SOMENOS BASIN COHO SALMON SUMMER HABITAT ASSESSMENT

for:

Somenos Marsh Wildlife Society

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Abstract

During the summer of 2014, we investigated the summer distribution and movements of juvenile Coho Salmon (*Oncorhynchus kisutch*), Steelhead (*Oncorhynchus mykiss*), and Cutthroat Trout (*Oncorhynchus clarkii*) in the Somenos basin and monitored temperature and other environmental variables to assess habitat suitability. We found that juvenile salmonids were absent from Somenos Lake by at least July and did not appear to have returned to the lake by the end of sampling in early November. Temperature was monitored by data loggers located in Somenos Lake and its three tributaries: Bings Creek, Averill Creek, and Richards Creek. Somenos Lake was also monitored daily by a team of volunteers who collected data on temperature, water clarity, dissolved oxygen and atmospheric conditions at a lakeside station. The Surface temperature of Somenos Lake was higher than 21ºC from the beginning of monitoring in July to the middle of September. Only Pumpkinseed Sunfish (*Lepomis gibbosus*) and Threespine Stickleback (*Gasterosteus aculeatus*) were found in Somenos Lake during trapping in October and November. Tributary temperatures never exceeded 18ºC throughout the monitoring period. Although temperatures in Richards Creek were suitable for juvenile salmonids, none were observed during trapping events. During trapping in early October, Juvenile Coho Salmon were caught in Averill Creek and Bings Creek and Cutthroat Trout in Bings Creek.

Introduction

Somenos Lake and its tributaries: Averill Creek, Richards Creek and Bings Creek (Figure 1), have long been recognised as spawning and rearing habitat for Pacific Salmon. Coho Salmon ascend the tributaries in relatively large numbers to spawn in the late fall and early winter. As many as 30- 150 spawning adults have been observed in Bings creek, 15 to 30 in Averill Creek, and several dozen to just over 1000 in Richards Creek (Burns 2002). After emergence in the spring, an unknown portion of the salmon fry will move downstream to Somenos Lake during the spring and early summer. Similar behaviour is observed in Mesachie Lake where some Coho Salmon juveniles rear in the lake while others remain in streams around the lake throughout their freshwater residency (Swain and Holtby 1989). Somenos Lake becomes very warm during the summer and also experiences very low oxygen concentration. Therefore, it has been thought that juvenile salmonids must re-ascend the three tributary streams as summer refuge habitat (Burns 1999).

Like other sub-basins of the Cowichan Valley, the Somenos area has been experiencing decreased surface water flow in the recent past. The Canadian Water Survey maintains a gauge near the mouth of Bings Creek. Average monthly discharges in August and September at the station have been declining since 1970 (Figures 2 and 3).

Given that these tributaries must provide a cool, oxygenated refuge for juvenile salmon in the summer, the declining trend in summer discharge may be a threat to juvenile salmon survival. Such a situation has previously been identified in portions of Richards Creek, near Somenos Lake. Low summer flow and extraction of water for agricultural use may have caused the lower reaches of Richards Creek to reverse flow. It is thought, this mechanism contributed to a die off of juvenile salmon in 1998 (Burns 2002). In order to prevent such an event from recurring and enhance upstream rearing habitat, summer water flow to Richards Creek has been expanded using stored water from Crofton Lake (Craig 2008).

Somenos Lake is also subject to extremely low oxygen concentrations during the warmest months of the summer. This situation arises from the dual action of lower oxygen solubility in warmer water combined with oxygen depletion by heterotrophic bacteria in the lake feeding upon dead blue green algae (Williams and Radcliffe 2001).

It has been demonstrated that water temperatures over 18ºC begin to exclude juvenile Coho Salmon from a given habitat. Exposures to temperatures over 21ºC for extended periods is deleterious to salmon growth and survival and long-term exposure to water over 25ºC is lethal (Carter 2005a). When oxygen concentration in aquatic habitats is lower than 6mg/l production impairment has been observed in Coho, Chinook and Steelhead Salmon and there is a strong risk of lethality when dissolved oxygen is lower than 3mg/l (Carter 2005b)

In order to assess the quality and use of available summer rearing habitat by salmon juveniles, we installed temperature data loggers at several points in the Somenos Basin. Our original proposal also included an intensive seining and trapping program to determine the timing of movement by juvenile salmon between the tributary and lake habitats in the spring, summer, and fall. Due to the funding realised for this project and the delay in obtaining a scientific fish collection permit from the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO - Provincial Government), we were only able to conduct two rounds of trapping in the tributaries; the first in early October and the second in early November. By determining the location and extent of favourable rearing habitat and the timing when juvenile salmon would be attempting to access new habitats, we hoped to inform management options regarding fish passage improvement and the protection of water flow and temperature.

Methods

We installed Onset Hobo temperature data loggers at 6 stations in the Somenos Basin: one in the lake and 5 in the tributaries (Figure 1). The devices were configured to record temperature every 15 minutes and are expected to function for 6 years. The temperature station in the lake was anchored to the bottom at about 7m depth, with a line to a surface float. Data loggers were hung at intervals of 1m from the surface to 6m depth.

Volunteers used a YSI Professional Plus handheld monitor to collect data on temperature and dissolved oxygen at the station by Drinkwater Road Dock (Figure 4). Data collected by volunteers, also included daily recordings of Secchi Disk depths and atmospheric conditions. Oxygen and temperature observations by the dock, were made at the surface, 1m depth and 2m depth. In October we obtained a Wet Pro water analysis kit (wet-pro.ca/) from Cura H_2O (curah2o.com/). Cura H_2O is a non-profit organisation building a network of citizen science teams collecting water quality data in Canada and around the world. The wet pro gear and the training provided by Cura H_2O allowed our team of volunteers to begin recording data related to pH, and nutrient load and improve the accuracy and precision of oxygen and temperature data.

Fish were trapped using salmon roe baited minnow traps. Traps were soaked for 24 hours at three tributary sites near the mouths of Averill Creek, and Richards Creek, and four upstream sites on Richards Creek, Bings Creek, Averill Creek, and Somenos Creek (Figure 1).

Results

Temperature data loggers were installed on the 23rd of July, 2014. Based on trends recorded both in the lake and in the tributaries, it would appear that installation occurred a few days before summer temperature maxima for all water bodies (Figure 4 and Figure 5). Peak temperature in the lake was 26ºC on the 05th of August, 2014, at 1m depth. The lake appears to have been stratified at the time the data loggers were installed. Temperature time series from the five depth strata show that the upper 4m temperatures converged at the beginning of September and that the lake was fully mixed by the end of September. Both mixing events were coincidental with significant rainfall, >10 mm. Temperature at the lake bottom rose steadily from the middle of July until the mixing event at the end of September. The rate of temperature decline accelerated after mid-October. The very steep decline in the middle of November coincided with a week in which daily high air temperature was rarely over 0ºC.

The time series of temperatures for the tributaries is similar in trend to that of Somenos Lake. However, the temperatures in Bings Creek and Richards Creek never exceeded 18ºC. Averill Creek exceeded 18ºC for a total of 11 days in August. The November drop in temperature in the tributaries was even more dramatic than that of the Lake. Temperature in the tributaries fell to 2.5ºC by the end of the time series on 18 November.

Due to limited trapping, very few salmonids were observed during the two fish sampling events (Table 1 and Table 2). No salmon were caught at the two creek mouth, i.e., 'lake', sites. No salmon were caught in Richards Creek but juvenile Coho were observed at the upper Richards Creek site during installation of the temperature data logger in mid-July. These Coho Salmon may have remained in upper Richards Creek for the summer rearing period. Cutthroat Trout and Coho Salmon were observed in Averill and Bings Creeks in the October sampling event. The most common species in the creek mouth sites were Pumpkinseed Sunfish, though some Sticklebacks were also observed. Catches in Somenos Creek had similar species composition to that of the creek mouth sites. Juvenile Peamouth Chub (*Mylocheilus caurinus*) were extremely abundant in the littoral zone of Somenos Lake and were also commonly observed in the lower reaches of Averill Creek.

Observations of dissolved Oxygen made by volunteers near the middle of the lake showed that in August and September the top 2m of the water was well oxygenated (6-11 mg/l) and water below 3m was almost anoxic (0.1-0.3 mg/l). Results from the volunteer water sampling work, lakeside and in the middle of the lake is ongoing and periodically uploaded to the Cura H_2O online database (curah2o.com/water-quality/).

Discussion

Our results show that Somenos Lake is very unlikely to provide summer rearing habitat for juvenile salmonids. For the period up to the middle of September, the surface water was sufficiently warm (>20ºC) that it would likely have caused juvenile salmonids to actively avoid it (Carter 2005a). While deeper lake water was sufficiently cool for salmonids during this period, the dissolved oxygen concentration was so low that it would have caused any salmonids present to perish (Carter 2005b). Our stream habitats exhibited temperatures between 12 and 17ºC until mid-October, a range that would promote the survival and growth of juvenile Coho Salmon (Carter 2005a). Although our trapping effort was very limited we caught and observed salmonids in tributary habitats. We also observed dozens of Coho Salmon fry swimming in pools near our Bings Creek sampling site. Future rounds of this work will require more efficient net gear and higher frequency/more intensive sampling throughout the spring, summer and fall to establish more accurate estimates of relative juvenile salmon abundance.

While Richards Creek is recognised to be the location of most adult Coho Salmon spawning in the basin, we saw no evidence of Coho Salmon juveniles at our Richards Creek trapping site, under the Herd Road bridge. Numerous juvenile Coho Salmon were observed, however, at our upper Richards Creek temperature data logger site immediately upstream of the Richards Trail crossing. Habitat conditions at the sampling site under the Herd Road bridge are likely unsuitable for juvenile salmonids, as the water is very slow moving and would tend to emulate the lentic conditions and associated temperature limitations found in Somenos Lake. Habitat in the upper reaches of Richards Creek is more suited to juvenile salmonids, given the presence of suitable substrate for spawning, functioning riparian vegetation (albeit limited) and faster flowing water, which is cooler with higher oxygen content. Temperature data suggests that Upper Richards Creek water should be suitable for juvenile salmonids.

Work to expand summer flow in Richards Creek may not have been successful in alleviating problems associated with anoxia in the lower reaches of Richards Creek, where the habitat is more representative of the conditions found in Somenos Lake. Lower reaches may therefore act as a barrier to movement of juvenile salmon back into Richards Creek during the hottest days of the summer and could prevent the fish from reaching summer refuge habitat in upper Richards Creek. Temperature data shows that the water in upper Richards Creek should be suitable for juvenile salmonid presence throughout the summer. As juvenile Coho Salmon were observed in late July 2014, it is assumed that suitable summer refugia exist in upper Richards Creek. A more intensive sampling effort using pole seines and increasing the spatial range of sampling locations in upper Richards Creek would help confirm this.

If Coho Salmon juveniles from Richards Creek are like those spawned in tributaries to Mesachie Lake, further up the Cowichan basin, it is likely that some remain in Richards Creek throughout the freshwater phase of their life history. It may therefore be useful to more regularly sample upper reaches of Richards Creek to keep track of relative abundance. It may also be instructive to see whether juvenile Coho Salmon in the Somenos display morphological divergences observed in Mesachie Lake in which those remaining in streams had deeper more vividly marked bodies and were much more aggressive and territorial than lacustrine individuals (Swain and Holtby 1989).

Resident Threespine Stickleback and invasive Pumpkinseed Sunfish were the most abundant fish overall in our trapping and, in addition to Peamouth Chub the only fish observed in the near-lake sites during the summer and fall. Although the November sampling event was well after the time when the lake would have been cool enough to again be suitable as salmonid habitat, it may be that salmonids remained in the tributaries or were in deeper lake water rather than near the shallow creek mouth environments where trapping was conducted. Another possibility is that the fish were low in abundance and/or too widely distributed to be picked up by our level of sampling. Seining throughout the Lake would help resolve the question of which portion of the Lake might be used by salmon juveniles.

One aspect of our temperature time series in the tributary environments that may be used towards a management decision making tool is the ability to predict stream temperature from air temperature. Daily temperature changes in smaller order streams, like those tributary to Somenos Lake, are largely controlled by ambient air temperature and other environmental variables such as altitude, slope and aspect Moore (2006). Using this logic we were able to develop a predictive model for average Daily temperatures in Bings Creek with a linear model parameterised by air temperatures for the previous four days and cloud cover (Figure 6). Our model is able to explain about 97% of the observed stream temperature variation. By developing similar relationships for other streams in the Cowichan Valley known to be summer refugia for salmonids, we could prioritise juvenile salmon salvage operations or target habitat enhancement efforts.

Our temperature observations also had an interesting parallel to temperatures observed in the Cowichan River. The water Survey of Canada has two gauges in the Cowichan River; one near the outflow of Cowichan Lake and the other near the city of Duncan. Until the end of October the trends, daily fluctuations and absolute temperature in the upper Cowichan were very similar to our observations at 1m depth in Somenos Lake (Figure 6). Conversely these characteristics in the lower Cowichan were very similar to our observations in the tributary environments (Figure 7). This should not be surprising given the fact that stored water in the lake is used to guarantee minimum flow during the summer. Water coming from the near surface of Cowichan Lake would be expected to have a similar temperature to that near the surface of the near-by Somenos Lake.

These temperature observations suggest that the upper Cowichan River main-stem is not as likely to provide suitable summer habitat for juvenile salmon as areas further downstream. Presumably the cooler downstream temperatures result from the infiltration of ground water combined with shading and turbulent mixing as the river progresses downstream. An important consequence of this observation is that the proposal to increase the storage of water in Cowichan Lake to meet declining water availability in spring and summer may have deleterious effects on salmon in the river during the summer. Increased flows of warmer water to the Cowichan River could have the effect of reducing the cool water habitat available to juvenile salmon. It could also be the case that juvenile salmonids could be forced into cool groundwater fed pools and a more restricted foraging environment with potential predators (Brown Trout) and competitors (juvenile Brown Trout, Pumpkinseed Sunfish and Smallmouth Bass).

Conclusions and Recommendations

Juvenile salmon appear to continue to use the tributaries of the Somenos basin as summer rearing habitat. The availability of upper Richards Creek as summer habitat may be restricted by the conditions of lower Richards Creek, which is unsuitable as summer rearing habitat and may act as a gauntlet to migration. Allowing juvenile salmon to access cool water in the summer is necessary to avoid die-offs in warm low oxygen waters found in the Lake during the period from July to September.

In order to determine the timing of movements by juvenile salmon between lake and tributary habitats, as well as the relative changes in their abundance we would like to do more monthly sampling that begins in May and ends in October. Sampling in the future should continue to include minnow trapping (over an increased time frame) and be expanded to pole seining in the tributaries and beach seining in the lake. Consideration may also be given to mark and recapture experiments to determine the proportion of the population of juvenile Coho Salmon that remains in stream at all times and whether they display the morphological divergence associated with stream versus lacustrine rearing Coho Salmon in Mesachie Lake.

The identification of migration windows used by juvenile salmon and their environmental cues (potentially in the form of changes in temperature or discharge) will allow the identification of management options to ensure the long-term survival of these fish populations. Management options which may be of use include:

- facilitation of fish passage at creek mouths where flow can be spread out over marshy habitat;
- improving fish passage in culverts to ensure that fish are able to access tributary streams from Somenos Lake, e.g., installing “baffles” to slow the water in the Averill Creek culvert as suggested by Burns (2002);
- habitat improvements in the lower reaches of Richards Creek which could increase available summer habitat and enhance fish passage;
- improving flow into tributary creeks, such as that done in Richards Creeks in 2008;
- enhancement of riparian vegetation to ensure shading and cooler water temperature in tributary creeks.
- development of long-term management of storm water in all watersheds to decrease the incidence of scouring associated with flooding in the winter and extreme low discharge during the summer;
- provision of suitable off-channel groundwater fed rearing habitat off the main stem of the Cowichan River.

This project was successful in creating a partnership between professional researchers and a team of community volunteers. The result of this partnership was the creation of a locally based monitoring plan that can assess habitat quality in the Somenos basin and will help identify future research priorities and management options. The participants in this project would like to express their thanks to the Pacific Salmon Foundation and TD Friends of the Environment Foundation for providing the grant support that made our research possible.

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Figures and Tables

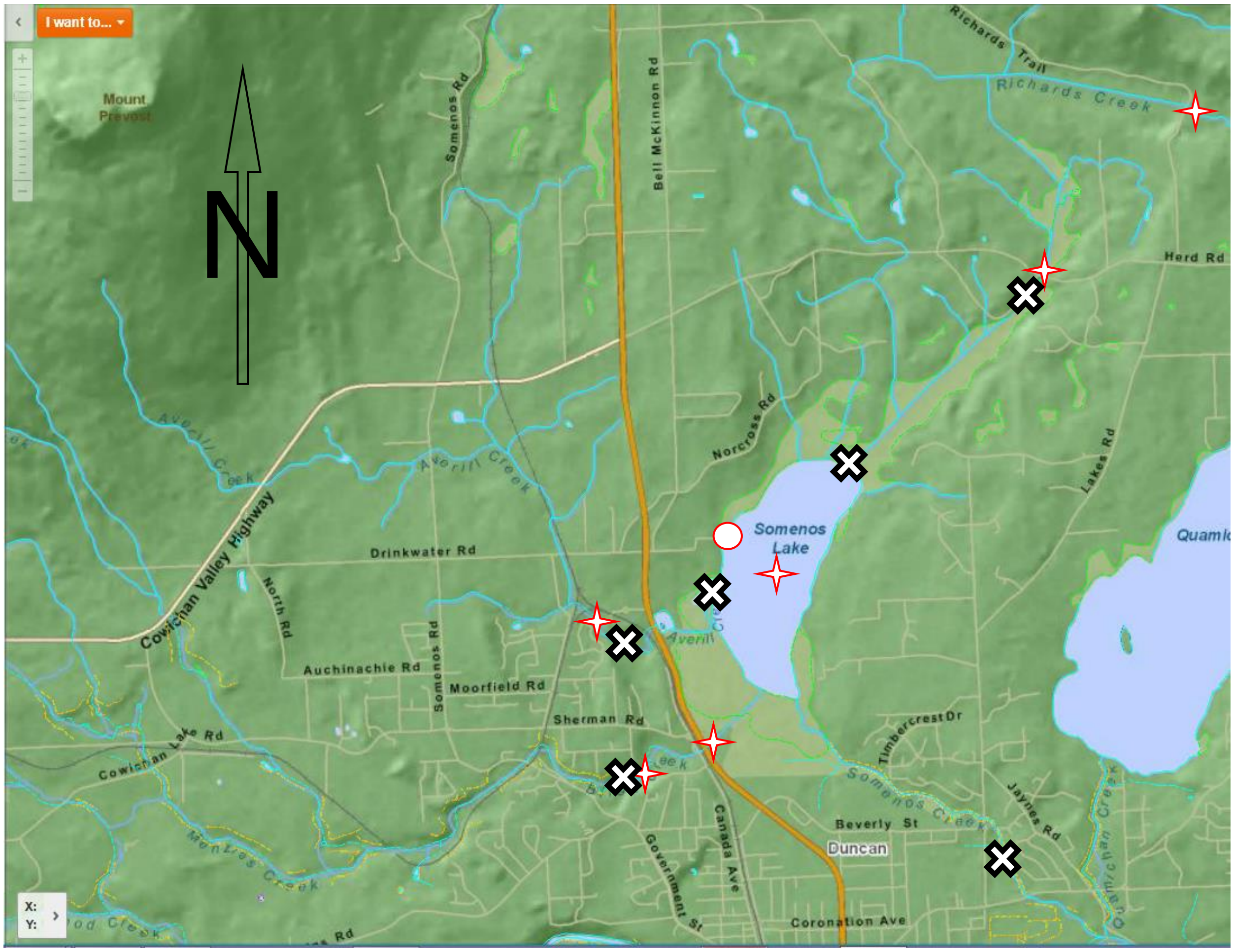

Figure 1: The Somenos basin in the Cowichan Valley, southeast coast of Vancouver Island and sampling sites used in this study. The map was developed courtesy of the British Columbia Ministry of Environment Habitat Wizard web GIS system (www.env.gov.bc.ca/habwiz/). Temperature data loggers are denoted by red stars. The lakeside sampling station is shown as the red circle. Fish trapping locations are shown as a black X.

Figure 2: Mean August discharge (circles) measured at the Bings Creek Environment Canada Water Office gauge. Time series is from 1961 to 2014, data was obtained from wateroffice.ec.gc.ca/. The smoothed trend line was obtained using a LOESS smoother with a 10 year window and a 2^{nd} degree polynomial function.

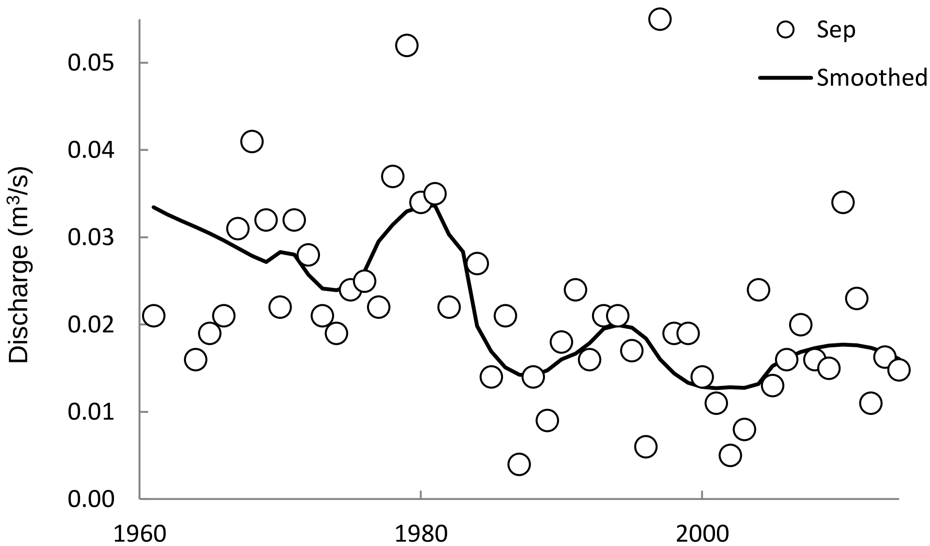

Figure 3: Mean September discharge (circles) measured at the Bings Creek Environment Canada Water Office gauge. Time series is from 1961 to 2014, data was obtained from wateroffice.ec.gc.ca/. The smoothed trend line was obtained using a LOESS smoother with a 10 year window and a 2^{nd} degree polynomial function.

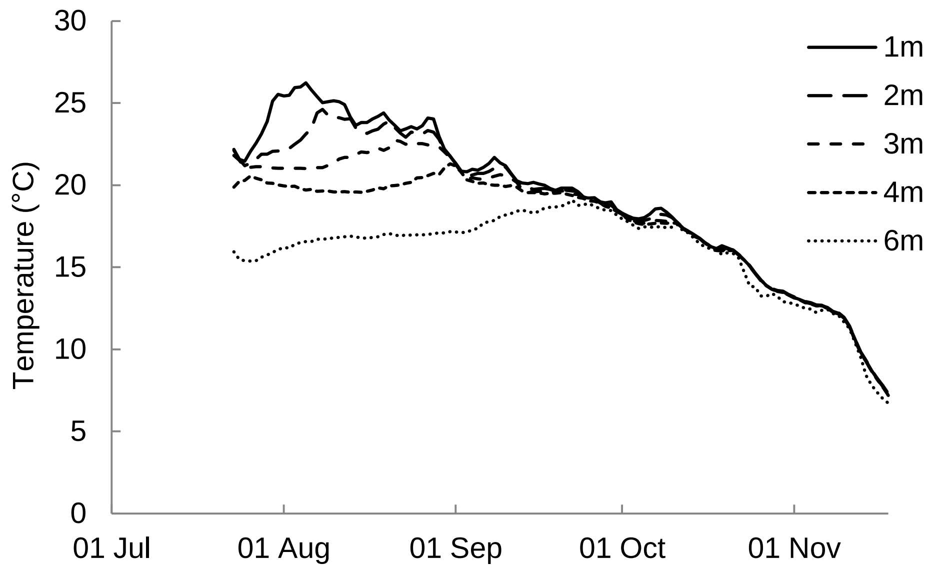

Figure 4: Average daily temperatures measured at the Somenos Lake station, July 23-November 18, 2014. Note that there is no record for the 5m depth logger due to failure of the device caused by water infiltration.

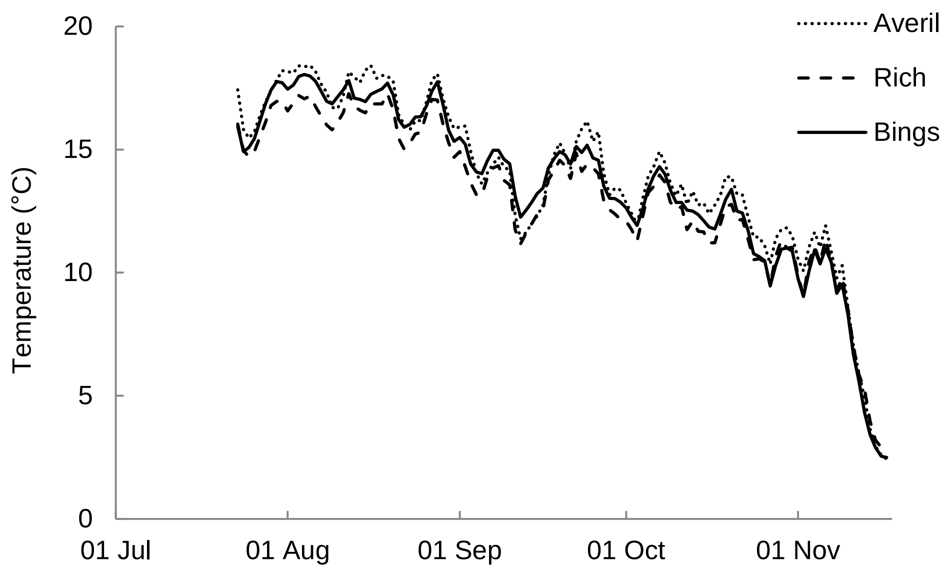

Figure 5 Average daily temperatures measured at the three upstream sites in Averill, Bings, and Richards Creeks. Due to the high correlation of the data the other two tributary sites are not shown.

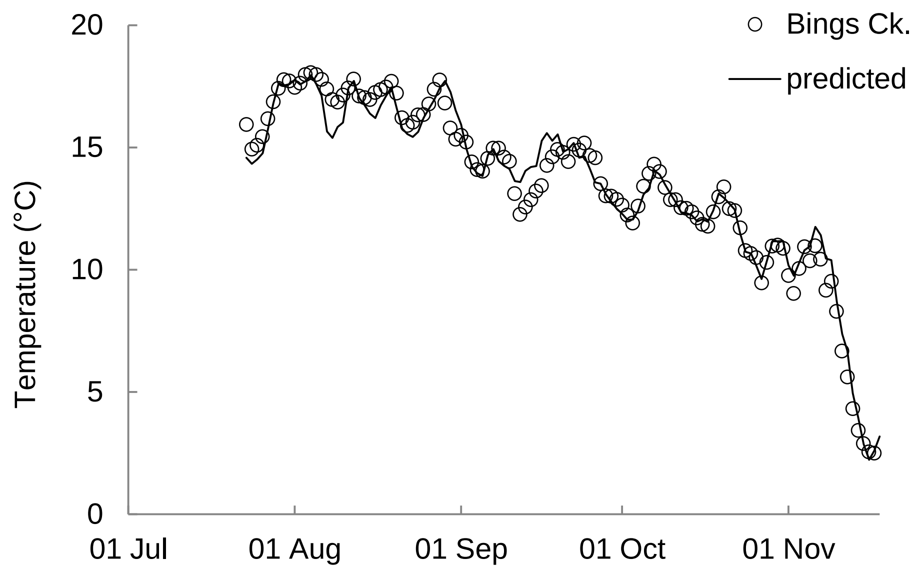

Figure 6: Mean daily temperatures in Bings Creek versus model predicted mean daily temperatures based on air temperature over the previous four days.

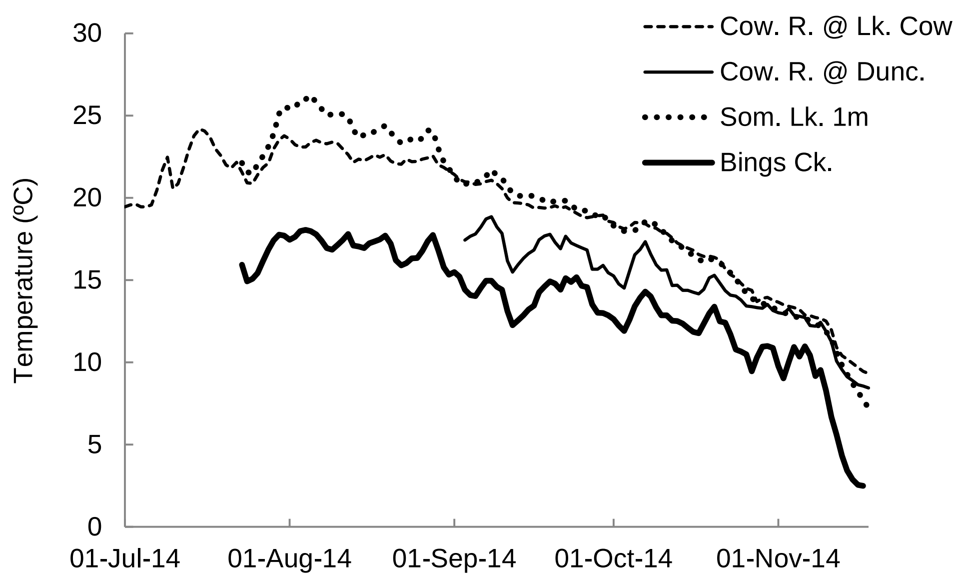

Figure 7: Mean daily temperatures measured in the Cowichan River at Duncan and near Lake Cowichan compared to Somenos basin temperatures measured at Somenos lake and Bings Creek. The time series for temperature in the Cowichan River at Duncan begins in early September due to prior data not being made available by the Water Survey of Canada. Cowichan River data obtained from wateroffice.ec.gc.ca/.

Table 1: Species and fork lengths of fish caught on October 2, 2014

Location	**Species**	**Length (mm)**
Richards Creek @ Herd Rd.	none	
Richards Creek Mouth	Pumpkinseed	33
	Pumpkinseed	54
	Pumpkinseed	38
	Pumpkinseed	42
	Pumpkinseed	48
	Pumpkinseed	44
	Pumpkinseed	37
Averill Creek near Fairview Way	Coho Salmon	77
	Coho Salmon	71
	Sculpin sp.	109
	Sculpin sp.	79
	Sculpin sp.	105
Averill Creek Mouth	none	
Bings Creek @ Philip and Mary St.	Cutthroat Trout	126
Somenos Creek @ Seine Dr.	Threespine Stickleback	51
	Pumpkinseed	73

Table 2: Species and fork lengths of fish caught on November 6, 2014

Location	**Species**	**Length (mm)**
Richards Creek @ Herd Rd.	none	
Richards Creek Mouth	Pumpkinseed	36
	Pumpkinseed	54
	Pumpkinseed	32
	Sculpin sp.	86
Averill Creek Near Fairview Way	none	
Averill Mouth	none	
Somenos Creek @ Seine Dr.	Threespine Stickleback	48
	Pumpkinseed	40
	Pumpkinseed	34
	Pumpkinseed	38
	Pumpkinseed	42
	Pumpkinseed	44
	Pumpkinseed	43
	Pumpkinseed	62
	Pumpkinseed	41
	Pumpkinseed	39
	Pumpkinseed	56
	Pumpkinseed	49
	Pumpkinseed	34
	Pumpkinseed	36
	Pumpkinseed	33
	Pumpkinseed	32
	Pumpkinseed	32
	Pumpkinseed	38
	Pumpkinseed	35
	Pumpkinseed	43
	Pumpkinseed	34
	Pumpkinseed	36
	Pumpkinseed	36
	Pumpkinseed	33
	Pumpkinseed	31
	Pumpkinseed	34
	Pumpkinseed	47