Regional Information Report No. 3A11-05

Temperature monitoring on select Yukon River tributaries, final report to the Yukon River Panel

by

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Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL INFORMANTION REPORT NO. 3AYY-XX

TEMPERATURE MONITORING ON SELECT YUKON RIVER TRIBUTARIES

FINAL REPORT TO THE YUKON RIVER PANEL

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ABSTRACT

As temperature affects many life history processes of salmon, and temperature within the Yukon River drainage is dynamic and varied along the mainstem and among tributaries, it is crucial to obtain water temperature data during months when adult salmon are migrating and spawning. The goals of this project were to compile existing river temperature data for salmon bearing waters in the Yukon River watershed, deploy data loggers at escapement projects where stream temperature is not currently monitored, and facilitate and maintain a dialogue among Alaskan and Canadian agencies regarding the importance of continued temperature monitoring within the drainage. The field work for this project was completed by August 1, 2010. Data loggers were sent to the Mountain Village Test Fishery project and Emmonak for deployment, one at each site; two more were replaced and deployed at Pilot Station Sonar. Six priority locations were established within the Yukon Territory, Canada: Teslin River, Pelly River, 30 Mile River, Blind Creek, Little Salmon River, and McQuesten River. Data loggers were exchanged at the Nordenskiold River station and a new anchoring method was employed. Data were compiled from 21 U.S. and 29 Canadian sites. The highest mean daily water temperature for 2010 was observed on two Yukon River tributaries: the Anvik River, Alaska and in the Teslin River, Canada. Database development is in the final stages and data will be imported over the next few months.

Key words Yukon River, temperature, climate change, spawning habitat, Chinook salmon.

INTRODUCTION

It is widely accepted that climate change is having an impact on Arctic environments, including thinning sea ice, increase in sea and air temperature, melting permafrost, and the potential for some fisheries to decline due to changes in Arctic ecosystem dynamics (Euskirchen et al. 2009; Stram and Evans 2009; Wendler and Shulski 2009). As a result of climate change, environmental conditions such as flooding, elevated water temperatures, and extremely low water may become more frequent and variable. These environmental changes, particularly water temperature, could affect salmon productivity.

Water temperature is critically important to salmon survival, migration, spawning, and development. Most species of salmon, including Chinook salmon *Oncorhynchus tshawytscha*, migrate and spawn within a specific temperature range, generally from 3°C to 20°C (Richter and Kolmes 2005). However, temperature tolerance varies by species, and often stocks within a species, and is adaptive to the natal environment (Hodgson and Quinn 2002). It has been demonstrated that Columbia basin Chinook salmon migration progress is hindered at water temperatures ranging from 19°C to 23°C (McCullough et. al. 2001). Prolonged exposure to these elevated temperatures and associated low dissolved oxygen levels have been shown to impact adult survival through increased respiratory demands, depleted energy reserves, and metabolic stress (McCullough 1999). Further, the progeny of adult salmon exposed to temperatures from 17.5°C to 19.5°C may experience higher egg and post-hatch mortality, as well as increased likelihood of developmental abnormalities (Berman and Quinn 1990). Though the environment within the Yukon drainage is not identical to the Columbia basin, the effects of climate change within the Alaska and the Yukon Territory are widespread and salmon may be experiencing similar temperature regimes. Identifying specific areas within the drainage as thermal refugia will increase in importance as these effects continue to be felt throughout the Yukon River drainage. Therefore, there is a need to monitor water temperature throughout the region in order to track these changes and assess their potential impacts on Yukon River salmon.

Although water temperature is measured for several escapement monitoring sites, much of the currently available data are spread among agencies and time series do not overlap. In 2008, the

U.S. Fish and Wildlife Service Office of Subsistence Management (USFWS OSM) initiated a collaborative effort with the Alaska Department of Fish and Game (ADF&G), Tanana Chiefs Council (TCC), Bureau of Land Management (BLM), and the Aquatic Restoration and Research Institute to conduct long-term temperature monitoring at 30 salmon escapement sites within Alaska. These sites were within the Yukon, Kuskokwim, Southeast, Southcentral, and Southwest regions. An important component of this project was to ensure that water temperature data are being collected using standardized methods throughout the Yukon River drainage. It is especially critical that temperature is being measured in the same way at both U.S. and Canadian assessment projects. Cooperation among agencies currently monitoring temperature at escapement sites, including the Department of Fisheries and Oceans Canada (DFO) in Whitehorse, Yukon must be a top priority in order to achieve this objective. Further, ensuring that all U.S. assessment projects are utilizing comparable data loggers and monitoring techniques is critical if data are to be compared between sites within each region. This project aims to enhance the data collection process and improve the temperature monitoring that is currently ongoing, while identifying other sites that are not currently monitored, but are known to be important escapement and spawning tributaries.

OBJECTIVES

The main objectives of this project were to: 1) inventory the available temperature data and assess the level of standardization; 2) initiate deployment of temperature data loggers following a standardized protocol; and 3) develop a database of existing data to set the stage for future analyses. These aims were to be accomplished through collaboration and open dialogue across State and Federal agencies, including those in Canada.

METHODS

TEMPERATURE INVENTORY

By networking with other agencies, such as USFWS, USGS, and DFO, as well as contacting staff within ADF&G, most of the known temperature data for escapement monitoring projects within the Yukon drainage was collected and compiled into Microsoft Excel[1] workbooks. These data were organized by country of origin and include detailed metadata regarding monitoring equipment used, site location, sampling duration, source of the data (i.e., from which agency) and name of project leader, where possible. Data were compiled into tables summarizing this metadata. Graphs were created for select data sets from U.S. and Canadian sites.

DATA STANDARDIZATION

Canadian and U.S. sites were ranked and priority was given to those locations for which no previous temperature information exists, that were logistically accessible, and that were known to have critical spawning habitat. Additionally, sites that were deemed of high importance where temperature is being monitored but data loggers are not currently employed, or do not conform to standard protocols, were given high priority. Further, current assessment projects that already have loggers in place were reviewed and modified to conform to standard protocols. We attempted to deploy a total of 3–5 loggers during this field season (1–2 per site) at sites that

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

satisfied the above criteria. This includes eight current projects located at or near spawning habitat, most of which are easily accessible by local road.

Data loggers were installed and calibrated following a standardized protocol (see Dunham et al. 2005; von Finster 2010). Data loggers will remain at the sites for an entire year (through winter and breakup), if possible, and will be replaced at the end of the summer with new equipment to be recovered in the spring. This will avoid loss of entire data sets if loggers are lost or malfunction through the winter. A modified anchoring method employing a flow-through housing made of PVC pipe was used. This method was preferred to a closed housing as it allowed water to flow around the data logger, facilitating more accurate temperature data collection. In locations where year-long deployment was not possible due to environmental conditions, loggers were deployed at the beginning of the summer and retrieved prior to ice build-up. Agency staff stationed at the chosen locations were asked to periodically monitor the loggers and report any problems that arose.

The HOBO Pro v2 water temperature data logger was used at U.S. sites and the Onsite Tidbit was used at Canadian sites. Installation location at each site was contingent upon local water conditions: water depth, freshwater input, and river width. At each new site, GPS coordinates were recorded, details of data logger placement, including inriver depth where possible, distance from the river bank, and landmarks along the banks, were noted, photographs were taken, and if necessary, a float demarcating the location of the instrument was utilized. Every effort was made to situate monitoring equipment in well-mixed areas in order to accurately represent inriver temperature (see von Finster 2010). Each data logger was programmed to record water temperature hourly, 24 hours per day, 7 days per week, from the time of deployment until retrieval. Hourly sampling ensured that minute changes in temperature throughout the day were recorded and accurately reflected the temperature regime at that site. All data were downloaded upon logger retrieval and imported into Microsoft Excel spreadsheets that can be imported into the database.

DATABASE DEVELOPMENT

The development of an information repository, created in SQL Server, was initiated to store all available temperature data compiled during this project and will include data across agencies including ADF&G, USFWS, USGS, BLM, the Yukon River Panel, and DFO. The water temperature data will be incorporated into the existing ADF&G AYK Database Management System (DBMS). All data will be imported in a standardized format, thus making all data comparable both within and across years and locations. When completed, the data will be accessible to other staff and the public via a website interface as part of the DBMS and will aim to present temperature data as clearly as possible. Further, database development will be ongoing and we will endeavor to continuously update the content every year.

RESULTS

TEMPERATURE DATA INVENTORY

Alaskan Projects

Through collaboration with USFWS, USGS, and other ADF&G staff, data were compiled from 21 locations throughout the Yukon River drainage (Table 1). However, this list is not yet complete, as data from 2010 are not yet finalized and some sites are missing historical data.

Water temperature data were collected using two main methods: a thermometer and a data logger. When thermometers were used, temperature was collected either daily or twice daily. Temperature was monitored at a variety of frequencies from data loggers, including hourly, every four hours and every six hours. Mean daily water temperatures from the 2010 season are presented for Pilot Station (Figure 1), Eagle (Figure 2), Anvik (Figure 3), Sheenjek (Figure 4), and Rampart Rapids (Figure 5). From sites presented here, water temperatures were warmest at Eagle, reaching over 21°C (Table 2). This high temperature was observed between July 25 and August 4 when temperatures varied by nearly 10°C (Figure 2). Among the four sites, the contrast between minimum and maximum daily temperatures was greatest at Anvik, with daily fluctuations of 5 and 6°C for July 9 and 10, respectively. Water temperatures were cooler in the Sheenjek River, less than 13°C, and decreased for the duration of the monitoring period. Daily mean, maximum, and minimum temperatures were monitored at the Rampart Rapids fish wheel (Figure 5); the overlapping trend lines are indicative of a well-mixed water column at this site. Seasonal maximum and minimum temperatures were similar to Pilot Station (Table 2).

Canadian Projects

Data were compiled from 29 locations throughout the Canadian portion of the Yukon River (Table 3). Compared to the U.S. data, only one method of data collection was used, the data logger. All deployments were seasonal, with data loggers being retrieved prior to ice build-up in the fall. In most cases, water temperature was measured hourly each day for the duration of the deployment. DFO was the main agency involved in collecting these data, however, the Ta'an Kwach'an Council established several monitoring stations in 2010 within their Traditional Territories. Many of these stations are not associated with assessment projects, as compared to the U.S. sites where temperature is typically measured in conjunction with an already established project. Hourly water temperatures collected from the Yukon River mainstem upstream of Lake Laberge (Figure 6) indicate fluctuations of up to 6°C within the summer season. Data from a large tributary, Takhini River, indicated fluctuations in temperature of a few degrees over several days (Figure 7). In contrast, larger daily fluctuations were seen in the smaller tributary, Fox Creek (Figure 8), similar to the Sheenjek River in Alaska. Water temperatures within the Teslin River at Hootalinqua showed similar fluctuations to Eagle, with maximum summer season temperatures reaching over 19°C (Figure 9).

DATA COLLECTION

Alaskan Sites

The field work for this project was completed by August 1, 2010 and data loggers were deployed at three locations on the mainstem Yukon: 1) Emmonak; 2) Mountain Village; and 3) Pilot Station. Data loggers were sent to the Mountain Village Test Fishery project and Emmonak for deployment, one at each site; two more were replaced and deployed at Pilot Station Sonar, one on each bank of the river. Travel to Eagle had been planned, but was canceled due to high water and road closures. These sites are critical for monitoring water temperature during the spawning migration and are associated with ADF&G assessment projects. Unfortunately, data loggers were lost in-season at both Emmonak and Mountain Village, thus no data were collected from those locations. Mean daily water temperature collected from the left bank site at Pilot Station is presented in Figure 1.

Canadian Sites

Travel to Whitehorse and Dawson City, Yukon Territory, Canada occurred from July 20 to 29. Effort was made to visit as many road-accessible streams as possible. Collaborating with Al von Finster, nearly 25 Chinook salmon spawning streams, creeks and tributaries were visited within the Pelly, Stewart, Teslin, White, and Klondike River drainages. These locations included important spawning tributaries such as the Takini River, Kluane River, Teslin River, Nisutlin River, Nordenskiold River, McClintock River, Tatchun Creek, and Blind Creek. In addition, we visited the Division of Fisheries and Oceans Blind Creek weir to observe the project operations and locate appropriate data logger deployment sites upstream. Data loggers were exchanged at the Nordenskiold River station and a new anchoring method was employed following protocols from von Finster (2010). This anchoring method was an improvment over old methods and was more reliable (Al von Finster, personal communication). A meeting with Rosa Brown of the Ta'an Kwach'an Council took place to discuss the TKC's water monitoring efforts within their territory, including the Takini River and upstream of Lake Laberge. Six priority locations were established after reviewing the sites visited: Teslin River, Pelly River, 30 Mile River, Blind Creek, Little Salmon River, and McQuesten River. Criteria for site selection included the lack of local groundwater input, appropriate stream bank topography, road accessibility, and average number of Chinook spawning at each location. Of these tributaries, only the Teslin River is currently being monitored for temperature by the Ta'an Kwach'an Council. All are important Chinook spawning habitats or migration corridors, thus should be the first suite of locations where additional temperature data loggers are deployed in future years.

DATABASE DEVELOPMENT

All available temperature data is currently being acquired, organized and summarized. USFWS, USGS, Division of Fisheries and Oceans Canada, and ADF&G have all contributed datasets. The first database organization and structure meeting took place in early August. Meeting topics included data organization to maximize query results, identify and label the data attached to each "project," establish the user interface and determine public access points, the creation of a timeline of database completion, work assignments, and deliverables.

A draft database structure was created within the existing Arctic-Yukon-Kuskokwim Database Management System (AYK DBMS) and the development will be ongoing as staff time allows. The database structure is in final draft, however, it may change as all data are gathered and imported. The initial data inventory has been completed along with the initial gathering of the data. The data has started to be reformatted in order to be imported into the database. This process has been slowed due to the bulk of the data and difficulty in locating data. Lack of staff time and the necessity to prioritize other ADF&G projects was one of the greatest challenges to database completion. Discrepancies between datasets and how data was collected and stored among projects created challenges when planning the overall structure of the database. In addition, incompleteness of some datasets posed problems when attempting to relate data to each other or match with specific dates and times.

DISCUSSION

DATA INVENTORY

The most important aspects of this project were to assess the level of standardization across agencies and monitoring sites, and to deploy data loggers if possible. Only a few new data loggers were deployed, due to time constraints and travel budgets. Results of this project confirmed the supposition that water temperature data protocols varied widely throughout the Yukon River drainage. This was especially evident throughout Alaska, where projects utilized two different data collection methods and employed a range of collection frequencies. Data loggers were the primary data collection method in the Yukon Territory. Despite the variation in methodology, water temperature data has successfully been collected for nearly 30 years at some locations within Alaska, whereas the longest running Canadian dataset dates back only six years. Several State, Federal and non-government organizations have collected and stored temperature data during this time period, which significantly complicated the data compilation process. As a result, the database to house this information and a complete list of projects and agencies has not yet been finished. However, through networking with other agencies, there is now new awareness that data collection standardization is a priority.

DATABASE DEVELOPMENT

During the next phase of the project, the data gathering will need to be completed before the database structure is finalized. All datasets will need to be reformatted and attributes added before data can be loaded into the current draft database. Also, before loading data, changes need to be made to the AYK DBMS system to incorporate the new data type. In addition, new projects will need to be created in the system and the new data type added to existing project years where applicable. Next steps for this project include creating “projects” for data not associated with established assessment projects, specifically for the Canadian temperature datasets. A new data type, called “water temperature” will need to be incorporated into the existing DBMS in order to access all temperature data through the DBMS website. Finally, data will be imported into the system and made searchable through the online interface via the ADF&G website. The ability to access all datasets within the Yukon River drainage will facilitate future analyses including, but not limited to, relationships between inriver temperature during parent years and the number of return spawners.

WATER TEMPERATURE SUMMARY

Summary data from selected 2010 projects presented here provide some insight as to the temperature regimes experienced by salmon as they migrate upstream to spawning grounds. Within the Yukon drainage, water temperature at mainstem locations such as Pilot Station, Rampart Rapids, Eagle and Lake Laberge exhibited little diel fluctuation and temperatures remained within a 1–2 degree range for several days. However, water temperatures occasionally exceeded 18°C, except at Lake Laberge, and remained high for days at a time, potentially impacting salmon movement upstream due to thermal stress (McCullough 1999). In areas where the water column is well mixed, such as Rampart Rapids, there may be limited cold water refugia for holding salmon, thus increasing physiological stress and prolonging exposure to potentially lethal temperatures (McCullough 1999). Rapid diel changes in temperature where salmon are exposed to elevated temperatures for a brief time, such as occurred in the Anvik River and Fox Creek, may also impact adult survival (McCullough 1999). Most data loggers monitor surface water, however, the depth at which the loggers were placed was not recorded at any project locations. Data loggers are often placed in somewhat protected, but well mixed, areas to avoid being buried by silt and damaged by debris and bedload traveling down the deepest part of the waterway. Therefore, depths across stations would not be comparable, as deployment sites are selected based on specific conditions at each project. Knowing depth of placement is critical, however, as salmon migrating through mainstem river sections could swim deeper to avoid high temperatures at the surface, but may not be able to do so when migrating through very shallow tributaries.

The results of this project indicate that salmon within the Yukon drainage may be experiencing thermal regimes at the upper end of their physiological tolerance. Exposure to these elevated water temperatures likely puts adults at risk for increased pre-spawning mortality or spawning failure (Schreck et al. 1994). This knowledge further highlights the importance of monitoring water temperature within the Yukon River mainstem and tributaries to better understand the changes occurring and their impacts on salmon.

ACKNOWLEDGEMENTS

Al von Finster was instrumental in organizing travel to Chinook salmon spawning sites within the Yukon Territory, provided thoughtful dialogue regarding data logger installation, assisted in selection of appropriate deployment locations, and provided datasets. Thanks to Rosa Brown for her collaboration through the Ta'an Kwätch'an Council. Holly Krenz and Christopher Lawn provided technical expertise for database development. Additionally I would like to thank Roger Dunbar, Jody Lozori, Malcolm McEwen, Stan Zuray, USGS, USFWS and ADF&G for providing temperature datasets. Funding was provided by the Restoration and Enhancement Fund of the Yukon River Panel, project 25N-10.

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TABLES AND FIGURES

Table 1.–Water temperature monitoring sites within the U.S. portion of the Yukon River drainage.

Location	Number of years	Collection frequency	Annual/Seasonal	Technology	Agency	Project	Watershed
Andreafsky	2	hourly	seasonal	data logger	USFWS	weir	Lower Yukon
Anvik	14	daily	seasonal	thermometer	ADF&G	sonar	Lower Yukon
		every 6 hours	seasonal	data logger	ADF&G	sonar	Lower Yukon
Beaver	2	hourly	seasonal	data logger	USFWS		Upper Yukon
Big Eddy	25	twice daily	seasonal	thermometer	ADF&G	test fish	Lower Yukon
Chandalar	1	hourly	seasonal	data logger	USFWS	weir	Upper Yukon
Chena	2	hourly	seasonal	data logger	USFWS	tower	Middle Yukon
Eagle	6	daily	seasonal	thermometer	ADF&G	test fish	Upper Yukon
		hourly; every 4 hours		data logger	ADF&G	sonar	
Emmonak		unknown	seasonal	data logger	ADF&G	test fish	Lower Yukon
Galena	2	hourly	seasonal	data logger	USFWS		Lower Yukon
Henshaw	1	hourly	seasonal	data logger	USFWS		Middle Yukon
HulaHula	1	hourly	seasonal	data logger	USFWS		Middle Yukon
Kantishna		every 4 hours	seasonal	data logger	ADF&G		Lower Yukon
Middle Mouth	25	daily; twice daily	seasonal	thermometer	ADF&G	test fish	
Mountain Village	1	hourly	seasonal	data logger	YDFDA	test fish	Lower Yukon
Pilot St.	15	daily	seasonal	thermometer	ADF&G	test fish	Lower Yukon
		every 4 hours		data logger	ADF&G	sonar	
Rapids	1	hourly	seasonal	data logger	USFWS		Middle Yukon
	8	hourly	seasonal	data logger	S. Zuray	video wheel	Middle Yukon
Salcha	2	hourly	seasonal	data logger	USFWS	tower	Middle Yukon
Selawik	2	hourly	seasonal	data logger	USFWS		
Sheenjek	30	daily	seasonal	thermometer	ADF&G	sonar	Upper Yukon
		every 4 hours		data logger	ADF&G		Upper Yukon
Tanana	1	hourly	seasonal	data logger	USFWS	test fish	Middle Yukon
Tolovana	1	hourly	seasonal	data logger	USFWS		Middle Yukon

Table 2.–Seasonal minimum and maximum water temperatures for select Yukon River locations within Alaska and Canada, 2010.

Country	Location	Dates monitored	Water temperature, °C	
			Min	Max
U.S.				
	Pilot Station (left bank)	May 29 – September 7	10.6	18.6
	Anvik River	July 2 – July 27	10.1	19.3
	Rampart Rapids fish wheel	June 16 – September 20	9.4	18.6
	Sheenjek River	August 19 – September 26	2.0	12.3
	Eagle	July 3 – October 6	3.0	21
Canada				
	Mainstem downstream of Lake Laberge	May 28 – September 14	5.5	16.7
	Takhini River	June 16 – September 13	8.9	17.4
	Fox Creek	June 16 – September 13	6.1	17.8
	Teslin River at Hootalinqua	June 23 – September 14	10.5	19.2

Table 3.–Water temperature monitoring sites within the Canadian portion of the Yukon River drainage.

Location	Number of years	Collection frequency	Annual/Seasonal	Technology	Agency	Project	Watershed
Caribou Creek	1	hourly	seasonal	data logger	DFO		Upper Yukon
Chandindu River	2	hourly	seasonal	data logger	DFO		Upper Yukon
Christmas Creek	1	hourly	seasonal	data logger	DFO		Upper Yukon
Clinton Creek	3	hourly	seasonal	data logger	DFO		Upper Yukon
Croucher Creek	5	hourly	seasonal	data logger	DFO		Upper Yukon
					TKC		
Deep Creek	1	hourly	seasonal	data logger	TKC		Upper Yukon
Fifteen Mile	1	hourly	seasonal	data logger	Bill Kendrick		Upper Yukon
Fishing Branch	2	hourly	seasonal	data logger	DFO	weir	Upper Yukon
Flat Creek	1	hourly	seasonal	data logger	TKC		Upper Yukon
Fox Creek	5	hourly	seasonal	data logger	DFO		Upper Yukon
Grayling Creek	1	hourly	seasonal	data logger	DFO		Upper Yukon
Horse Creek	1	hourly	seasonal	data logger	TKC		Upper Yukon
Joe Creek	1	hourly	seasonal	data logger	TKC		Upper Yukon
Klondike River	6	hourly	seasonal	data logger	DFO	sonar	Upper Yukon
					Bill Kendrick		
Klusha Creek	2	hourly	seasonal	data logger	DFO		Upper Yukon
Laberge Creek	1	hourly	seasonal	data logger	TKC		Upper Yukon
Laurier Creek	1	hourly	seasonal	data logger	TKC		Upper Yukon
Mayo River	3	hourly	seasonal	data logger	DFO		Upper Yukon
Mica Creek	1	hourly	seasonal	data logger	DFO		Upper Yukon
Mickie Creek	3	hourly	seasonal	data logger	DFO		Upper Yukon
Sheep Rock	6	daily	seasonal	data logger	DFO	fish wheel	Upper Yukon

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Table 3.–Page 2 of 2.

Location	Number of years	Collection frequency	Annual/Seasonal	Technology	Agency	Project	Watershed
Takhini River	1	hourly	seasonal	data logger	TKC		Upper Yukon
Tatchun Creek	1	hourly	seasonal	data logger	DFO		Upper Yukon
Teslin River	1	hourly	seasonal	data logger	DFO, TKC		Upper Yukon
Willow Creek	1	hourly	seasonal	data logger	DFO		Upper Yukon
Yukon River							
near Lake Laberge	1	hourly	seasonal	data logger	TKC		Upper Yukon
at Whitehorse hospital	1	hourly	seasonal	data logger	TKC		Upper Yukon
above Klondike River	1	hourly	seasonal	data logger	Bill Kendrick		Upper Yukon

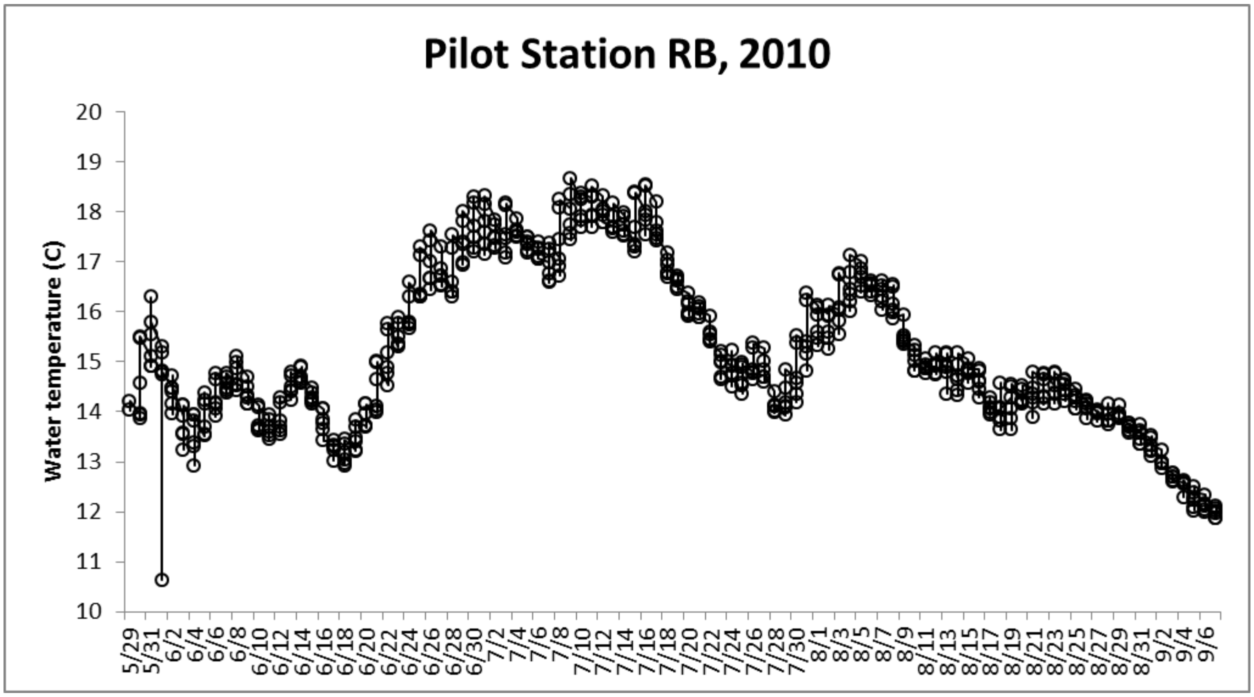

Figure 1.–Data were collected every four hours at the right bank sonar site at Pilot Station, Alaska.

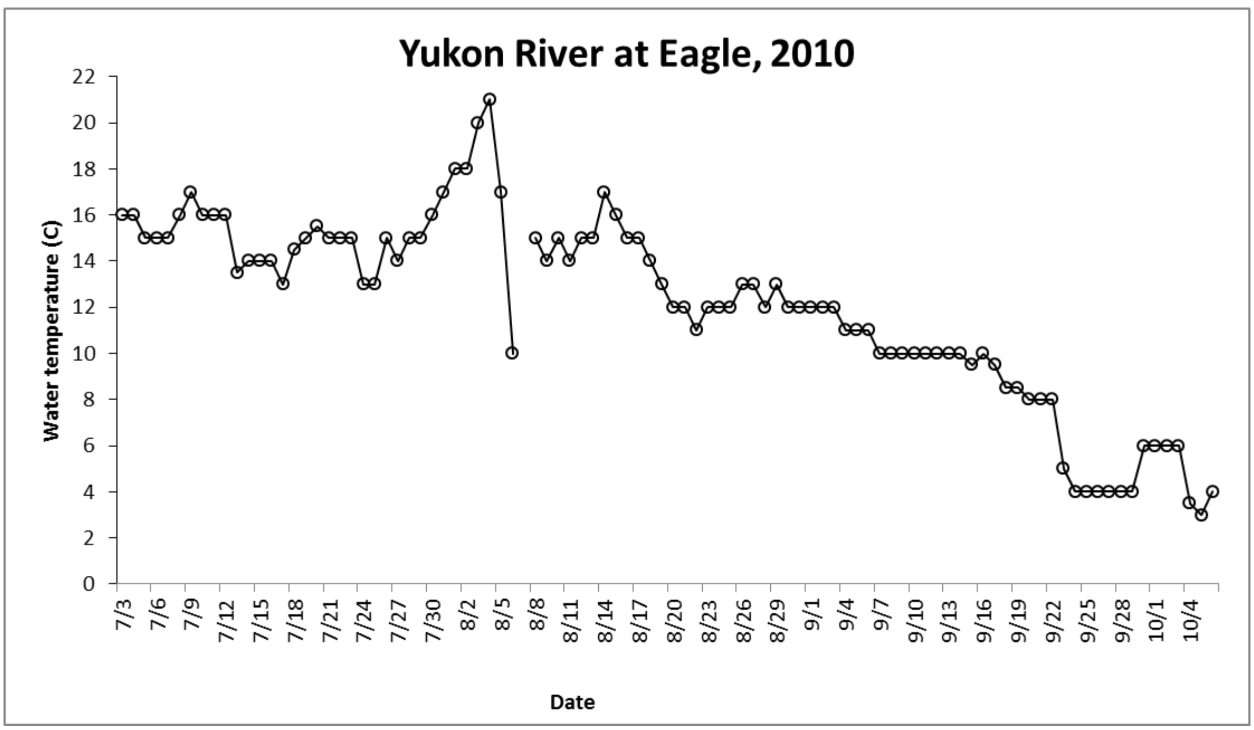

Figure 2.–Data were collected every four hours at the sonar site at Eagle, Alaska, but only the daily average was provided for this report.

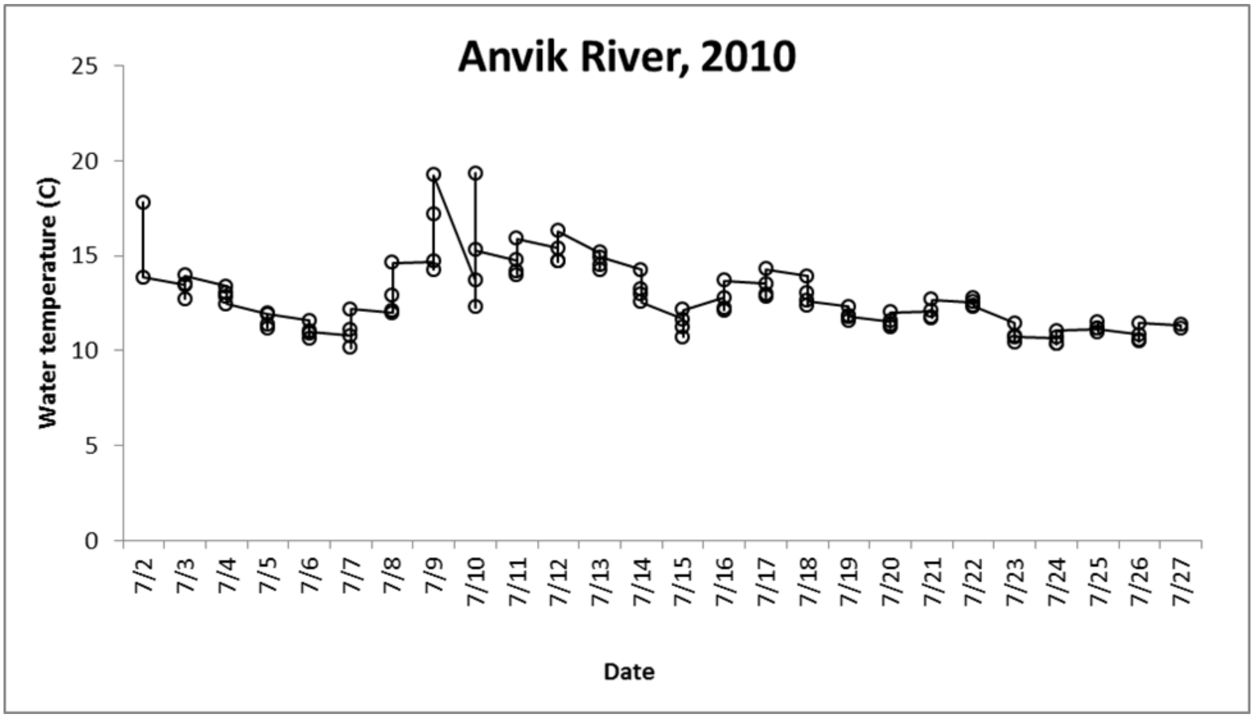

Figure 3.–Data were collected every six hours at the Anvik River sonar site.

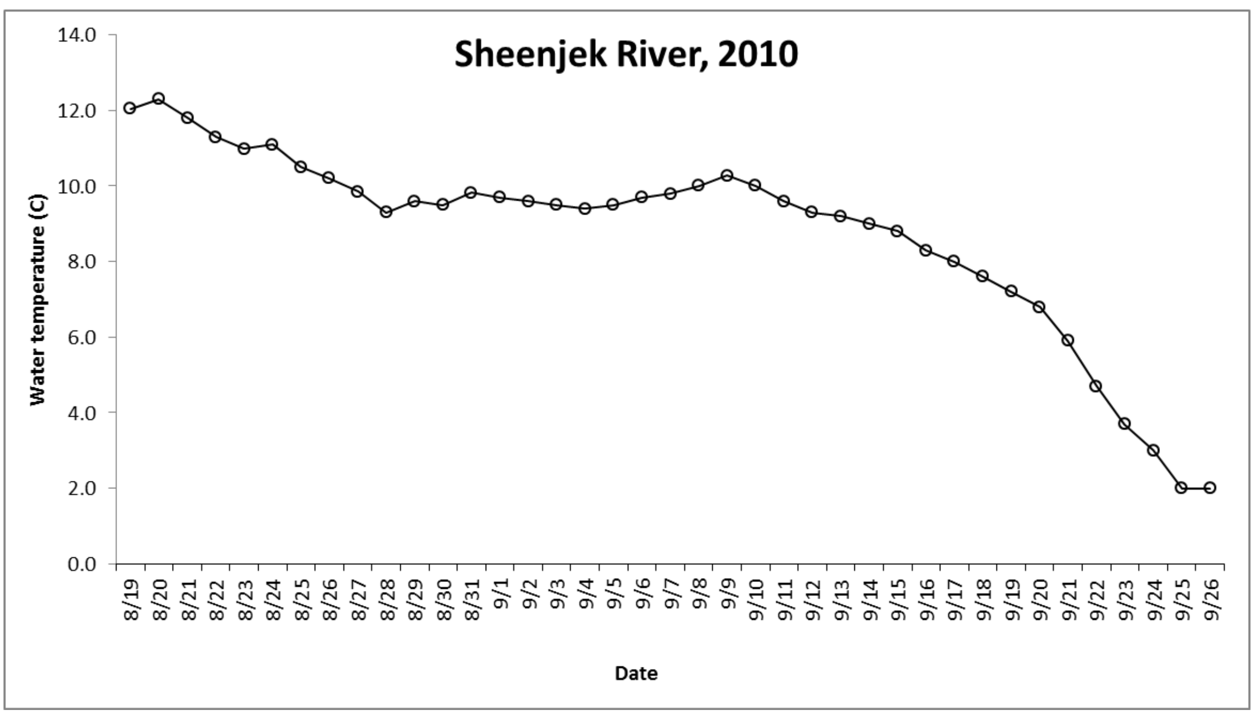

Figure 4.–Data were collected every four hours at the Sheenjek River sonar site, but only the daily average was provided for this report.

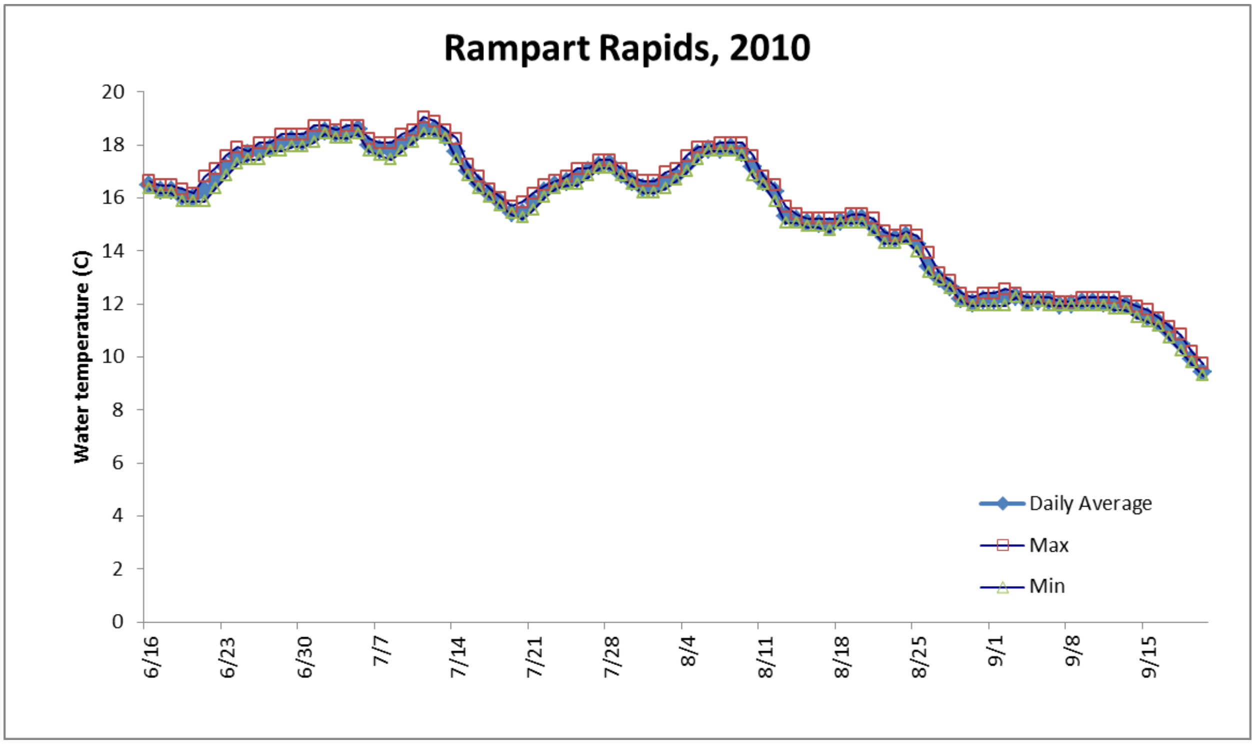

Figure 5.–Mean daily water temperature compared to maximum and minimum taken at Rampart Rapids fish wheel project.

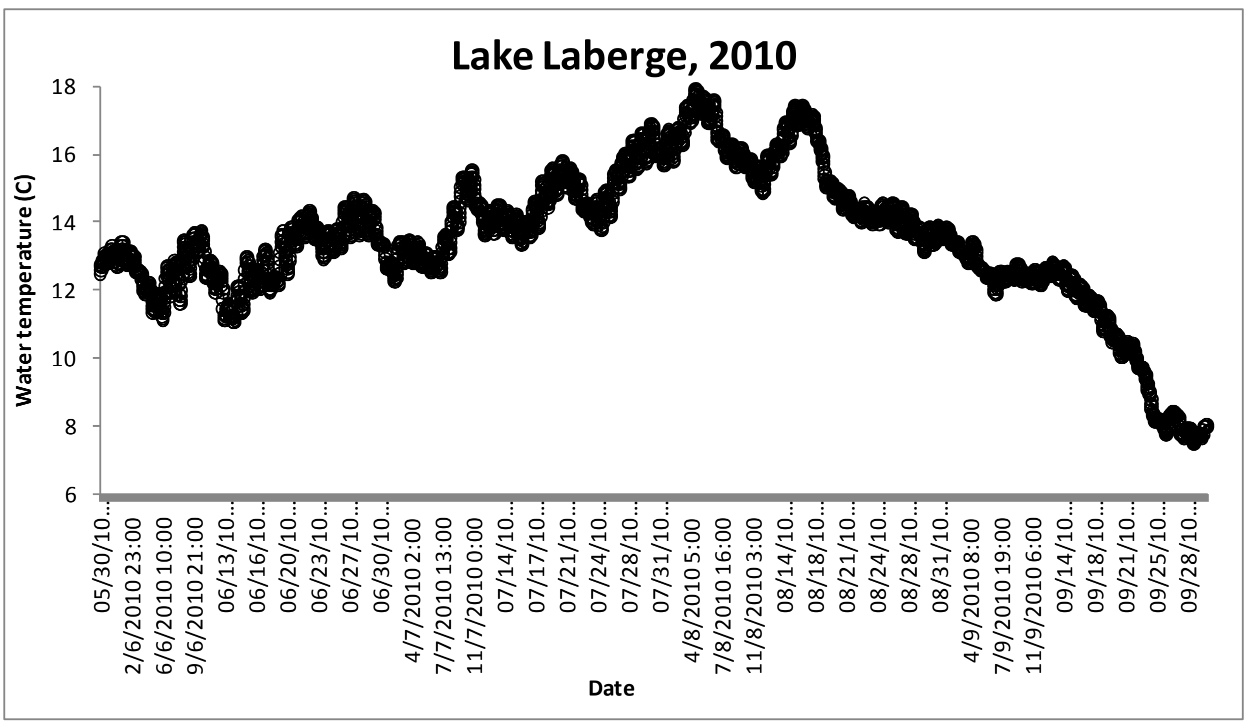

Figure 6.–Data were collected from a site directly upstream of Lake Laberge within the Yukon River mainstem, Yukon Territory.

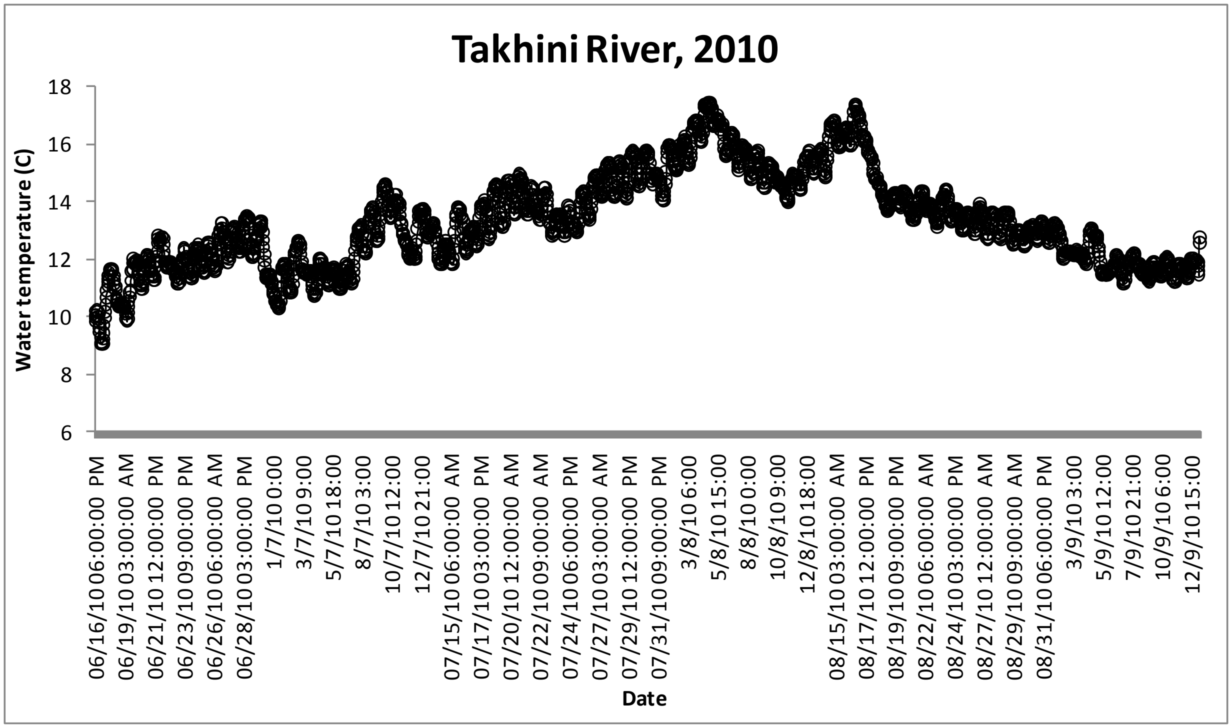

Figure 7.–Data were collected from Takhini River, a tributary to the Yukon River, in the Yukon Territory.

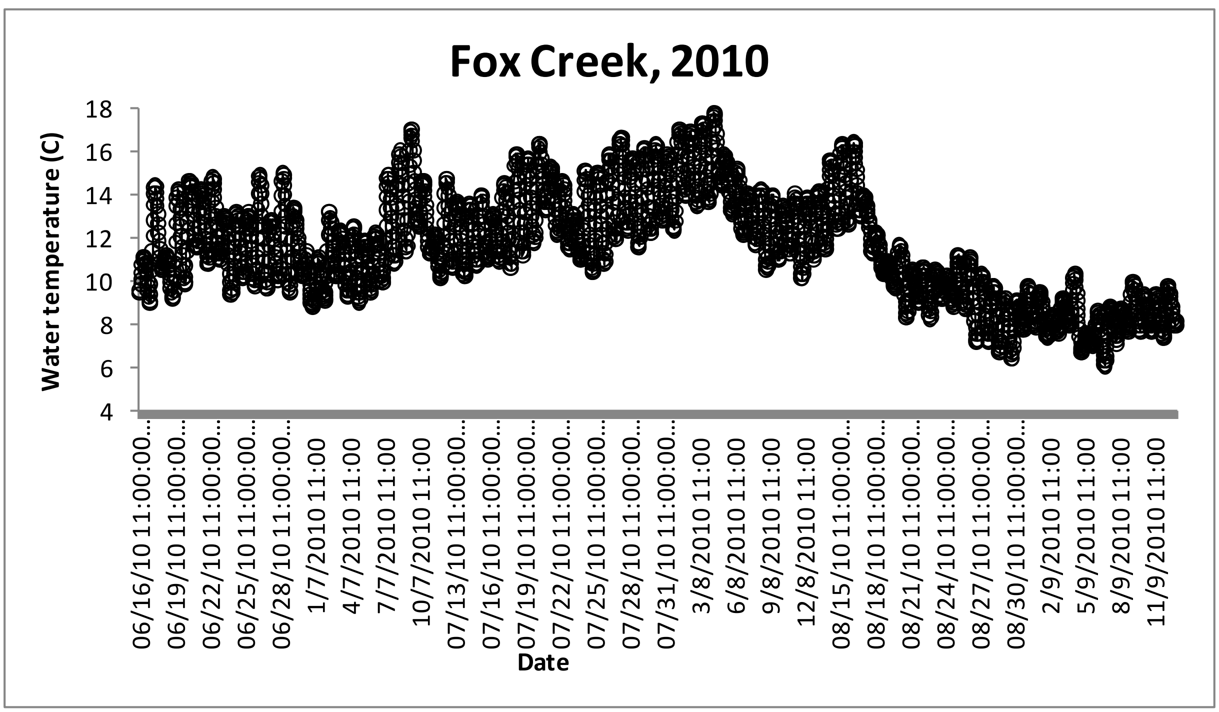

Figure 8.–Data were collected from Fox Creek, a tributary to the Yukon River, Yukon Territory.

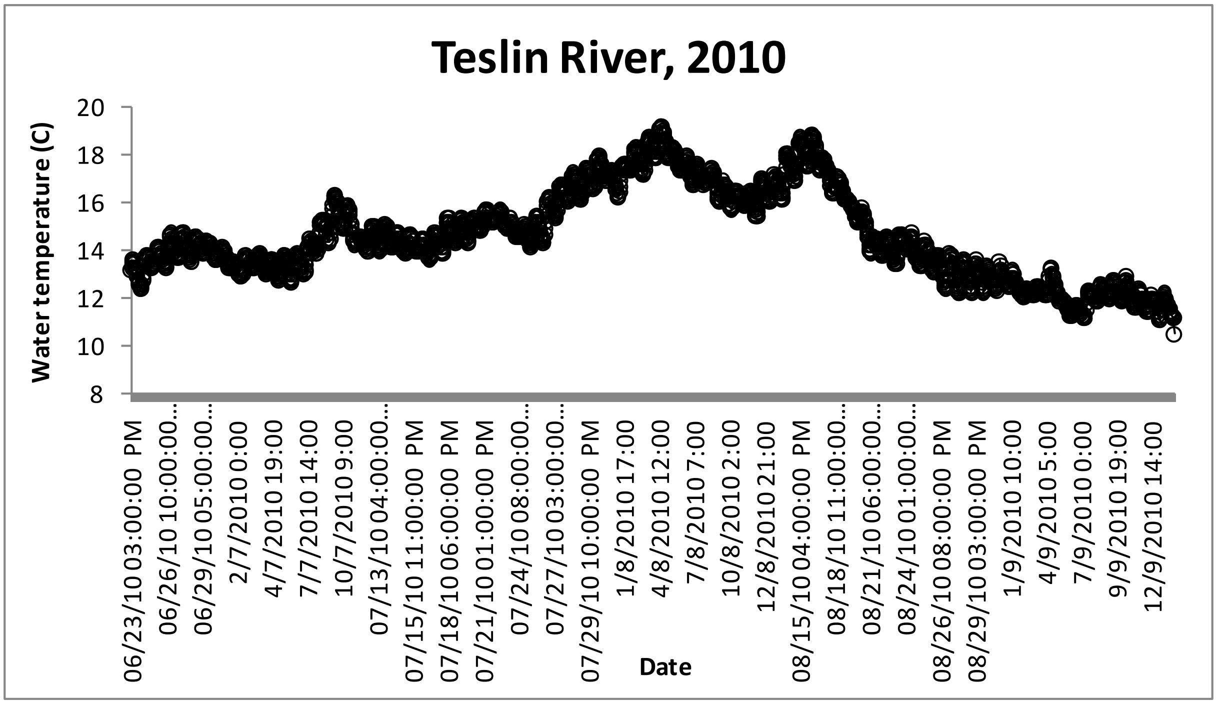

Figure 9.–Data were collecte14-18d from Teslin River, a tributary to the Yukon River, Yukon Territory.