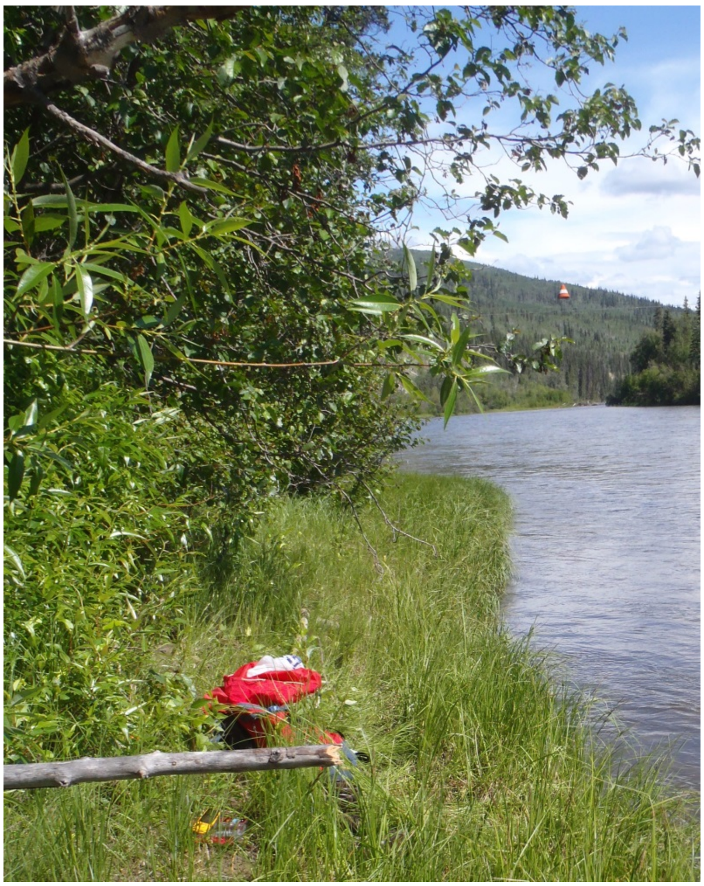
Water Temperature Monitoring of Yukon River Chinook Salmon Spawning and Migration Habitats in Canada

Progress Report

2013



Yukon River Restoration and Enhancement Fund
CRE-20-13

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Abstract

This report details the first year of the implementation of the Temperature Monitoring of Yukon River Chinook Salmon Spawning and Migration Habitats in Canada Program. The Program was successfully conducted in 2013. The Program comprises a network of 3 Seasonal Stations that collect data during the Chinook Salmon upstream migration period and 10 Annual Stations that collect data throughout the year. Data is collected in 7 of the 8 watersheds in the Canadian Yukon River Basin (CYRB) and 9 of 11 DFO Conservation Units (CUs). All Stations are geo-referenced with GPS. A single make and model of data logger is used. Measurements are taken each hour, on the hour. Data is downloaded and saved as data sets. Each data set is checked to ensure integrity of the data. Mean Daily Temperatures (MeDTs) are calculated. The data is sorted to provide Maximum Daily Temperatures (MaxDTs). Data is analysed against established Standards and Thresholds. Annual Accumulated Thermal Units (AATUs) and Annual Biological Accumulated Thermal Units (ABATU) are calculated for Annual Stations. Preliminary results indicate that Alaskan Standards are exceeded even in cold years for migration and spawning habitats. Canadian Thresholds for migration are exceeded much more rarely. AATUs and ABATUs vary widely and imply significant differences in potential productivity between different YR Chinook spawning streams. Substantial numbers of data sets have been distributed and more is in progress. Data is not yet publicly available through a third party web site. Temperatures are currently being measured and recorded at 10 Annual Stations.

Cover: McQuesten River at Water Survey of Canada Station

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Background and Summary.

The Temperature Monitoring of Yukon River Chinook Salmon Spawning and Migration Habitats in Canada Program (the Program) was supported in 2013 with funding from the Yukon River Panel's Restoration and Enhancement Fund (the Fund). 2013 was the first year that the Program existed as a separate entity. A predecessor series of annual projects was conducted by the Alaska Department of Fish and Game (ADF&G), with data being collected from mid-summer 2011 forward. The ADF&G data logger network was locally operated and maintained. The data was either collected using personal loggers or, if ADF&G loggers were available, companion loggers were set.

At the time that the 2013 Panel funding was announced, ADF&G loggers remained at four Stations. Fourteen personal loggers were deployed. The ADF&G loggers were retrieved in spring of 2013 and returned to them. The funded portion of the Program started in June, 2013.

The Program's Goal is to develop a baseline of the inter-annual range of water temperatures of Yukon River Chinook Salmon spawning and migration habitats in Canada. The stated objectives of the Program and a summary of the degree to which they were addressed in the funded period of 2013follows:

Objective 1. Operating, maintaining and adaptively managing the water temperature monitoring network.

Operation and maintenance of most components of the network proceeded as planned. Adaptive management actions included the deletion of the Pelly River at Faro Bridge Seasonal Station due to a high risk of loss of loggers as a result of accelerated bank erosion. The Yukon River at Anson Bend Annual Station was added to the network in anticipation of increased rates of hydrologic modification by Yukon Energy Corporation and potential restoration of the Lewes River Chinook Salmon Spawning stock. The scheduled activities in the Program were generally completed before the milestone dates (Table 1).

Objective 2. Distributing data collected in the Program to interested parties.

Potentially interested parties were offered the data collected on November 24. Other interested parties have been since been identified or have requested data. At present, 240 data sets and 113 Working Mean Temperature Worksheets have been distributed.

Objective 3. Finding a publicly accessible data warehouses or equivalent facility to store the data, and providing the data to the facility .

Data was provided to the ADF&G and the YRITWC for inclusion in their public data bases, should they decide to do so. Discussions with the YRC took place and some data sets were sent to the technical contact they identified. Personnel changes occurred and the impetus was lost. Contact will be re-established in the New Year.

Table 1. 2013 Schedule, showing planned versus completed Program components		
Planned	Completed	Component
By July 1	July 2	Deploy Seasonal Stations
By July 1	July 2	Replace & download Annual Stations
By Oct 10	Sept 9	Retrieve Seasonal Stations
By Oct 10	Sept 22	Replace & download Annual Stations
By Dec 1	Nov 24 (& ongoing)	Prepare and distribute data sets
By Dec 31	Dec 14 (analysis)	Complete analysis, submit Report to PSC
By Dec 31		Submit annual invoice to PSC

Table 1 shows the activities that were planned during the period from June – December, 2013. These were committed to by the proponent in the Detailed Proposal were included in the contract. Progress towards completion was measured by the degree to which the milestones in the schedule were met. The July 1 milestones for deploying the deployment of the Seasonal Stations and the replacement and download of the Annual Stations were missed by one day. The submission of the Report follows its completion: the intent is to have the report couriered to the PSC by December 31.

Monitoring and evaluation functions for field activities includes close attention to the siting of Stations; designing and following procedures to ensure that data loggers from one Station cannot be confused for another; maintenance of a Master Data Logger Tracking Spreadsheet to track each logger and each deployment; and maintenance of one layer of redundancy through deploying two loggers at each Station. Program related monitoring and evaluation includes application of time, travel and materials accounting and management to the project activities. Personnel time and watercraft use is tracked by the hour and vehicle use by the km.

Tangible benefits to date include 47 data sets that have been collected on the 3 Seasonal and 10 Annual Stations. Six Yukon First Nations, one Government of Canada, one Yukon Government, one international non-governmental agency and two Yukon consulting firms have between them received 240 individual data sets and 113 Working Mean Daily Temperature worksheets. Another 47 data sets will be sent to a United States Government Agency early in the New Year.

Less tangible, but arguably more important is that there are now two full years of data for 2 of the Seasonal Stations, and 3 years for the third. Upon replacement of the Annual Stations in early summer of 2014 there should be 2 full calendar years of data for six of the 10 Stations and 1 year for three others. The period of record includes 2012, which was a cold and wet year. 2013 was much warmer despite a late spring. Regardless, the Program's documentation of the range of temperatures between the two years is a fundamental step towards meeting the Programs Goal of establishing a baseline of the range of water temperatures of Chinook Salmon migration and spawning habitats in the CYRB.

Detailed descriptions of the activities undertaken to address each of the three Objectives follow.

Operation, Maintenance and Adaptive Management of the Water Temperature Monitoring Program

This includes deploying, retrieving, and downloading loggers, preparing data sets, and conducting analyses. The physical viability of each Station is assessed at each site visit, and the ability of each Station to collect data of sufficient quality is assessed during data set preparation. Stations are deleted from the Network if their physical viability is compromised due to channel instability or repeated disturbance by people or animals. They are also deleted or re-established elsewhere if they prove unable to collect high quality data. New Stations may be added to meet an opportunity or need.

Program design and description

The Program includes Seasonal and Annual Stations. Seasonal Stations are located on major migration routes where the risk of losing the loggers during ice out is high. Loggers are deployed prior to the upstream migration of salmon and retrieved after the migration is over. Annual Stations record temperatures throughout the year. Loggers at Annual Stations are replaced after spring high water and again prior to freeze up.

When the Detailed Proposal for 2013 was composed in January 2013 four Seasonal and nine Annual Stations were planned. During the post freshet implementation of the Program, erosion of the river bank at the Pelly River at Faro Bridge Seasonal Station was found to have accelerated, with about 8 meters of bank having eroded in spring of 2013. This caused an unacceptably high risk of losing the logger. There were no viable alternate locations in the area. The Station was deleted from the Network. Temperatures were measured at the remaining 3 Seasonal Stations and at all planned Annual Stations. An additional Annual Station was established on the Yukon River at Anson Bend. This is located in the Yukon River about half way between the Whitehorse Rapids dam and the Lewes River dam.

The Stations were designed to stand alone or to be aggregated into a Canadian Yukon River Basin Water Temperature Monitoring Network (the Network). A set of principles guided the design of the Network. These included:

- Implementation over a wide geographical area to ensure a reasonable degree of coverage of the portion of the Canadian Yukon River Basin (CYRB) utilized by Chinook Salmon. This principle addressed the wide distribution of Yukon River Chinook Salmon migration and spawning habitat in the CYRB. This includes spawning in 112 watercourses (von Finster, 2006). These watercourses, and the rivers they contribute to, span 7 terrestrial ecoregions (Smith et al, 2004) and, more importantly, 4 climatic zones (Wahl, 2004);
- Implementation over a variety of types of chinook salmon spawning habitats, and on the primary tributaries (ie Teslin, Stewart and Pelly) of the Yukon River used as major Chinook upstream migration routes;
- Compliance with current Yukon Occupation Health and Safety regulations in the operation of the Network by locating Stations where they can be safely accessed and maintained;
- Maintaining close attention to economy in Program design. Stations have to be efficiently and economically accessible;
- Maintenance of data security. The data loggers chosen are acceptably robust, accurate, simple to operate and download. Two loggers are set at each Station on each deployment to maintain one level of redundancy. Loggers and associated equipment left in the field are carefully concealed to reduce the potential for disturbance from humans. Stations are located on reasonably stable channels to reduce the potential for loss due to channel shift and bank erosion;
- Scheduling operation and maintenance activities, and adhering to the schedule.

The principles provided the framework for the Network and for identifying candidate rivers and stream. Suitable locations for Stations were guided by the following principles:

- <u>All data collected must be comparable.</u> Comparison may be between different years at one or more Stations, or between different Stations in a single year. The make, model and serial number of each logger is provided as metadata for each data set, allowing future data users to determine the capabilities of the equipment used. All loggers record temperatures each hour, on the hour.

- All Stations must be representative. The data collected represent the temperature of the water course being monitored and the purpose for which the monitoring is being conducted. Specifically:
  - Stations are located at sufficient distance from the mouths of tributaries entering from same side of the river to reduce the potential risk of measuring the temperature of the tributary rather than the subject watercourse;
  - With the exception of Stations purposefully located downstream of lake outlets to represent this type of Chinook Salmon spawning, Stations located downstream of lakes are far enough downstream that the effects of the lakes are minimized;
  - Stations are located in areas with no obvious ground water discharges. Discharging ground water may be in excess of 15^{o} C cooler than surface waters in midsummer and up to 7 degrees warmer in the winter. This causes a temperature induced difference in density and may result in the surface and ground water not readily mixing. Avoiding ground water discharges reduces the potential risk of measuring the ground water temperatures rather than those of the subject watercourse.
- All data collections will be repeatable. Stations are geo-referenced by GPS. Should data collection cease for whatever reason, future investigators will be able to return to the Site and resume data collection.

The Stations which comprise the Network are described below. The descriptions are prefaced by explanations for the terms and identifiers used.

Stations are named in relation to named geographical features such as lakes or towns; long-standing physical features such as bridges, signs, or landings; or historical events. Of necessity, many of the names are local and will not be familiar to some readers. The Coordinates provided allow stations to be located on Google Earth or another mapping tool.

Watersheds are the principal tributaries to, or mainstem segments of, the Yukon River in Canada. Tributary Watersheds include the Stewart, White, Pelly and Teslin. Mainstem segments include the Yukon River North Mainstem, from the border with Alaska and extending upstream to immediately above the mouth of the Selwyn River, and including the Yukon River and all tributaries save the White and Stewart Rivers; the Yukon River Mid Mainstem, from immediately above the mouth of the Selwyn and extending upstream to the mouth of the Teslin, and including the Yukon River and all tributaries except for the Pelly River; and the Yukon River Upper Lakes, including the Yukon River and all tributaries upstream from the mouth of the Teslin. The Network includes all Watersheds except for the White River Watershed.

Conservation Units are a management unit developed to implement Canada's Wild Salmon Policy. Yukon River Chinook Conservation Units include:

- CK-68 – Yukon River-Teslin headwaters – Teslin River and all tributaries;
- CK-69 – Upper Yukon River – Yukon River and all tributaries above the mouth of the Teslin;
- CK-70 – Big Salmon – Big Salmon River and all tributaries;
- CK-71 – Nordenskiold – Nordenskiold River and all tributaries;
- CK-72 – Pelly – Pelly River and all tributaries;

- CK-73 – Middle Yukon River & tributaries – Mainstem Yukon River and all tributaries between the mouth of the Teslin River and the White River except the Big Salmon, the Nordenskiold and the Pelly;
- CK-74 – Stewart – Stewart River and all tributaries;
- CK-75 – White – White River and all tributaries; and
- CK-76 – N Yukon River & tributaries – Mainstem Yukon River (migration only) and all tributaries except for the Stewart and White Rivers.

The Network includes all Conservation Units except for the White River and the Big Salmon River. These are excluded due to geographical isolation and the related expense of operating and maintaining Stations. Spawning in the White River is limited to the Nisling and Klottasin Rivers and Tincup Creek. All are only accessible by air. Most spawning in the Big Salmon occurs well above the mouth. A representative Station would have to be operated and maintained by air. Efficient boat (ie powered) access is not possible in the mid-Big Salmon River under low water conditions.

Sides of streams or rivers. "Right" or "left" is determined by looking downstream.

Seasonal Stations

Mid Stewart River at Stewart Crossing.

Type of Station: Seasonal
Watershed: YR Stewart River
Conservation Unit: CK-74 Stewart
Coordinates: NAD 83 63 22.947/136 41.036
Use by Chinook: upstream migration
Existing data: 2012 & 13
Rationale for inclusion: The Stewart River is a principal tributary of the Yukon River and a major Chinook Salmon migration route. The Station is downstream of 8 documented spawning rivers and streams in the mid and upper Stewart River Watershed. The Upper Stewart River Basin is poorly explored. It is likely that there are more Chinook Salmon spawning streams that are currently not documented. Low river flows in 2002 were suggested as a reason that Chinook Salmon appeared to be experiencing difficulties in migrating over Fraser Falls (Osbourne et. al., 2003). Low summer flows generally result in high(er) water temperatures. The Station is in an excellent location, on the right side of river, against a bedrock bluff. Access is by vehicle from the Dawson Road/Klondike Highway.

Pelly River downstream of Pelly Crossing.

Type of Station: Seasonal
Watershed: YR Pelly River
Conservation Unit: CK-72 Pelly
Coordinates: NAD 83 62 50.467/136 40.988
Use by Chinook: upstream migration
Existing data: 2012 & 13
Rationale for inclusion: The Pelly River is a principal tributary of the Yukon River and a major Chinook Salmon migration route. The Station is downstream of all 25 documented spawning rivers and streams in the Pelly River Watershed. The Station is in an excellent location, on the right side of river, against a bedrock bluff. Access is by vehicle from the Pelly Farm Road

Teslin River at Hootalinqua.

Type of Station: Seasonal
Watershed: YR Teslin River
Conservation Unit: CK-68 Teslin River Headwaters
Co-ordinates: NAD 83 61 35.118/134 53.897
Use by Chinook: upstream migration past the Station and spawning within 30 km upstream
Existing data: 2011 – 13
Rationale for inclusion: The Teslin River is a principal tributary of the Yukon River and a major Chinook Salmon migration route. The Station is downstream of all 25 documented spawning rivers and streams in the Teslin River Watershed. The lower Teslin River is laterally unstable. There are no suitable sites for establishing and servicing a Station. Sites exist upstream but are difficult to access with a propeller boat at low water levels. The Station is at the confluence of the Yukon and Teslin Rivers upstream of where the mixing zone between the two rivers reaches the river bank. Access is by boat from the Deep Creek Launch on Lake Laberge.

Annual Stations

North Klondike River at North Fork Bridge

Type of Station: Annual
Watershed: YR North Mainstem
Conservation Unit: CK-76 North Yukon River
Coordinates: NAD 83 - 64 00.102/138 35.761
Use by Chinook: spawning and incubation.
Existing data: 2011 – 13
Access: by vehicle from the North Fork Road.
Rationale for inclusion: The North Klondike River is a mid-sized mountain river typical of spawning rivers flowing south from the Ogilvie Mountains. These include the Coal Creek, the Fifteen Mile River and Twelve Mile (Chandindu) River, and possible spawning tributaries in the little explored upper South Klondike. The Station is located at or near the apex of the alluvial fan the North Klondike River has formed in the Klondike Valley.

McQuesten River below WSC Station

Type of Station: Annual
Watershed: YR Stewart River
Conservation Unit: CK-74 Stewart
Coordinates: NAD 83 - 63 36.489/137 16.634
Use by Chinook: spawning and incubation. Upstream migration to the confluence of North and South McQuesten and then to spawning locations up each fork.
Existing data: 2011 – 2013 (discontinuous)
Access: by four wheel drive vehicle from the Vancouver Creek Trail.
Rationale for inclusion: The McQuesten River is the primary Chinook Spawning river in the Stewart River Watershed. The Station is located at approximate mid-point of the main spawning area and is at or near the apex of the alluvial fan the McQuesten River has formed in the Stewart River valley.

Blind Creek below abandoned bridge

Type of Station: Annual
Watershed: YR Pelly River
Conservation Unit: CK-72 Pelly
Coordinates: NAD 83 62 11.624/133 10.799
Use by Chinook: Spawning and incubation.
Existing data: 2011 – 13
Access: by vehicle from the Blind Creek Road and the original Faro Mine Access Road.
Rationale for inclusion: Blind Creek is a small stream with a number of minor headwater lakes. It is typical of a number of spawning streams tributary to the Pelly and upper Stewart River. The enumeration fence located near the mouth of the creek has the longest wild Chinook data set in the CYRB (Wilson, 2011). Summer flows have been measured by Government of Yukon Water Resources and its predecessor agency since 1992 (Yukon Government 2005). The Station is located at or near the apex of the alluvial fan Blind Creek has formed in the Pelly Valley.

Tatchun River downstream of Tatchun Lake outlet

Type of Station: Annual
Watershed: YR Mid-Mainstem
Conservation Unit: CK-73 Yukon River Mid-Mainstem
Coordinates: NAD 83 62 17.216/136 14.316
Use by Chinook: spawning and incubation.
Existing data: 2011 – 13
Access: by vehicle from the Tatchun Lake Road
Rationale for inclusion: Tatchun Creek is relatively small and has significant lake storage in its lower reaches. It is typical of a number of streams distributed across all Watersheds of the CYRB except for the YR North Mainstem Watershed. These include, among others, Tincup Creek in the White River Watershed; Janet Creek in the Stewart River Watershed; Glenlyon Creek in the Pelly River Watershed, the Swift River (North) in the Teslin River Watershed and Michie Creek in the Yukon River Upper Lakes Watershed. These streams often have very high densities of spawning Chinook and extensive spawning dune complexes. They are also vulnerable to direct effects of periods of low flow/high water temperatures, and to indirect effects such as beaver damming of spawning streams.

Nordenskiold River at Elk Sign

Type of Station: Annual
Watershed: YR Mid-Mainstem
Conservation Unit: CK-71 Nordenskiold
Coordinates: NAD 83 61 51.438/136 06.539
Use by Chinook: spawning and incubation. Upstream migration during high water years to Hutshi Lake outlet and Kirkland Creek.
Existing data: 2010 – 2013 (discontinuous)
Access: by vehicle from the Mayo Road/North Klondike Highway.
Rationale for inclusion: The Nordenskiold River is a mid-sized river during wet weather years. Much of its drainage basin is in the rain shadow of the coastal range. There is only limited high elevation terrain to act as seasonal water storage. During drought periods flows in the river are greatly reduced. The river is vulnerable to the direct and indirect effects of climate change. A Chinook Salmon stock on one tributary,

Klusha Creek has already been extirpated due to extended droughts and associated effects of low flows .

Little Salmon River at canoe landing

Type of Station: Annual
Watershed: YR Mid-Mainstem
Conservation Unit: CK-73 Yukon River Mid-Mainstem
Coordinates: NAD 83 62 05.610/135 18.381
Use by Chinook: spawning and incubation. Upstream migration to upper Little Salmon River, Bearfeed Creek and Drury Creek.
Existing data: 2012 - 13.
Access: by vehicle from the Campbell Highway
Rationale for inclusion: The Little Salmon River is a mid-sized river with significant mid- and upper elevation lake storage. It is typical of a number of mid-sized rivers with lake storage and Chinook Salmon spawning extending some distance downstream from the lake outlet. These include, among others, the Woodside River below the Pelly Lakes; the Morley River below Morley Lake; and the Big Salmon River below Big Salmon Lake. These streams often have pockets of very high densities of spawning Chinook and the resulting spawning dune complexes. Many of the lakes are deep and cold and are located in glacial troughs with adjacent high altitude areas. They tend to be less subject to low flows during drought periods than are smaller streams. Assuming a continuing warming trend, they may become of increased importance to Chinook Salmon due to extirpation of stocks in warmer streams.

Yukon River at Policeman's Point

Type of Station: Annual
Watershed: YR Upper Lakes
Conservation Unit: CK-69 Upper Yukon River
Coordinates: NAD 83 60 56.808/135 5.647
Use by Chinook: upstream migration.
Existing data: 2011 - 2013.
Access by boat from Lake Laberge or Whitehorse.
Rationale for inclusion: The Yukon River at this location is a large river. All documented spawning in the Yukon River Upper Lakes Watershed (spawning downstream of Lake Laberge is suspected but not yet documented) occurs upstream of the Station. The river ice rots out in the spring rather than breaking up. This reduces the risk of loss to an acceptable level and allows an annual Station to be maintained.

Takhini River downstream of Kusawa Lake

Type of Station: Annual
Watershed: YR Upper Lakes
Conservation Unit: CK-69 Upper Yukon River
Coordinates: NAD 83 60 38.593/136 07.410
Use by Chinook: spawning and incubation.
Existingdata: 2012 - 13.
Access: by vehicle from the Kusawa Lake Road
Rationale for inclusion: The Takhini River is a mid-sized river. It is the only unregulated spawning river to receive significant input from actively melting glaciers. Augmentation of flows from glacier melt has been increasing in the South West Yukon, particularly late summer flows. Glacier mass has been decreasing. A tipping point where the glacial augmentation of flows declines is anticipated. When this occurs late summer

flows in the rivers will be correspondingly reduced (Moore et. al., 2009). These are the flows that are used by spawning Chinook Salmon.

McIntyre Creek downstream of Mountainview Drive

Type of Station: Annual
Watershed: YR Upper Lakes
Conservation Unit: CK-69 Upper Yukon River
Coordinates: NAD 83 60 45.578/135 06.045
Use by Chinook: spawning and incubation.
Existing data: 2011 – 2013
Access: by vehicle from Range Road.
Rationale for inclusion: McIntyre Creek is a small spawning stream. It supports the only Chinook Salmon stock that is known to have developed during the last century. The capture of watershed area by a hydro-electrical development in the early 1950s increased the size of the creeks watershed. This action, and the release of a constant volume of water in the winter for electrical generation, created habitat for adult Chinook to enter the creek and then spawn and incubate. The Yukon Government is actively looking for hydro-electrical sites, which may include projects with similar characteristics to McIntyre Creek. The effects of development could be similar, with the conversion of Chinook Salmon rearing streams to spawning streams. The creek provides an opportunity to investigate the effects of water regulation on a small stream in a northern environment.

Yukon River at Anson Bend

Type of Station: Annual
Watershed: YR Upper Lakes
Conservation Unit: CK-69 Upper Yukon River
Coordinates: NAD 83 60 56.808/135 5.647
Use by Chinook: possible spawning and incubation. Upstream migration to M'clintock River, Michie Creek and Byng Creek.
Existing data: 2010 (seasonal) 2013.
Access: by boat from the Schwatka Lake East Boat Launch
Notes: The Yukon River in this area is large. The Station is in the first Chinook Salmon spawning area in the Yukon to be documented (Dawson, 1887). The stock appears to have been negatively affected and possibly extirpated by dams at the outlet of Marsh Lake and the Whitehorse Rapids. Whitehorse Rapids Hatchery fry have been released near the Station since 2004 (JTC, 2013). The current stock status is unknown. Data from this Station complements temperature data collected at the Whitehorse Rapids Fishway as the Yukon River generally sounds in Schwatka Lake and flows through the lake. Flows in the Fishway are from the top layers of water, and may be warmer than the river water,

Methods - Measurement of temperatures and analysis of data

Onset Tidbit v2 Water Temperature Data Loggers are used exclusively. An example is shown in image 1. They are waterproof to 305 meters and accurate within 0.2^0 C. The instruments stability, or drift, is about 0.1^0 C per year. The memory capacity is approximately 42,000 temperature measurements, or about 5 years of collecting hourly data. Each logger is in a sealed epoxy case. The case has a hole to allow it to be secured. There are two epoxy pins through which the logger is programmed and downloaded. The case is vulnerable to abrasion or impact.

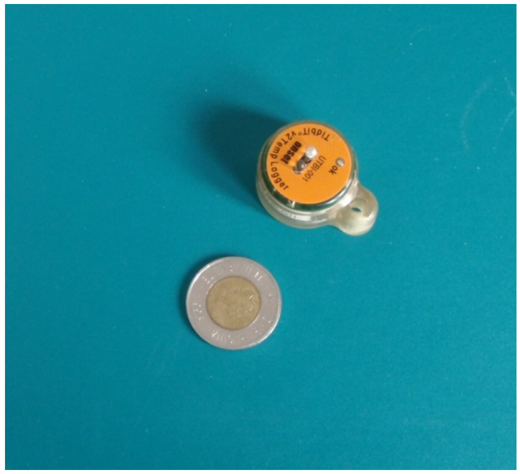

Image 1. Onset Tidbit v2. A Canadian two dollar coin provides scale. The hole used to secure the logger is to its lower left.

All loggers are placed in housings. The housings are manufactured from 40 mm inner diameter black PVC pipe. Black pipe is used as it is much less visible than white pipe and therefore less likely to be disturbed by the curious or destructive.   Concerns of the housings heating up under conditions of bright sunlight are mitigated by the design of the logger, which measures the water temperature rather than the air temperature within a case and by setting the loggers where they will be shaded and in moving water. The housings are 120 mm long. Eight 18 mm diameter holes are drilled in each housing, with 4 at each end. The holes are drilled free-hand at roughly right angles and are 10 – 15 mm from the end of the housing.   Each logger is secured to the housings with 2 sets of cable ties.   Two loggers are secured in each housing.

Commercial plastic coated clothesline is used to tie the logger to a feature on shore.   The clothesline is passed through the end of the logger, and then through one of the 18 mm holes. It is then passed through a 18 mm hole at the other end of the logger and through the end itself. This allows a straight pull and maximizes the strength of the clothes line should the logger be displaced by ice or debris.   The clothesline is secured to a weight, which is usually a 1 kg or larger piece of scrap metal.   The housing is cable tied to the clothesline at the desired distance from the weight. The distance varies depending on the observed characteristics of the stream or river: if there is a risk of the logger being buried in bed load it is secured so it will be above the stream or river bed. The housing, loggers, weight and clothesline securing them are termed a “data logger string”.   Image 2 provides an example of a data logger string being prepared for deployment.

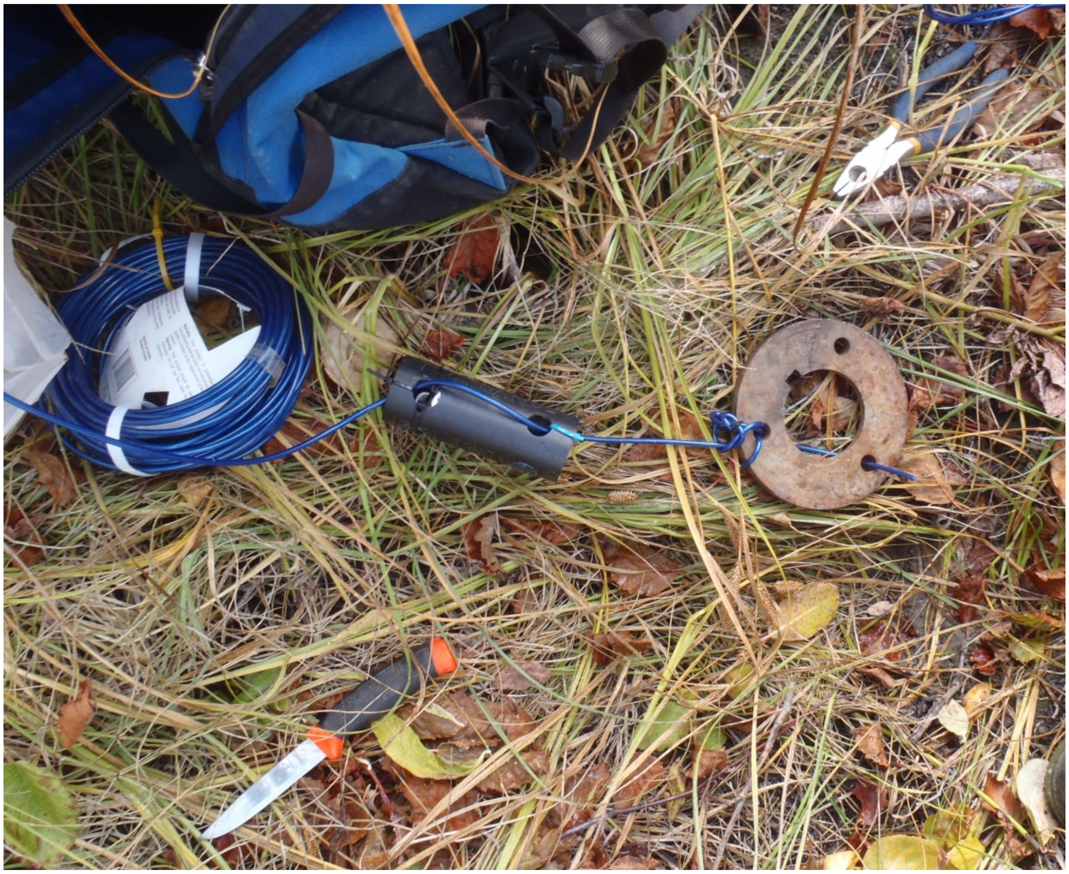

Image 2. Data logger string. The housing is in the center of the image. One logger has been cable tied into the left end of the housing. The second will be cable tied into the right end of the housing. Scrap metal is used as a weight to hold the logger in place.

The weight and logger are then lowered or placed on the stream or river bed or at the desired distance above it. To the extent possible the loggers are set so that they are in a shaded area with turbulent flow. The clothesline is then tied to a reasonably stable feature, such as a live tree. As a final measure, the clothesline is concealed under debris or in a cut made in the river bank with a knife.

Loggers to be deployed are launched (commence measuring temperatures) prior to leaving for the field. Their serial numbers and Station to be deployed at are entered into the Master Data Logger Tracking spreadsheet. The loggers for each Station to be replaced (Annual) or deployed (Seasonal) are tied with a length of flagging on which the Station name has been written in indelible ink. At the Station the flagging is untied from the replacement loggers. The data loggers that have been recording are then removed from the housing and tied together with the same piece of flagging. The replacement loggers are cable tied to the housing which is placed back in the stream or river.

Upon return from the field, each logger is cleaned and its serial number checked against the Master Data Logger Tracking Spreadsheet. The date of retrieval is recorded. Each logger is downloaded and the status of the battery and remaining memory checked. It is then placed in storage or discarded. The downloaded data from each Station is exported and saved to an Excel Workbook. Where both loggers at any given Station record data, the data is graphed from each and visually compared to the other. If the graphs are concordant the data from the newest logger (highest serial number) is accepted as the data set of record, as newer loggers are likely to be more accurate.

Quality Control of the data is conducted by scanning each graph to determine periods where the data may be questionable. This includes periods during the winter when the logger may have been frozen in ice or dewatered. The latter is relatively easy to determine, as the recorded temperatures are below -0.2^{o} C. This temperature is used for three reasons: first, the data loggers are accurate within 0.2 degrees; second, slush/frazil ice is usually slightly below 0^{0} C and often accumulates under ice cover during freeze-up and again in the spring; and third, winter flows in the Yukon River Basin depend on ground water discharges in most locations. Most ground water has elevated levels of total dissolved solids (Brabets et. al., 2000). This is likely to result in a minor freezing point depression, as 0^{0} C is the freezing point for pure (ie distilled) water.

Siting the loggers in areas of turbulent flow and that are shaded from direct sunlight reduces the potential for questionable data being collected during the summer. However, the loggers are occasionally disturbed by wildlife or people and are pulled up onto the stream bank. The daily range of air temperatures is much wider than for water temperatures. Additionally, air temperatures warm earlier in the day and fall more quickly in the evening. The date of disturbance is generally simple to determine.

Questionable data is identified as such in the data sets and excluded from the calculations of Daily Mean Temperature and determination of Daily Maximum Temperatures.

Descriptive metadata for each data set includes the following fields:

Stream/River:
Tributary to:
Watershed:
WSP Conservation Unit:
Co-ordinates:
Date deployed:
Date retrieved:
Person/agency deploying/retrieving:
Make/model/serial number:
Purpose:
Notes:
Funder:

As noted, loggers are placed in locations with turbulent summer flow patterns. This results in the water mixing from bed to surface. Water levels rise and fall seasonally and as a result of precipitation (or lack thereof). Depth is therefore not a meaningful metric and is not recorded.

Only full daily data sets are used to calculate Daily Mean Temperatures, or sorted to determine the Maximum Temperatures for each day for each Station. A “day” is from 0100 to 2400.

Analysis of potential risk from elevated water temperatures was conducted for each Station against Standards given in an American process and Thresholds in a Canadian process.

The American process is based on the significant effort expended in the US West Coast on the effects of water temperatures on Chinook salmon and other salmonid species. Reviews were prepared (McCullough 1999, Carter 2005) and made operational through guidance documents (US EPA 2003). A primary driver was the United States Clean Water Act (US CWA) which compelled States and Tribes to set Water Quality Standards. Water temperatures are a specified standard (von Finster 2010). Alaska has complied with the US CWA and has prepared temperature standards (Alaska DEC 2012). The standards are based on ***Maximum Instantaneous Temperature*** (MaxDT) and are:

- For migration, not to exceed 15 degrees C;
- For spawning, not to exceed 13 degrees C;
- For egg and fry incubation, not to exceed 13 degrees C;
- For rearing, not to exceed 15 degrees C.

If a stream has "natural" temperatures in excess of these Standards, a variance may be applied for. The US EPA (2003) recommends that the application of the Standards be based on a 7 day average of the daily maxima (7DADM). The 7DADM is a rolling mean: that is, each maximum daily temperature may contribute to up to 7 separate 7DADM values. Even so, the Standards are highly restrictive, in part as they were largely based on the effects of constant temperatures on fish in laboratory experiments. As such, the studies poorly represent the variable temperatures characteristic of natural environments.

The Canadian process reflects the legal and socio-economic characteristics of Canada. Water is, constitutionally, a provincial area of responsibility. Fisheries and fish habitat is a federal responsibility. Water temperature is not recognised as a statutory quality of water by either level of government except for a limited number of specified purposes. British Columbia has been working toward a guideline for water temperatures since a drought in the late 1990s and early 2000s. The drought resulted in high water temperatures which are believed to have contributed to pre-spawn mortalities of sockeye salmon in the Fraser River Basin (Mathes et. al, 2010). Results of scientific investigations and local information were used to set water temperature risk Thresholds for the Fraser River ewatch http://www.pac.dfo-mpo.gc.ca/science/habitat/frw-rfo/index-eng.htm The Thresholds are based on ***Mean Daily Temperature*** (MeDT) and are:

- 18°C - Decreased swimming performance;
- 19°C - Early signs of physiological stress and slow migration;
- 20°C - Associated with high pre-spawn mortality and disease;
- 21°C - Chronic exposure can lead to severe stress and early mortality.

The number of days with MaxDT above 13, 14, 15 degrees, and those with MeDT above 18, 19, 20 and 21 degrees were calculated for each Station. Assumed migration and spawning periods were developed for the presentation of the results.

Accumulated Thermal Units are the sum of the mean daily temperatures over a specified period of time. The Annual Accumulated Thermal Units (AATU) for a stream is the sum of all mean daily temperatures for an entire calendar year. AATUs are a valuable indicator of the potential productivity of a stream's environment. As a rule, a warm(er) stream in a north temperate environment such as the South and Central Yukon will have a more diverse and numerous invertebrate community than a cool(er) stream (Castella et. al., 2001). Additionally, there is a reasonable understanding of the number of ATUs required for Chinook egg incubation and emergence from the spawning beds (Fisheries and Oceans Canada 2003). The ATUs calculated can therefore give some insight regarding the range of dates that these life processes may occur in a stream in any given year.

AATUs are calculated by calendar years and extend from 0100 hours on January 1 to 2400 hours on December 31.. Annual Biological Degree Days (ABATU) were also be calculated to make the metric more specific to Yukon River Chinook Salmon. They are based on a general model of Chinook spawning and extend from August 15 to the following August 14.

Results

Environmental Conditions

Environmental conditions have a paramount influence on the temperatures of Yukon streams and rivers and on the results of the analysis of the data collected to date. They will therefore be briefly described to provide context. The summer of 2012 was atypically cool and established what will probably be the lower end of the range of annual stream temperatures. Flows in most rivers and streams remained high to very high throughout the open water period. Water temperatures were low in 2012. This reflected the weather and the inverse relationship between flow rates and water temperature (Gu et. al., 1998).

The spring of 2013 was late. On May 1 snow water equivalent in the CYRB was greater than normal (Environment Yukon, 2013). When warming did eventually occur, it was rapid. Stream flows were high to very high. An extended period of fair weather followed. Flows in those streams and rivers without significant high elevation areas or ground water storage fell to usual summer low flows. Higher than normal flows were maintained in other rivers as high elevation snow patches melted. Ground water discharged from areas that were normally dry, implying that some or perhaps most aquifers were fully charged. In mid to late July a series of precipitation events occurred that affected different parts of the south central and south west Yukon. Elevated flows and declining water temperatures resulted. The most extreme example in the streams that were monitored was the Nordenskiold River at Elk Sign Station. The mean daily temperature fell from 16.2 degrees on July 19 to 11.83 on July 23. Temperatures rebounded as the fair weather returned. Another series of precipitation events occurred in late August, with similar affects to water temperatures.

Upstream Migration

These include the Seasonal Stations and those Annual Stations through which migrating salmon pass to spawn in upstream areas. The assumed migration periods are conservative. This is to address a potentially wide range of annual or inter-annual migration timing. Stations assessed for upstream migration-related temperatures, and the assumed upstream migration periods for each, follow:

Mid Stewart River at Stewart Crossing - July 5 – August 31
Mcquesten River below WSC Station - July 5 – August 31
Pelly River downstream of Pelly Crossing - July 5 – August 31
Nordenskiold River at Elk Sign - July 21 – September 3
Teslin River at Hootalinqua - July 15 – September 10
Yukon River at Policeman’s Point - July 21 – September 3
Yukon River at Anson Bend - July 25 – September 3

Table 2. Alaska DEC Water Temperature Standards for Upstream Salmon Migration				
Station	Year	Dates	Maximum Hourly	Days exceeding 15 degrees
Stewart River at Stewart Xing	2012	July 5 - Aug 31	17	14
	2013	July 5 - Aug 31	18.7	43
Mcquesten River at WSC station	2012	July 5 - Aug 31	14.2	0
	2013	July 5 - Aug 31	16.7	26
Pelly River downstream of Pelly Xing	2012	July 5 - Aug 31	17.3	20
	2013	July 5 - Aug 31	20.8	49
Nordenskiold River at Elk Sign	2012	July 21 - Sept 3	16.8	10
	2013	July 21 - Sept 3	16.8	22
Teslin River at Hootalinqua	2012	July 15 - Sept 10	16.5	28
	2013	July 15 - Sept 10	19.8	46
Yukon River at Policemans Point	2012	July 21 - Sept 3	16	20
	2013	July 21 - Sept 3	18.2	31
Yukon River at Anson Bend	2013	July 25 - Sept 3	18.2	34

The results of applying the Alaska Department of Environmental Conservation Standards are presented in Table 2. In 2012 all Stations except for the Mcquesten River at WSC Station exceeded the Standard of 15^{0} C. In 2013 all Stations exceeded the upstream migration Standard, and most did so for significant periods of time.

Table 3. Fraser River Water Temperature Thresholds for Upstream Migration							
Station	Year	Dates	Maximum mean daily	MeDT exceeding 18	19	20	21
Stewart River at Stewart Xing	2012	July 5 - Aug 31	16.5	0	0	0	0
	2013	July 5 - Aug 31	18.1	2	0	0	0
Mcquesten River at WSC station	2012	July 5 - Aug 31	13	0	0	0	0
	2013	July 5 - Aug 31	15.3	0	0	0	0
Pelly River downstream of Pelly Xing	2012	July 5 - Aug 31	16.8	0	0	0	0
	2013	July 5 - Aug 31	19.1	15	2	0	0
Nordenskiold River at Elk Sign	2012	July 21 - Sept 3	16.1	0	0	0	0
	2013	July 21 - Sept 3	18.4	3	0	0	0
Teslin River at Hootalinqua	2012	July 15 - Sept 10	15.8	0	0	0	0
	2013	July 15 - Sept 10	19.2	7	3	0	0
Yukon River at Policemans Point	2012	July 21 - Sept 3	15.6	0	0	0	0
	2013	July 21 - Sept 3	18.2	3	0	0	0
Yukon River at Anson Bend	2013	July 25 - Sept 3	18	2	0	0	0

The results applying the Fraser River ewatch Temperature Thresholds are presented in Table 3. None of the rivers exceeded any Threshold in 2012. In 2013 all Stations except the Mcquesten River at WSC exceeded the lowest Threshold, that of potentially decreased swimming performance. The Pelly and Teslin Rivers had short excursions beyond the second Threshold, that of early signs of physiological distress and slow migration.

Spawning

Stations on all spawning streams and rivers collect temperature data throughout the year. The assumed spawning periods are conservative. This is to address a potentially wide range of annual or inter-annual spawning timing. Stations assessed for spawning related temperatures and the assumed spawning periods follow:

North Klondike River at North Fork Bridge - July 15 – August 20
Mcquesten River below WSC Station - July 15 – August 31
Blind Creek at abandoned bridge - July 20 – August 20
Tatchun River below Tatchun Lake - August 5 to September **5**
Nordenskiold River at Elk Sign - August 1 - 31
Little Salmon River at canoe landing - August 1 - 31
Teslin River at Hootalinqua – July 20 – September 10
Takhini River below Kusawa Lake - August 1 - 31
McIntyre Creek below Mountainview Drive - August 1 - 31
Yukon River at Anson Bend - August 1 - 31

Table 4. ADEC Water Temperature Standards for Spawning

Station	Year	Dates	Maximum Hourly	Days exceeding 13 degrees
North Klondike River at North Fork Bridge	2012	July 15 - Aug 15	12.2	0
	2013	July 15 - Aug 15	12.6	0
Mcquesten River at WSC station	2012	July 15 - Aug 31	14.1	5
	2013	July 15 - Aug 31	16.7	35
Blind Creek at abandoned bridge	2012	July 20 - Aug 20	13.9	8
	2013	July 20 - Aug 20	15.7	19
Tatchun River below Tatchun Lake	2012	Aug 5 - Sept 5	17.9	31
	2013	Aug 5 - Sept 5	22.1	All
Nordenskiold River at Elk Sign	2012	Aug 1 - Aug 31	14.6	19
	2013	Aug 1 - Aug 31	16.7	20
Little Salmon River at Canoe Landing	2013	Aug 1 - Aug 31	19.2	24
Teslin River at Hootalinqua	2012	July 20 - Sept 10	16.5	45
	2013	July 20 - Sept 10	19.8	All
Takhini River below Kusawa Lake	2013	Aug 1 - Aug 31	17.4	All
McIntyre Creek below Mountainview Dr	2012	Aug 1 - Aug 31	15.2	18
	2013	Aug 1 - Aug 31	18.1	19
Yukon River at Anson Bend	2013	Aug 1 - Aug 31	18.2	All

The results of applying the Alaska Department of Environmental Conservation Standards for spawning are presented in Table 4. In 2012 and 2013 all Stations except for the North Klondike River at North Fork exceeded the Standard of 13^0 MaxDT. In 2012, the Tatchun, Nordenskiold, Little Salmon and Teslin Rivers and McIntyre Creek exceeded the Standard for more than 50% of the days during the assumed spawning period. In 2013 Stations on the Tatchun River, Little Salmon River, Takhini River and Yukon River at Anson Bend exceeded the spawning and incubation standard on all days of the assumed spawning period.

No Canadian temperature Standards or Thresholds for wild Chinook Salmon spawning were found.

Annual Thermal Budget

The Annual Accumulated Thermal Units for the Annual Stations are presented in Table 5. AATUs could only be calculated for those Stations with complete data sets. This excluded the McQuesten River at the WSC Station as the data loggers had been lost sometime between September 2012 and June 2013. Stations at the Little Salmon River at Canoe Landing and the Takhini River below Kusawa Lake were excluded as data collection for both Stations started in 2012. The Yukon River at Anson Bend was not established until 2013. In 2012 the AATUs varied widely, from 991.4 at the North Klondike River at the North Fork Bridge to 2398.4 at the Tatchun River below Tatchun Lakes.

Table 5. Annual Accumulated Thermal Units: calendar year

Station	AATU 2012
North Klondike River at Viceroy Bridge	991.4
Mcquesten River at WSC Station	Incomplete data
Blind Creek at abandoned bridge	1174.8
Tatchun River below Tatchun Lake	2398.4
Nordenskiold River at Elk Sign	1580.5
Little Salmon River at Canoe Landing	Insufficient data
Yukon River at Policemans Point	1842.3
Takhini River below Kusawa Lake	Insufficient data
McIntyre Creek below Mountainview Dr	1744.8
Yukon River at Anson Bend	Not established

The Annual Biological Accumulated Thermal Units for the Annual Stations are presented in Table 6. There was sufficient data for ABATUs to be calculated for 2011-12 and 2012-13 for Stations with complete data sets. Where comparisons could be made between the two years, the 2012-13 ABATUs were greater. The differences were not large: for Blind Creek, +23.7 Thermal Units (TU); Tatchun, +148.4 TU; McIntyre Creek, +130.2 TU; and Yukon River at Policemans Point, +66 TU. As with the AATUs there was a wide range variation among the ABATUs. These extended from the North Klondike River at North Fork Bridge Station 2012-13 value of 965.2 to the Tatchun River below Tatchun Lake value of 2012 – 13 value of 2503.

Table 6. Annual Biological Accumulated Thermal Units: Aug 15 to the following Aug 14

Station	Degree Days 2011-12	Degree Days 2012-13
North Klondike River at Viceroy Bridge	Incomplete data	965.2
Mcquesten River at WSC Station	1500.8	Incomplete data
Blind Creek at abandoned bridge	1167.3	1191
Tatchun River below Tatchun Lake	2354.6	2503
Nordenskiold River at Elk Sign	Incomplete data	1656
Little Salmon River at Canoe Landing		insufficient data
Yukon River at Policemans Point	1816	1882
Takhini River below Kusawa Lake		insufficient data
McIntyre Creek below Mountainview Dr	1674.1	1804.3
Yukon River at Anson Bend		insufficient data

Discussion

Application of the Alaska DEC Upstream Migration and Spawning Standards implies that many CYRB Chinook salmon stocks are at risk during these life processes even in cold years. However, Standards prepared in other jurisdictions for other purposes and based other species must always be cautiously applied. The Alaska DEC Standards appear to have been transferred from US Pacific North West Standards developed in Pacific North West States. The ADEC standards appear to be too conservative to assess risk for the upstream migration of Chinook Salmon in the CYRB.

The Standards do, however, provide a framework to communicate the results of water temperature monitoring to scientific/technical/regulatory staff, and particularly those from Alaskan and US Federal Agencies. The inter-annual differences in the number of days that the Standards were exceeded in 2013 in comparison to 2012 demonstrated clearly the effects of inter-annual variation in air temperature on Yukon River migration and spawning habitats.

Less clear is the effect of the depletion of surcharged surface and subsurface storage in the watershed. Surface storage includes ice and snow at high altitudes, and water held in flooded meadows, wetlands, ponds and lakes. Subsurface storage includes water stored in confined and unconfined aquifers and as permafrost. Multi-year periods of increased precipitation and low air temperatures results in the storage capacity being realized or exceeded. If precipitation and temperatures return to more dry and warm conditions stream flows will lag somewhat as the stored waters drain. Watersheds with plentiful storage, such as those in the glaciated portion of the Yukon, commonly exhibit these characteristics. This is believed to have happened during the summer of 2013. Despite relatively warm weather, stream and river flows remained high through much of the summer.

The Fraser River ewatch Thresholds for Upstream Migrating salmon are believed to be more applicable to Yukon River Chinook Salmon, despite being developed for sockeye salmon. An important consideration is that they were based on both in-river and laboratory investigations. The Thresholds are at significantly higher temperatures than are the ADEC standards. Pending development of YR Chinook specific Thresholds the Fraser River Thresholds are considered the best tool to provide guidance for the conduct of risk assessments related to elevated water temperatures. Application of the ewatch Thresholds to the data collected in the CYRB during 2012 and 2013 indicates that water temperatures did not negatively affect upstream migration in 2012 at any Station. Effects in 2013 would probably have been minor. However, they provide early identification that the Teslin and Pelly Rivers are temperature sensitive for upstream migrating salmon.

The AATUs calculated to date do not allow inter-annual comparisons at any station. 2012 was atypically cold and comparisons between Stations are at best provisional. However, the data to data suggests that grouping of Annual Stations by AATUs is possible: as an example, into cold, cool and warm groups. Extending this to 2012, the North Klondike River at the North Fork Bridge and Blind Creek at the abandoned Bridge Stations AATUss of 991.4 and 1174.8 were cold; the Nordenskiold River at Elk Sign, McIntyre Creek below Mountainview Drive, and the Yukon River at Policeman's Point with AATUs of 1580.5, 1744.8 and 1842.3 were cool; and the Tatchun River below Tatchun Lake, with an AATU of 2398.4 was warm.

The AATUs provide insight into temperature related potential productivity of the measured streams, where productivity is defined as either the "Capacity or ability of an environmental unit to produce organic material" or the "Rate of formation of new tissue or energy use by one or more organisms" (Armantrout, 1998). This relates to the effects of temperature on the aquatic ecosystem and on the ability of the ecosystem to produce food organisms that are available for juvenile chinook salmon. The observed differences in abundance and diversity of invertebrates on the loggers and housings at retrieved from Tatchun Creek below Tatchun Lake is remarkable as compared with other Stations, and particularly the coldest, was remarkable.

A value of calculating the AATUs on the calendar year is that it facilitates the communication of temperature related potential productivity in the specific streams being measured, or in classes of streams which they are representative of, to the public or to regulatory agencies or associated environmental assessment entities.

The ABATUs closely tracked the AATUs but allowed a limited degree of inter-annual comparison due to much of the data collected in 2011 being able to be used. The results indicated only limited differences between 2011/2012 and 2012/13. Reasons for this include data from the cold year of 2012 contributing to both ABATUs. Additionally, the 10 – 14 day delay in the spring of 2013 resulted in depressed early season temperatures. This in turn reduced the number of ATUs that were contributed to 2012/13.

The ABATUs provide insight into potential temperature related effects on the incubation and emergence phases of Chinook salmon. Unlike juvenile Chinook salmon, which can move to warmer micro-habitats in the spawning stream or leave it entirely, eggs and alevins are obliged to remain at spawning sites. DFO Habitat and Enhancement Community Involvement Guidelines for Chinook Salmon husbandry provide a range of 825 – 1029 ATUs from egg deposition to to emergence. Application of these guidelines to the ABATUs calculated to date indicate that emergence of Chinook fry in the North Klondike River may not occur until immediately before the adults appear on the spawning grounds. This late emergence would limit the rearing period for the emergent fry and could be expected to negatively affect their growth prior to entering the overwintering phase. Fry emerging in Blind Creek could be similarly affected.

Distribution of Data to Interested Parties

Methods

Address of this objective took place after all data had been organized into data sets and the Working Mean Daily Temperature spreadsheets calculated. On November 24, 2013 emails were sent to contacts in various government agencies to determine their agencies interest in receiving copies of the data within their geographical area of responsibility. If there was interest, they were asked to provide the name of whomever within their organisation they wished to have the data sent to. The Yukon River Intertribal Watershed Council was also contacted.

Following the substantive offer to interested parties, offers to send the data to other individuals and individuals were made as opportunities presented themselves.

Results

To date, a total of 240 data sets have been distributed. Recipients have been government agencies including DFO, YG Fisheries, ADF&G, TKC, SFN, CAFN, TH, TTC and NND: a non-governmental agency, the YRITWC; and two local consulting firms. Responses have not been received from 2 First Nations. Staff changes at the Yukon Research Centre have created difficulties in contacting them electronically. Telephone contact with all three organizations will be made in the New Year.

The US National Oceanic and Atmospheric Administration was contacted and expressed interest in the data. All 47 data sets will be sent to them early in the New Year.

A total of 113 Working Mean Daily Temperature spreadsheets have been distributed. The spreadsheets were sent to recipients for each Station they were given data sets for. A complete set was provided to the Water Survey of Canada at their request.

Discussion

Response from interested parties has been gratifying. It indicates the increasing interest in the role that temperature plays in the aquatic ecology of the waters of the CYRB. It also indicates the level of concern with the effects of changing climates on the stream and river temperatures and on the Chinook Salmon that spawn and rear there.

The large number of data sets distributed to date reflects in part the practice of sending all data sets developed to date for each station. Assuming that funding continues, only current year data and updated Working MeDT Worksheets will be distributed to those interested parties which have received the material this year. A reduced annual number of data set distributed is anticipated.

Ensuring Public Accessibility of Data collected

Methods

A complete set of the data was provided to the ADF&G for inclusion in the web-based, publicly available data base referred to by Leba (2011, 2012). A complete set of data was provided to the YRITWC. Discussions took place with the YRC and data sets were sent to them so that suitable protocols could be developed.

Results

Personnel changes have taken place at the ADF&G and the trajectory of the development of the publicly available data base may have slowed. Regardless, the data is in their hands. The YRIWC has the data and a publicly available water quality data base, but have not committed to hosting the water temperature data on it. Personnel changes have occurred in the YRC and contact will be re-established in the New Year.

Discussion

Ensuring public accessibility to water temperature data has not proceeded as quickly as hoped. This has been largely due to personnel changes within agencies and institutions during the formative stage of program development. High rates of turnover in government and agency staff are a feature of the northern technocracy. Additional investment of time and effort will be required to assist new staff of the advisability of meeting the Program's objectives.

Conclusion

The first year of implementation of the "Temperature Monitoring of Yukon River Chinook Salmon Spawning and Migration Habitats in Canada Program" was successfully completed. The Temperature Monitoring Network was operated, maintained and adaptively managed. One Seasonal Station was deleted due to river channel destabilization. An Annual Station was added to address future development pressures and to support efforts to assess releases of artificially propagated juvenile Chinook Salmon.

Considerable interest was shown in the data collected. Data sets were widely distributed and the distribution continues.

There is as yet no database from which the temperature data may be accessed by the public. However, discussions, and potentially development, continues.

As this document is being completed, 20 data loggers are measuring temperatures at 10 Annual Stations. They are developing the base line with which future salmon managers will compare the environments that, hopefully, they and the salmon will be contending with.

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