit the link below.

http://www.globalw.com/downloads/flowprobe/flowprobe_manual_past.pdf

Depth

Use a retractable measuring tape or velocity meter with measured increments. In Areas of high depth use a fishing rod with a weighted end. Apply 1 ft increments on fishing rod to allow for rough depth estimation. Immerse into water until the bottom of pond is reached.

Copper

Extract 30-50mL of pond water from test site. Immerse Sensafe Copper check II strips into water sample for 60 to 80 seconds. Compare color of test strip to given chart to determine concentration of copper. For a detailed procedure please visit link below.

http://www.sensafe.com/copper.php

Iron

Remove 50-60mL of pond water and analyze using the Aquacheck test strips. Add test powder and sample water to vial and mix thoroughly. Insert test strip in vial for 15 seconds. Compare color of test strip to the provided color chart. For a detailed procedure please visit link below.

http://www.poolgeek.com/AquaChek-Iron-Test-Strips-P2943.aspx

Nitrate

Using the Lamotte test kit extract 5mL of pond water. Insert nitrate tablet #1 and mix until dissolved. Next insert nitrate tablet #2 mix and dissolve. Wait 5 minutes and compare the color of solution to the colors provided on the octa-slide viewer. For a detailed procedure please visit link below.

http://www.lamotte.com/images/pdfs/instructions/3354.pdf