Managing Atlantic salmon and other cold-water species in a changing climate

Focus on water temperature of the Cheticamp River, key tributaries, and the Cheticamp reservoir

Summary report of 2020 investigation

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Background:

The Cheticamp River Salmon Association (CRSA) and Cape Breton Highlands National Park (CBHNP) share an interest in conserving Atlantic salmon and their habitat on the Cheticamp River and have collaborated on a variety of projects and studies over the years to this end. While past collaborations included operating counting fences and conducting river surveys, recent activities undertaken jointly between the CRSA and CBHNP have been largely motivated by their shared concern about elevated summer water temperatures. Specifically, these concerns led to a five-year (2014-2018) instream restoration project focused on improving fish passage through overwidened sites on the lower Cheticamp River, as well as the ongoing water temperature investigation that is the focus of this report.

The CRSA and CBHNP initiated the Cheticamp River water temperature investigation in 2017 with the goal of gaining a better understanding of the summer thermal regime of the Cheticamp River. In addition to collecting water temperature data along the main stem of the Cheticamp River and several key tributaries, the CRSA and CBHNP also focused attention on the Cheticamp reservoir. The CRSA and its partners hope that this investigation will leave them better prepared for mitigating elevated water temperatures that threaten Atlantic salmon and other coldwater species.

While data collection was somewhat limited the first year of the investigation due in part to the learning curve associated with the new equipment and methodology, the 2017 investigation revealed several noteworthy findings, including the following:

1. The presence of a small but perhaps significant thermocline in the Cheticamp reservoir,
2. Evidence of gradual cooling of water temperatures as the river makes it way from the upper canyons, and
3. Evidence that Faribault Brook's cooling influence on the main river appears to be negligible.

Over the last four years, the CRSA and CBHNP have collected additional data to verify these and other initial observations, begin the process of identifying trends, and strengthen findings. Among the additional findings over the last two years were evidence of gradual cooling between the barrier falls and Third Pool followed by slight warming through stretch between Third and First Pool, and evidence of additional slight cooling between Faribault Brook and Petit Cap, as well as evidence of gradual warming through the lower river to the estuary (from Petit Cap to Terre Rouge), with minimal/negligible cooling effect of Aucoin Brook tributary.

The CRSA and CBHNP have also expanded the scope of their investigation and with help from new partners with Dalhousie University's Groundwater Lab (part of the university's Centre for Water Resource Studies), have begun working on the development of a thermal map of the lower Cheticamp River. A site visit and trial with some of the equipment occurred in fall 2019, followed by a start of data collection in 2020 (summarized in this report).

In addition to Cape Breton Highlands National Park and Dalhousie University, several other partners and funders have made important contributions to the 2020 Cheticamp River water temperature investigation. The Atlantic Salmon Conservation Foundation, the Nova Scotia Salmon Association's Adopt-a-Stream Program, and the Atlantic Canada Opportunities Agency provided funding to support the continuation of the water temperature investigation. The Atlantic

Water Network provided access to water quality monitoring equipment and technical support, the Institut national de la recherche scientifique contributed an additional water temperature logger, and the Cheticamp conservation unit of Fisheries and Oceans Canada provided a boat and officers to assist with the deployment and retrieval of water temperature loggers at the Cheticamp Reservoir. The Clean Foundation, Canada Summer Jobs Program, and Young Canada Works Program each helped cover costs of employing summer students with the CRSA, whose responsibilities included helping install and periodically check water temperature loggers on the Cheticamp River and tributaries.

Loggers and deployment:

The water temperature loggers used in the 2020 investigation were a combination of HOBO Water Temperature Pro v2 Data Loggers and HOBO 8k Pendant Data Loggers. Twenty-one loggers were deployed over the study period in 2020: the Cheticamp River Salmon Association contributed 14 loggers to the study, six were provided by Cape Breton Highlands National Park, and a final logger was loaned to the CRSA by L'Institut national de la recherche scientifique (specifically INRS' RivTemp: A water temperature network for Atlantic salmon rivers in Eastern Canada). As was the case in the previous years of the study, the water temperature loggers were programmed to record water temperature at one-hour intervals (on the hour, i.e., 1:00pm, 2:00pm, etc.) over the sampling period. The loggers were again installed in homemade protective housings made from PVC pipe with holes drilled to allow for water flow, and either secured to the streambed by anchors or weighted down with rocks and secured to fixtures such as trees or boulders using a combination of clothesline and rope. Deployment sheets were filled out when each logger was installed and later retrieved and included information such as depth of deployment and type of habitat (e.g., pool, riffle).

The target period for data collection was June 15 – September 15. Challenges due to COVID-19 restrictions and public health directives caused delays that resulted in none of the loggers being successfully deployed for the full three-month period. As shown in Table 1, however, most of the loggers were installed within two days of the June 15th target. All loggers were able to be retrieved after the September 15th target end date.

Table 1. ***Locations and dates of deployment of water temperature loggers that the investigators were able to successfully obtain data from as part of the 2020 Cheticamp River water temperature study.***

Cheticamp Lake Surface	July 7, 2020	46.641, -60.65728
Cheticamp Lake - 1.5 m from surface	July 7, 2020	46.641, -60.65728
Cheticamp Lake bottom	July 7, 2020	46.641, -60.65728
Below D1	June 12, 2020	46.65167, -60.67353
3rd Pool	June 16, 2020	46.637, -60.876467
2nd Pool	June 16, 2002	46.636117, -60.886283
1st Pool	June 16, 2020	46.633183, -60.905083
Faribault confluence	June 26, 2020	46.63029, -60.92478
Faribault Pool	June 16, 2020	46.63055, -60.925117

Midway Faribault - Fence	June 16, 2020	46.63428, -60.930757
Above Fence Pool	June 16, 2020	46.635583, -60.936267
Fence Pool	June 16, 2020	46.636817, -60.939117
Midway Fence – Petit Cap	June 16, 2020	46.641333, -60.94436
Petit Cap	June 16, 2020	46.63791, -60.946317
Robert Brook	June 22, 2020	46.64475, -60.94495
Above Cabot Trail	June 22, 2020	46.64707, -60.95388
Below CT - Channel Divide	June 22, 2020	46.65006, -60.95762
South Channel - Above Aucoin Bk	June 22, 2020	46.65196, -60.96232
Aucoin Brook	June 17, 2020	46.65111, -60.96472
Terre Rouge	June 17, 2020	46.65611, -60.96333

The middle to upper stretch of the river (from Third Pool to the logger site ~ 0.5km below the dam) has been largely unstudied as part of this investigation, with the exception of data obtained from a logger installed at the barrier falls in 2018 and periodic point sampling undertaken by kayakers on a July trip in 2017. As a result, the research team planned to install loggers at several locations in this section in 2020, including below the barrier falls and at one or more of the upper tributaries, in order to help fill in some of the data gaps. However, access to these remote locations would have been difficult and due to pandemic-related restrictions, the CRSA and CBHNP delayed this logistically challenging component of the investigation. As a result, the bulk of the loggers were deployed between Terre Rouge (tidal area) and Third Pool (see Figure 1), with no data collected on the over 20 kilometer stretch of river between the logger at Third Pool and the logger below the dam. Figure 2 more clearly shows the distribution of loggers on the lower river.

Figure 1. ***Map of Cheticamp River showing the locations of the water temperature loggers successfully deployed as part of the 2020 water temperature investigation.***

Figure 2. ***Map of Cheticamp River focusing on the lower river showing the locations of the water temperature loggers successfully deployed between the estuary and Third Pool as part of the 2020 water temperature investigation.***

In addition to the 21 loggers deployed over the study period, the CRSA also acquired two Hobo Pendant MX Water Temperature Data Loggers in 2020. These wireless loggers allow data to be downloaded via Bluetooth Low Energy and were used as part of pool point sampling to compare surface and bottom water temperatures.

Results:

Temperatures ≥ 20°C

Adult Atlantic salmon prefer water temperatures between 14 – 20°C and are considered sensitive to temperatures exceeding 20°C (Breau, 2013). For this reason, the research team used 20°C as their threshold when quantifying and comparing elevated water temperatures across the study sites.

Except for the logger installed on Robert's Brook, a tributary of the Cheticamp River, temperatures reached and exceeded 20°C at all loggers, including the Aucoin Brook tributary and all three loggers at the Cheticamp reservoir (see Table 2). This is consistent with data from 2019. The majority of 2020 sites saw both more days with temperatures above 200C and higher temperatures than in 2019. In 2020, all the loggers installed on the main river from Faribault Pool downwards recorded temperatures more than 250C over the study period. The highest temperatures were recorded on August 12th at Terre Rouge (28.2), Petit Cap (26.9), Above the Cabot Trail Bridge (26.8), and Fence Pool (26.3). Of particular concern to the investigators, the 2020 data also included the longest stretch of sustained temperatures ≥ 20°C. Many of the loggers on the main channel from Faribault Pool downriver recorded temperatures

above 20°C for 64 hours straight between August 11th and August 14th. Sites on the lower Cheticamp River also reached temperatures above 25°C earlier in 2020 than previous years of the study, with temperatures above 25°C first recorded in 2020 on July 2 recorded at both the loggers at Petit Cap and the channel divide below the Cabot Trail bridge (both locations reached 25.4°C).

Table 2. ***Number of hours and degree hours where water temperatures exceeded 20 degrees Celsius for period from July 8 to September 15, 2020.***

Water Temperatures Cheticamp River 2020 – Period July 8 - Sept 15

Logger	n (hrs)	n (days)	hrs T > 20	deg-hrs T > 20
Cheticamp Lake Surface	1680	70	819	1001
Cheticamp Lake 1.5m from Surface	1680	70	731	714
Cheticamp Lake Bottom	1680	70	478	286
Below Dam	1680	70	505	410
Third Pool	1680	70	256	264
Second Pool	1680	70	280	290
First Pool	1680	70	309	354
Faribault Confluence	1680	70	428	376
Faribault Pool	1680	70	357	534
Midway Faribault-Fence	1680	70	278	398
Fence Pool	1680	70	422	873
Midway Fence to Petit Cap	1680	70	420	834
Petit Cap	1680	70	455	996
Above CT bridge	1680	70	396	805
Channel divide below CT	1680	70	444	989
Aucoin Brook	1680	70	581	806
Terre Rouge	1680	70	724	1412

Unlike what was observed in 2019, the lowest temperatures were not recorded on the logger at the bottom of the reservoir in 2020. The loggers with the fewest hours above 20°C were the loggers installed in the upper pools, with the same pattern of slight temperature increase moving down the river observed as in 2019, with the following numbers of hours above 20°C recorded during the July 7th to September 15th period of comparison: Third Pool (256), Second Pool (280), First Pool (309). The temperatures did not reach 250C at the upper pools, with the following maximum temperatures recorded: Third Pool (23.4), Second Pool (23.3), and First Pool (23.8).

An unexpected finding from 2019, that there appears to be cooling happening between Faribault Pool and Fence Pool, is observed again in 2020. Although the cooling observed in 2020 is less pronounced, temperatures at the logger installed at a midway point between Faribault Brook and Fence Pool were again the coolest in the lower river, with temperatures closer to those recorded at First Pool. There is also further evidence (to add to the data from 2019) of significant warming occurring between the logger midway between Faribault and Fence Pool and the logger installed in Fence Pool. Again, a pattern of gradual warming is observed moving down river from Fence Pool, with the highest temperatures recorded on the logger at Terre Rouge, as has consistently been the case in previous years.

Data from the logger installed below the dam in previous years (2017 and 2019 – comparison was not possible in 2018 as no data was available from the surface logger) revealed temperatures that generally corresponded with the water temperatures recorded from the logger at the surface of the reservoir. The 2020 data did not support this finding from previous years. Instead, the data from the logger below the dam in 2020 was closer to the bottom temperatures from the reservoir. In previous years, the temperatures from the logger below the dam were also among the highest measured across the study sites. In 2020 the opposite was found – the temperatures recorded at the logger below the dam were among the lowest, with lower temperatures only recorded at the upper pools, the logger at the confluence with Faribault Brook, and the logger at the bottom of the reservoir. The 2020 data also provided evidence, as observed in previous years, of cooling occurring between the logger below the dam and the Third Pool.

Pool point sampling

On August 11th, 2020, the CRSA used the HOBO MX wireless water temperature loggers to do point sampling at some of the major pools on the Cheticamp River, including all the pools containing loggers for the full study period. The intent was to compare surface and bottom temperatures to determine if, and to what extent, the larger pools contained a cooler bottom layer that could provide important thermal refuge habitat during periods of elevated water temperatures. The data obtained was from locations in the pool that appeared to approximate maximum pool depths. Coincidentally, the data was collected occurred early on during the longest continuous stretch of temperatures above 20°C during the 2020 study period.

The maximum difference between surface and bottom temperatures at any of the pools measured on August 11th was 0.3°C (see Table 3). Two of the pools had surface temperatures slightly warmer than bottom temperatures, while unexpectedly, the opposite was also true for two pools. Surface and bottom temperatures were equal at the location measured at First Pool. These preliminary findings warrant further investigation.

Table 3. ***Comparison of bottom and surface temperatures from pools on the Cheticamp River measured on August 11th, 2020.***

Pool	Bottom temp (°C)	Surface temp (°C)	Time
Petit Cap	21.1	20.9	11:18 AM
Fence	21.3	21.5	11:25 AM
Faribault	21	21.3	11:38 AM
First	21.8	21.8	1:39 PM
Second	20.9	20.6	2:07 PM
Third	20.9	21.1	2:23 PM

Cheticamp reservoir

Three water temperature loggers were secured to a weighted line and deployed at the Cheticamp reservoir between July 7th and September 16th. The loggers were located at 1m above the bottom (anchor), 1.5m below the surface, and at

the surface. At the time of deployment, the water level in the reservoir where the line was located was estimated at 7.5m.

In previous years of the Cheticamp River water temperature investigation (2017 and 2019 – data is not available from 2018 due to malfunction of surface logger), the researchers found evidence of what appeared to be a small thermocline in the reservoir, with temperatures between the surface and bottom loggers differing as much as 4.2°C. The 2020 data from the Cheticamp reservoir strengthens these previous findings, as temperatures differed as much as 4.7°C between the surface and bottom loggers, with the greatest difference occurring between July and early August. The data displayed in Table 1 also supports the existence of a thermocline, with significant differences in numbers of hours and degree hours above 20 recorded across the loggers at the reservoir (surface – 819 hours and 1001 degree hours, 1.5m below surface – 731 hours and 714 degree hours, and 1m above bottom – 478 hours and 286 degree hours).

Thermal imaging and mapping

A research team affiliated with Dalhousie University's Groundwater Lab (part of Dal's Centre for Water Resource Studies) collected additional data in 2020 to support the CRSA and CBHNP's Cheticamp River water temperature investigation. The researchers, three graduate students working as part of Dr. Barret Kurylyk's research team, spent three days in the field (August 19-21) with CRSA and CBHNP staff collecting data with a Matrice 210 V2 RTK drone equipped with an XT2 thermal/visual camera.

Unfortunately, high winds and issues with local helicopter tours operating near some of the planned flight paths limited the amount of data that was collected. As a result, the research team decided to focus on scouting flights, instead of the more time consuming and repetitive flights at higher elevations that are necessary to produce thermal maps (high resolution imagery with sufficient overlap between images is required in order to be able to yield reliable results when processing images into maps). The scouting flights involved the operator keeping the drone at lower elevations and manually flying the drone to scan over the desired areas, instead of programming the drone to fly the precise flight paths necessary for thermal mapping work. Despite not resulting in imagery that can be developed into thermal maps, the researchers were able to use the scouting flights to identify areas in the river with potentially significant variations in water temperature. The researchers successfully conducted scouting flights from the tidal area to Faribault Brook. Although the thermal imaging camera was equally capable of identifying sites of warm water/thermal pollution, the sites identified by the Dal research team in 2020 were all locations of potential cool-water inputs (e.g., groundwater seeps or springs).

Kathryn Smith, the lead researcher on the visiting team from Dalhousie's Groundwater Lab, is working on an ArcGIS map that will contain the locations of potential cool-water inputs and the associated thermal images obtained as part of the 2020 fieldwork.

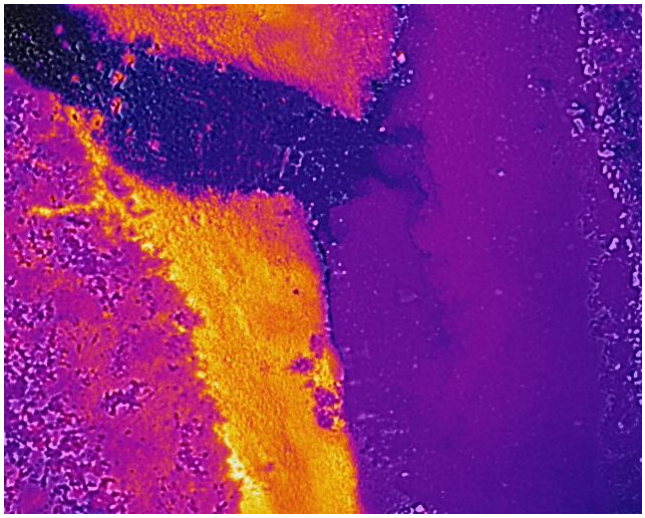

Figure 3. ***Sample of one of the thermal images of the Cheticamp River obtained in August 2020 by Kathryn Smith with Dal's Groundwater Lab.***

Next steps:

The CRSA and CBHNP intend to continue their collaboration in 2021, with a focus on expanding work with their partners at Dalhousie University. Given that data collection with Dal's distributed temperature sensing equipment was not possible in 2020, the research team is hoping to include this additional source of data as a way of verifying, pinpointing, and quantifying the temperature variations picked up by the thermal imaging camera in 2020. The CRSA and CBHNP are also looking to expand on the areas covered by the drone in 2020, with a goal of obtaining thermal imaging data up to Third Pool.

In addition to the data collection involving the research team with Dalhousie, the CRSA and CBHNP are interested in deploying water temperature loggers in the remote and data-deficient stretch of river between Third Pool and the logger location below the dam. The research team is also planning to deploy loggers in the vicinities of suspected cool-water inputs as identified with the drone and thermal imaging camera in 2020. The data collected by these loggers will help to quantify temperature differences and may influence future thermal management options for the Cheticamp River.

The CRSA and CBHNP are also interested in further exploring the surface-bottom temperature differences in the major pools on the Cheticamp River. The 2020 data was limited but given the unexpected results, the investigators hope to deploy additional bottom and surface loggers at some of the pools and/or increase the point sampling.

Finally, the CRSA intends to consult with not only CBHNP and its partners at Dalhousie University, but other experts including Dr. Eddie Halfyard – biologist with the Nova Scotia Salmon Association who has experience with cool-water refugia work on the West River-Sheet Harbour, and Kris Hunter, the Atlantic Salmon Federation's Director of Programs for Nova Scotia and Prince Edward Island, to continue to identify specific thermal management options suitable for the Cheticamp River.

Works cited:

Breau, C. 2013. Knowledge of fish physiology used to set water temperature thresholds for inseason closures of Atlantic salmon (Salmo salar) recreational fisheries. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/163. iii + 24 p.