Improving Water Temperature for Kokanee Salmon of Mission Creek, B. C. – Toward Ecosystem Sensitive Water Management

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[Slide number 1] I appreciate this opportunity to tell you a little of the work I have done in Mission Creek with regard to Climate Change. Since our last meeting I attended a public meeting in Penticton about salmon concerns. It was jointly hosted by the Okanagan Nation Alliance and the **Pacific Fisheries Resource Conservation Council**. The council reports to Federal and Provincial Governments on the status of BC salmon.

A major theme of their presentation was a concern for salmon exposed to increased water temperatures as climate change unfolds. This brochure that was given to me sets the topic for my talk. The question is asked: Can we help salmon survive Climate Change? [2]

My title: Improving water temperature for kokanee salmon of Mission Creek – Toward ecosystem sensitive water management.

[3] In the warm Okanagan, the stream spawning kokanee salmon are of particular concern during the trends of Climate Change. The time of greatest risk of high temperature exposure occurs during September when adults are migrating into streams and spawning, and eggs are in the early stages of development.

Sockeye salmon, and their landlocked relatives – the kokanee, are very sensitive to warm water. Above 14C eggs are killed, and above 17C adults exhibit avoidance behaviour and reduced energetics. Tony Farrell, a fish physiologist at UBC (V) demonstrated that even a couple of degrees above normal migration can impair cardio-respiratory fitness. Already, higher summer temperatures in the Fraser River may be causing large numbers of sockeye to die before they reach their spawning grounds (www.fish.bc.ca).

September in Mission Creek, where this study occurred, starts warm and progressively cools at a similar rate during most years. What varies is the timing of the downward trend. Some years it occurs early in the month and migrating kokanee move into cool streams. Other years it occurs later and kokanee encounter warm streams. For example [4], in 1996, with an average September daily mean water temperature of 11.5C, adults migrated into the stream and spawned early. However, in 1995, with an average September water temperature of 14.4C, spawners appeared to be stalled by the warm water. It was late in the month, when either the stream cooled below 17C or the fish finally ignored the warm water, that they spawned. That was a 12 day shift in spawning time.

[5] The delay in spawning due to high temperature appears to reduce egg deposition ability. Early spawners deposited over 80% of their eggs, while egg deposition by late spawners - those fish delayed by warm water - dropped to less than 30%.

Estimates of changes in the number of September days that had daily means over 14C appear to have increased since the 1960s - more years with September days >14C, and more days per September >14C. [6] Given that climate change models are predicting that stream discharge will be reduced and solar radiation increased during Okanagan Septembers, it does not bode well for stream spawning kokanee.

Can we do anything to help the kokanee [7]?

In this study I explored three possible ways to reduce stream temperature during September – increasing shading by riparian planting, cooler source water, and increased discharge [8].

INCREASED SHADING USING RIPARIAN PLANTINGS

Direct solar radiation increases the peak water temperatures each sunny afternoon in September, and therefore increases the daily average stream temperatures. Shading has the potential of decreasing afternoon peak temperatures by 3C, and daily average stream temperatures by 1.5C.

However, the difficulty with this strategy on Mission Creek is that its very wide flood path, created during spring runoff (100CMS), results in the trees necessary for shading the very small stream that flows in September (1CMS) being too far from the water to be effective. [9,10,11]

COOLER SOURCE WATER [12]

The common suggestion for cooling a salmonid stream that is impounded is to introduce cool water from deep behind the dam [13]. For some high flow coastal rivers this can reduce water temperature up to 100 km downstream. However, some researchers have found that any cooling effect of the source temperature on smaller streams is undetectable after only 5 -15km (Webb, Crisp). For this method to cool Mission Creek downstream where kokanee spawn, the impact had to be retained for over 35km.

[14] I investigated the impact of source water temperature on Interior streams using Pearson Creek as a natural – non-impounded- “free-flow” stream, and Belgo Creek as the impounded – “controlled” stream. Most of you are aware that Belgo Creek is the outfall of Ideal Lake which is managed by the BMID. The two streams are at similar altitudes in the Mission Creek watershed. Temperature loggers were installed at approximately 1km intervals along the creeks. [15]

As expected, Pearson Creek had a temperature pattern that was at natural equilibrium [16]. Typically, in “free-flowing” streams the temperature gradually increases as the water progresses downstream.

The objective was to see how far downstream it would take Belgo Creek water, the impounded source, to reach its natural equilibrium, and be like the Pearson Creek – a gradual increase in temperature with progress downstream. This was assessed for two years (2000 & 2001). Energy flux to return to natural equilibrium occurred very rapidly. In 2000 there was no remnant of source water temperature by 5 km. In 2001 it occurred in under 10 km. [17]

Indeed, data from Pearson Creek suggested that the natural equilibrium of Belgo Creek, if the dam was not there, would be approximately 7C. Therefore, at best, water from deep behind the dam at 4C would give only a 3C cooling impact on equilibrium temperature.[18] Therefore, its persistence to reduce water temperature would probably be lost within 4-5km. Remember, we needed the cooling to persist for at least 35km.

For Mission Creek, and probably any stream in the Okanagan were the flows are low and atmospheric energy flux is high, source temperature change that is distant from the spawning and incubation habitat is an ineffective management strategy for cooling streams [19].

GREATER DISCHARGE

[20] In theory, as discharge is increased, solar energy should be dissipated into a greater amount of water and the water temperature should rise less.

Our focus for the discharge study was the lower 18 km of Mission Creek were the kokanee spawned [21]. Here, I recorded stream temperature each hour during September for 4 years. I then used this data to develop a MODEL that would account for Mission Creek temperature using five variables selected from the literature as important in determining stream temperature (Sinokrot) [22]. These were then used in a least squares multiple linear regression analysis [23]. Without going into details on the model, the most important function that relates to this talk is its ability to predict daily average stream temperatures to within 0.5C. [23]

(Air temperature from Kelowna Airport and discharge from Environment Canada Hydrometric Station 08NM116 in lower Mission Creek.)

Now, using the MODEL, I isolated the effect of discharge on Mission Creek temperature [25]. In general, it appeared that if stream flow managers could increase the flow by 1CMS the average daily temperature could be reduced by 1C [26]. This effect may seem small but a reduction in daily average temperature of 1C has the potential for making creek temperature habitable for kokanee four days earlier during warm Septembers.

The Model was then applied to stream conditions for the 10-year period from 1989 to 1998 to see the effect of various discharge changes on daily average temperature. Also, in order to minimize water use for cooling purposes, I focused only on hot days from September 8 to 30, the peak migration time [27]. Flow was only increased on days that had a preceding 6-day average air temperature exceeding 13C.

For the 10 years from 1989 to 1998, I found that in 4 of the years the water temperature was cool enough that no change in discharge would have been called for. For the remaining 6 years, September days >14C would have dropped from 11.8 to 10.5 to 7.2 to 5.7 with discharge increase from empirical to 1.13CMS to 2.13CMS to 3.13CMS, respectively [28]. A plot of the number of days that dropped below 14C with reduced temperature against the water cost in CMS-days shows it is most effective during low flows.[29]

After reviewing water discharge from Ideal Lake I think this amount of water is available provided water release over the entire season (September through December) is under day-to-day control. Only on two of the 10 years between 1989 and 1998 would there have been difficulty (1991 & 1994). However, daily control of discharge is only possible using remote adjustments. The cost of an ability to adjust water release on a daily basis, based on the cost to do this for Hydraulic Creek by the SEKID, would be between $150,000 and $200,000.

In addition, ability to adjust discharge on a day-to-day basis would also enable managers to provide discharge limits at levels enough for the fish to spawn, yet, not so much that the eggs would be washed out of the gravel.

With what I call ‘Ecosystem Sensitive Water Management’ flows can be adjusted to meet the needs of the organism within each watershed - in this example, kokanee in Mission Creek. Through this change in management practice we could return the spawning temperature to what it was in the 60s and 70s [30,31].

Reflecting back on the brochure I referred to at the beginning of this talk [32] , I would slightly rephrase the question to: Will we help salmon survive Climate Change?

This talk was based on one aspect of a larger project report entitled ‘Lower Mission Creek Kokanee Habitat Enhancement’ (Dill, 2002). Thank you [33,34]

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