Salmon Stream Temperature Monitoring In the Chilkat & Chilkoot Watersheds

Summary Report – March 2021

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This report provides an update in progress and summary statistics for water temperature sites monitored by Takshanuk Watershed Council. Monitoring at these sites is part of an ongoing collaboration with the Southeast Alaska Freshwater Monitoring Network. Funding was provided by Chilkat Indian Village, National Fish and Wildlife Foundation, US Fish and Wildlife Service, and Patagonia.

Contents

Background

The Chilkat and Chilkoot watersheds are two of the most productive salmon systems on the west coast of North America. They host significant wild runs of all five species of Pacific salmon, as well as steelhead, Dolly Varden, coastal cutthoat trout, and eulachon. This abundance has supported the Chilkat and Chilkoot people since time immemorial, and continues to support them today. The commercial fishing industry accounts for 15% of local incomes and virtually all residents benefit from subsistence and traditional hunting, fishing, and gathering (adfg.alaska.gov). Beyond economic benefits, the practice of subsistence food collection and preservation promotes family ties, community resiliency, and passes on tradition and cultural identity to future generations. Although local freshwater habitats are relatively intact, they are nonetheless facing a significant near-term threat: the unpredictable effects of climate change.

The climate is changing rapidly in the North. Over the next 50 years, Southeast Alaska can expect to see an increase in mean annual air temperature of 2 to 4 °C, as well as drier summers and wetter autumns (Schoen et al. 2017). These factors, along with watershed characteristics and stream morphology, drive the potential for widespread and rapid changes in stream temperature and the local aquatic environment (Kovach et al. 2015, Shanley et al. 2015). The region is also heavily glaciated, and we expect to see significant changes in both glacial runoff and precipitation patterns, which will greatly impact habitat. The generalized effects of water temperature on the health, growth, and behavior of aquatic life, especially salmon, are well studied and well understood (Steel et al. 2012, Taylor 2008, Webb et. al 2008). What are not well documented are the specific local processes that are occurring on the landscape and within the habitat, especially over a time scale of years and decades.

Purpose

The immediate purpose of this project is to develop a baseline, year-round temperature dataset to document the current condition of sites within the Chilkoot and Chilkat watersheds. Over time we aim to generate a long term dataset to discern thermal trends across both watersheds. In addition, these data contribute to collaborative efforts supported by The Southeast Alaska Freshwater Temperature Monitoring Network to standardize, share, and interpret data across the region, and may also be used to create predictive models to inform management decisions regarding aquatic habitat (Bellmore and Winfree 2019).

This report is intended to provide an update in progress for this project and to help identify areas to expand our monitoring efforts. The data summaries are also useful for identifying sites that exceed ADEC maximum temperature limits for aquatic life and may be experiencing, or at risk of experiencing, habitat degradation for salmon.

Methods

Methods for data collection, management, and summary were adapted from *Stream Temperature Data Collection Standards and Protocol for Alaska* (Mauger et al. 2014). Refer to that manual for a more detailed description of methods, protocols, and equipment.

Site Selection

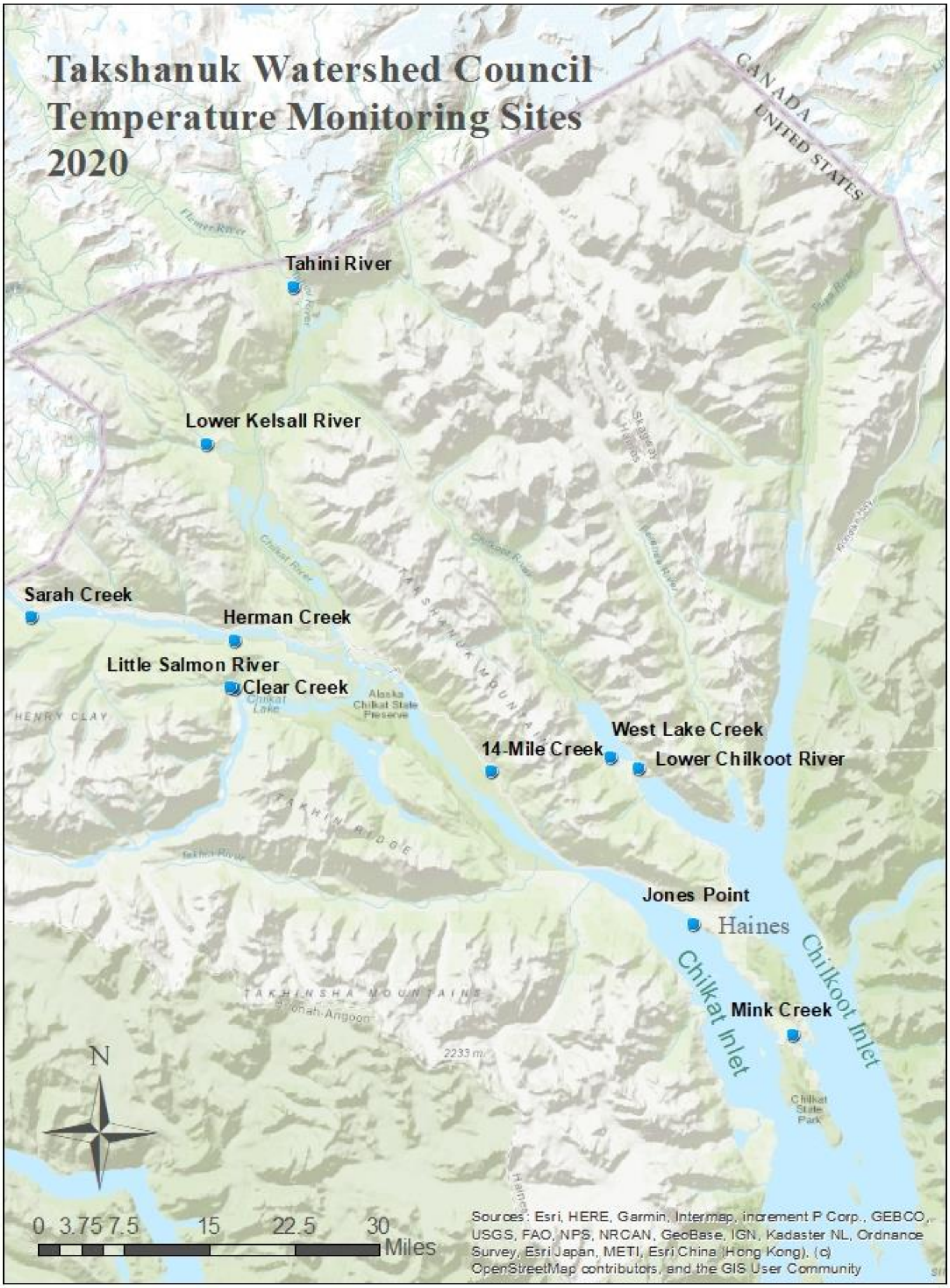
Sites were selected to cover a broad range of hydrological and physical characteristics, and all sites contained salmon habitat (Table 2). Relative ease of access was an important factor in determining where to deploy data loggers, although some off-road and remote sites were also selected. Instantaneous temperature measurements were taken across the stream to verify that sites were well mixed before deploying loggers, and loggers were placed in locations where they were unlikely to become dewatered due to low stream flow.

Table 1. Takshanuk Watershed Council data logger locations and activity periods.

Site	Latitude	Longitude	Date Deployed	Latest Download Date*
West Lake Creek	59.33748	-135.59080	5/28/2016	10/28/2020
Herman Creek	59.41326	-136.06848	5/29/2016	11/30/2020
Clear Creek	59.38226	-136.06812	5/29/2016	11/30/2020
14-Mile Creek	59.32871	-135.74188	5/8/2018	3/3/2021
Lower Chilkoot River	59.33070	-135.55608	11/21/2018	10/28/2020
Little Salmon River	59.38322	-136.07504	9/29/2017	5/27/2020
Lower Kelsall River	59.54015	-136.10397	9/18/2018	9/12/2020
Mink Creek	59.15719	-135.35882	7/17/2019	9/17/2020
Tahini River	59.64146	-135.99401	9/11/2019	5/22/2020
Jones Point	59.22998	-135.48507	4/15/2020	9/22/2020
Sarah Creek	59.42850	-136.32688	6/5/2020	10/20/2020

*Data loggers are still active at each site. The "Latest Download Date" is the most recent date that data were downloaded and summarized for this report.

TWC data logger locations.



Stacie Evans (TWC Science Director) and Richard Chapell (TWC Board Member) headed back from the Tahini site. Photo by Derek Poinsette.

Apparently there's more than one way to test the water. Chilkoot Lake. Photo by Derek Poinsette.

Preparing to swap data loggers at the West Lake Creek Site. Photo by Derek Poinsette.

Data Collection

HOBO Water Temp Pro v2 data loggers were checked for ±0.25˚C accuracy against a National Institute of Science and Technology (NIST) certified thermometer before each deployment in the field. Data loggers were programed to record temperature every 30 minutes, except for at Herman Creek, Clear Creek, and West Lake Creek where loggers were programmed to record temperature every one hour from May 2016 to November 2018.

Three data loggers were deployed at each site – two in-stream to record water temperature, and one out of stream to record air temperature. Each logger was secured with zip ties in a protective PVC housing. In-stream loggers were attached to heavy chain (to weigh the loggers down) and secured with a loop of cable and clamps to a large rock or sturdy object on the stream bank. Air temperature loggers were hung in a shady location in nearby vegetation.

Data loggers were retrieved and fresh loggers were deployed every spring and fall to the extent possible. Loggers were checked again for accuracy and battery power upon retrieval. Sites were checked opportunistically to ensure that loggers were in place, operating, and free from sedimentation.

Derek Poinsette (TWC Executive Director) and Richard Chapell (TWC Board Member) deploying data loggers at the Tahini Site. Photo by

Data Management and Summarization

Data were downloaded from each data logger using HOBOware software. Hobo graph outputs were examined for erroneous data due to dewatering or sedimentation before data were exported to comma-separated values (CVS) files for backup and Excel files for summarization. Pre deployment, post retrieval, and erroneous data were removed from Excel spreadsheets. The remaining data (for days containing at least 90% of the daily measurements) were organized in pivot tables and summarized into daily minimum, maximum, and mean water temperatures. Maximum 7-day rolling average (MWAT) and maximum 7-day rolling maximum (MWMT) temperatures were also summarized for summer months at each site. MWMT was calculated by selecting the yearly maximum from weekly averages of maximum daily temperatures and MWAT was calculated by selecting the yearly maximum from weekly averages of average daily temperatures.

Daily temperatures, MWMTs, and MWATs at each site were compared to the ADEC water temperature criteria for aquatic life in freshwater (ADEC 2020). These standards are as follows:

May not exceed 20°C at any time. The following maximum temperatures may not be exceeded, where applicable:

Migration routes	**15°C**
Spawning areas	**13°C**
Rearing areas	**15°C**
Egg and fry incubation	**13°C**

Additional years of data are needed to consider inter-annual variability at some sites, however, daily mean temperatures were compared by year for sites with at least three years of useable data.

Results

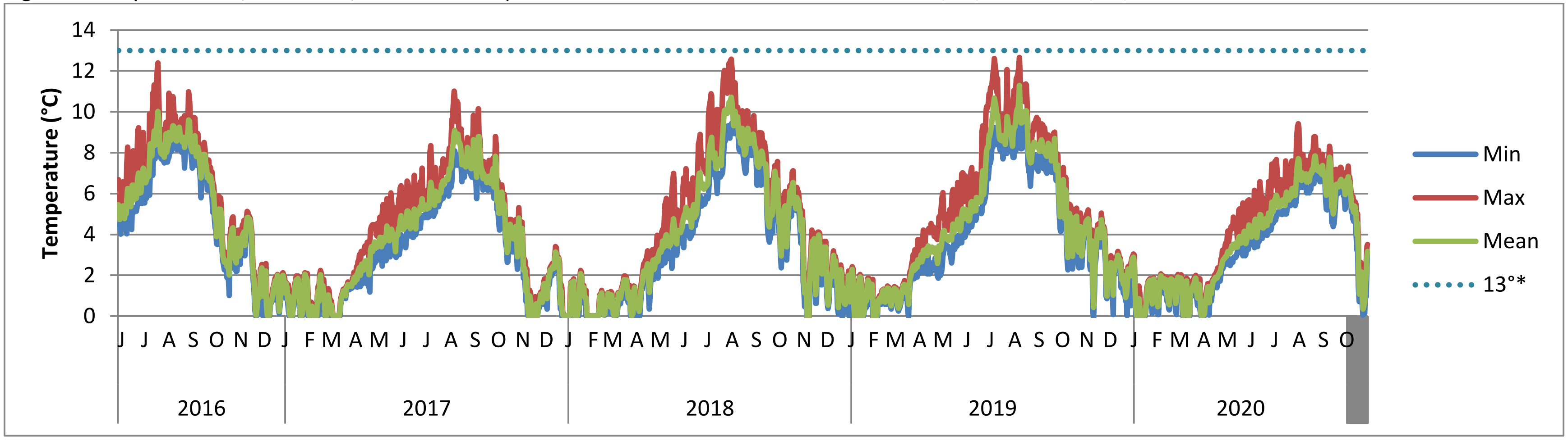
Data loggers were deployed at 11 sites, beginning with three sites established in May 2016 (Table 1). Sites were subsequently added, with the latest site established in June 2020 (Table 1). A single data logger was lost at the Lower Kelsall site for the October 2019-May 2020 period, and another was lost at the same site for the May 2020-September 2020 period. The remaining data logger was dewatered at the Lower Kelsall site during the October 2019-May 2020 period, so data are not included in summaries for that period. Data were also removed for the July 2019-May 2020 period at the Mink Creek site where both loggers were buried in sediment during that time. Short periods of subzero temperatures were also removed for several sites.

Summary graphs with daily minimum, maximum, and mean temperatures are presented below for each site. Sites that exceeded ADEC water temperature criteria for aquatic life in freshwater are reported in Table 2. No temperatures above 20°C were recorded. The number of days in which temperatures exceeded ADEC standards at sites is reported in Table 3 by year. Summary graphs are also included for yearly maximum 7-day rolling maximums (MWMTs) and maximum 7-day rolling averages (MWATs), and exceedances with these metrics are included in Table 2. MWMTs and MWATs are useful metrics because they describe thermal conditions that are experienced by fish over an extended period of time (a week), rather than discrete measurements which may only represent short spikes in temperature.

Yearly comparisons of daily mean temperatures are included for sites where at least three complete years of data were available (West Lake Creek, Herman Creek, Clear Creek, 14-Mile Creek, and Lower Chilkoot River). Mean July/August temperatures at these sites are presented in Figure 18 by year.

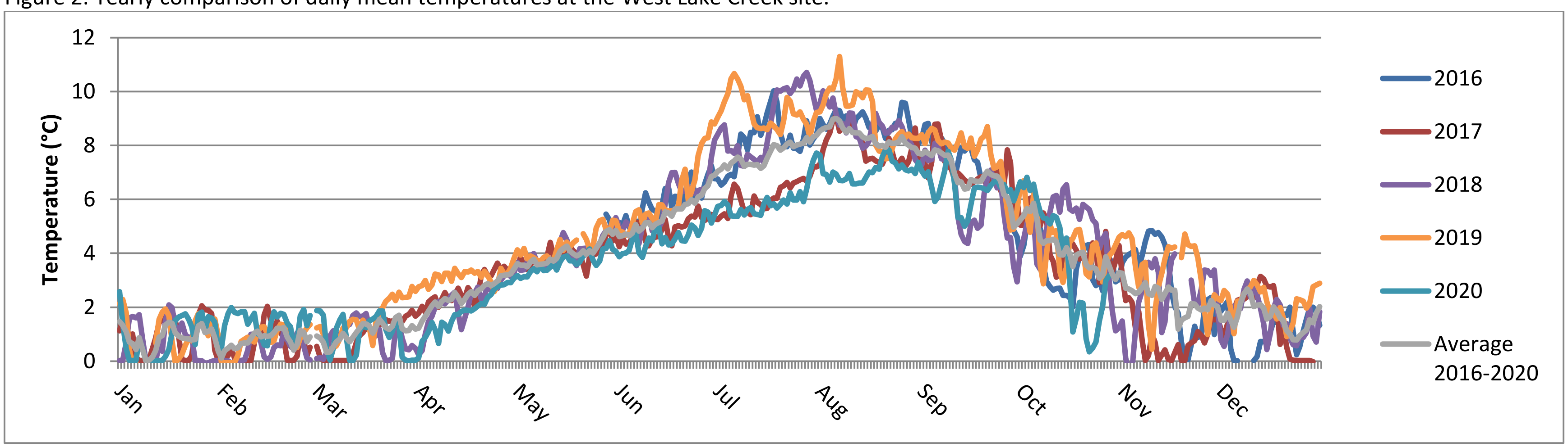
West Lake Creek

Figure 1. Daily minimum, maximum, and mean temperatures at the West Lake Creek site from 5/28/2016 to 10/28/2020.



*13°C = ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C = ADEC maximum temperature limit for migration routes and rearing areas.

Figure 2. Yearly comparison of daily mean temperatures at the West Lake Creek site.



Herman Creek

Figure 3. Daily minimum, maximum, and mean temperatures at the Herman Creek site from 5/28/2016 to 11/30/2020.

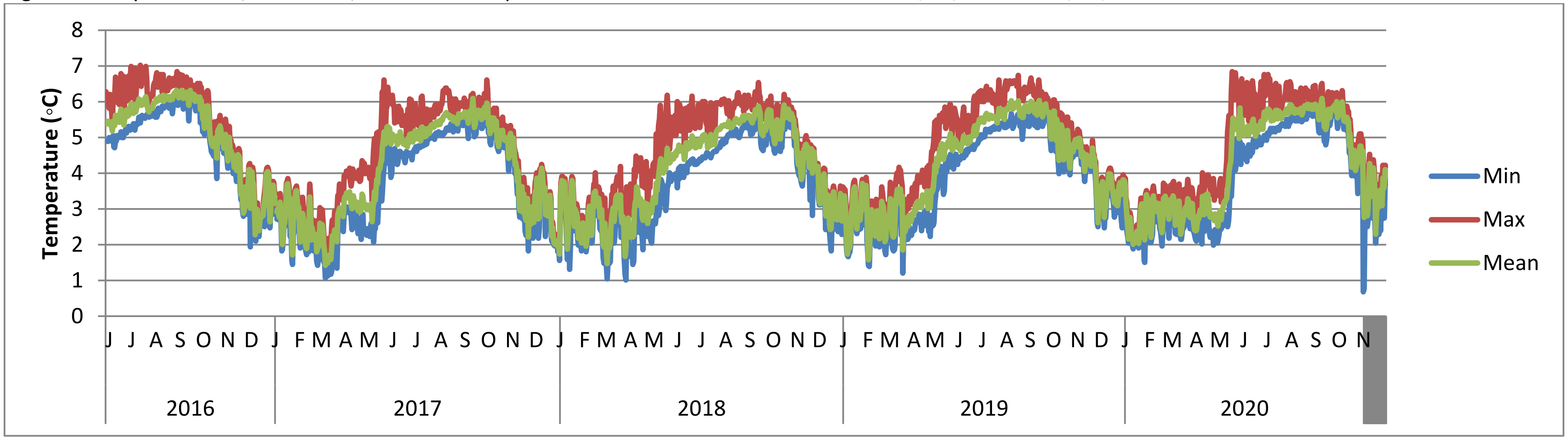
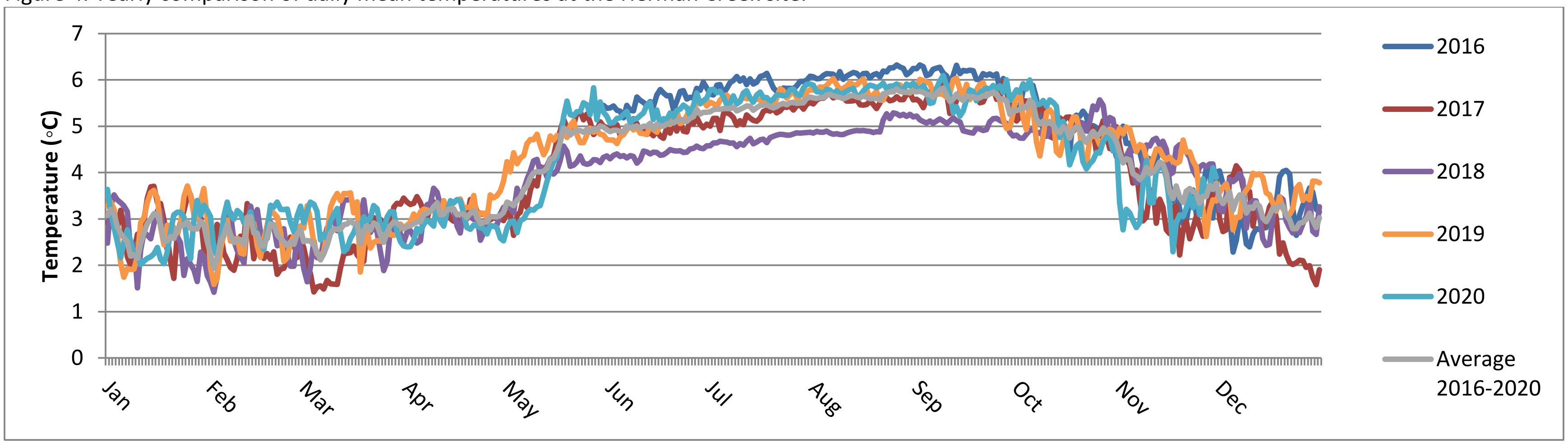


Figure 4. Yearly comparison of daily mean temperatures at the Herman Creek site.



Clear Creek

Figure 5. Daily minimum, maximum, and mean temperatures at the Clear Creek site from 5/29/2016 to 5/27/2020.

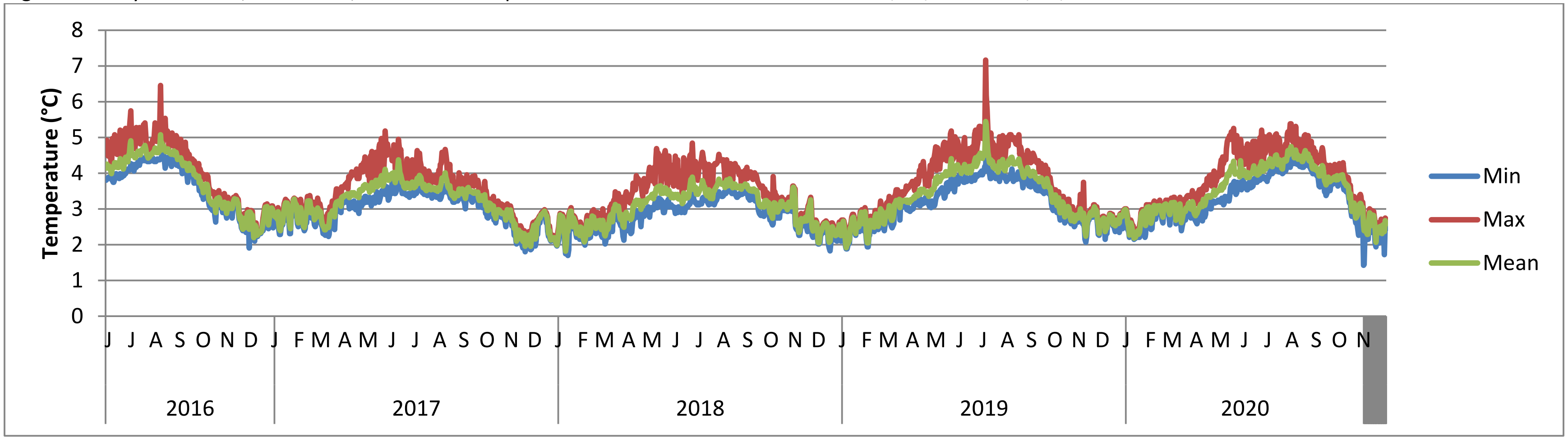
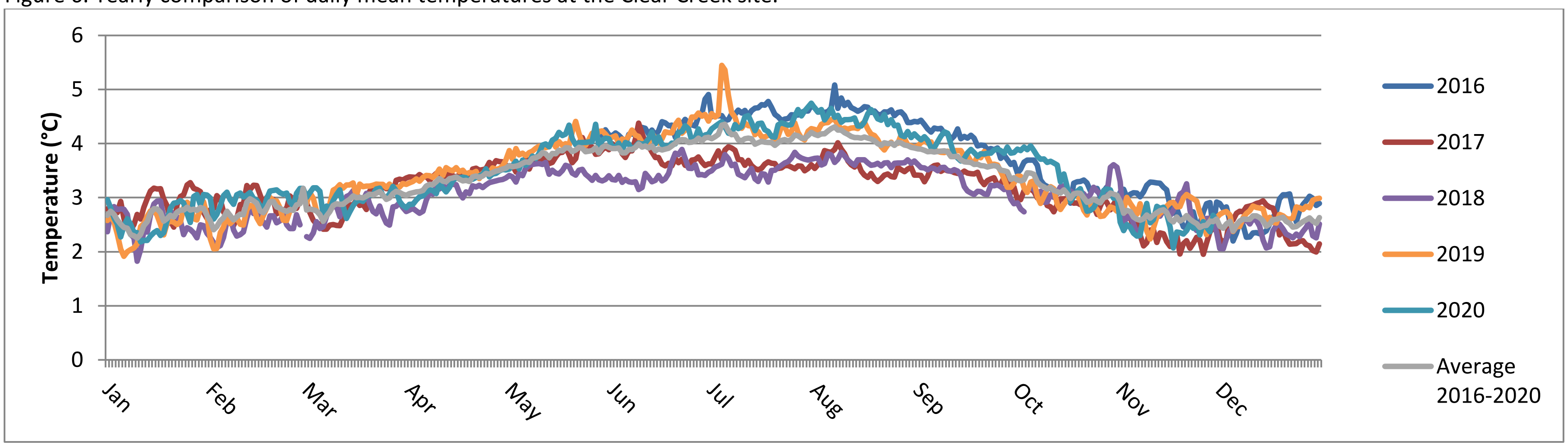


Figure 6. Yearly comparison of daily mean temperatures at the Clear Creek site.



14-Mile Creek

Figure 7. Daily minimum, maximum, and mean temperatures at the 14-Mile Creek site from 5/8/2018 to 3/3/2021.

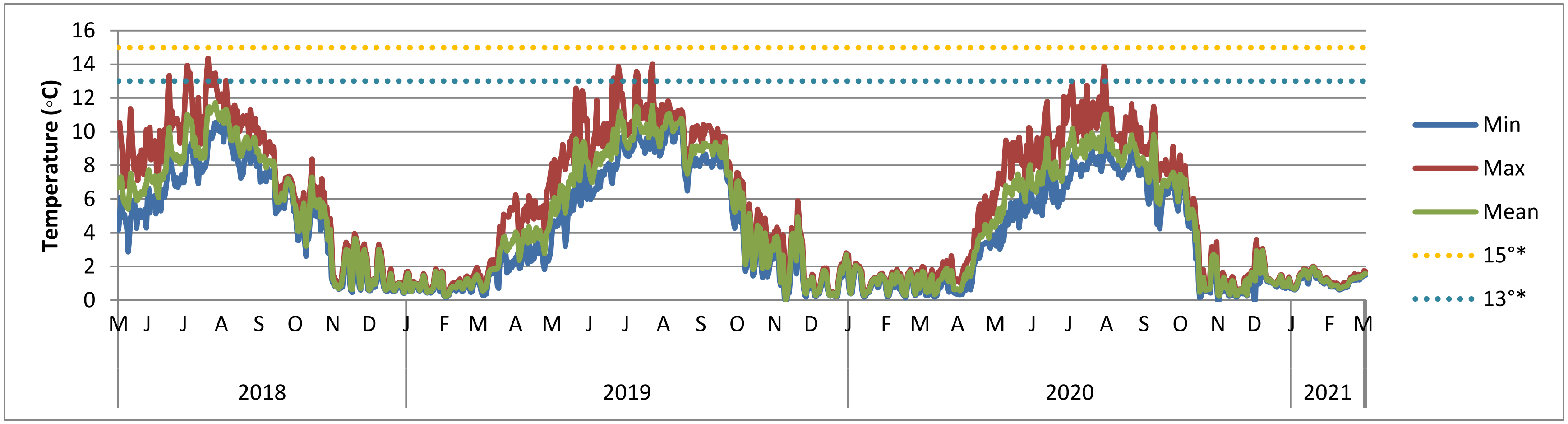
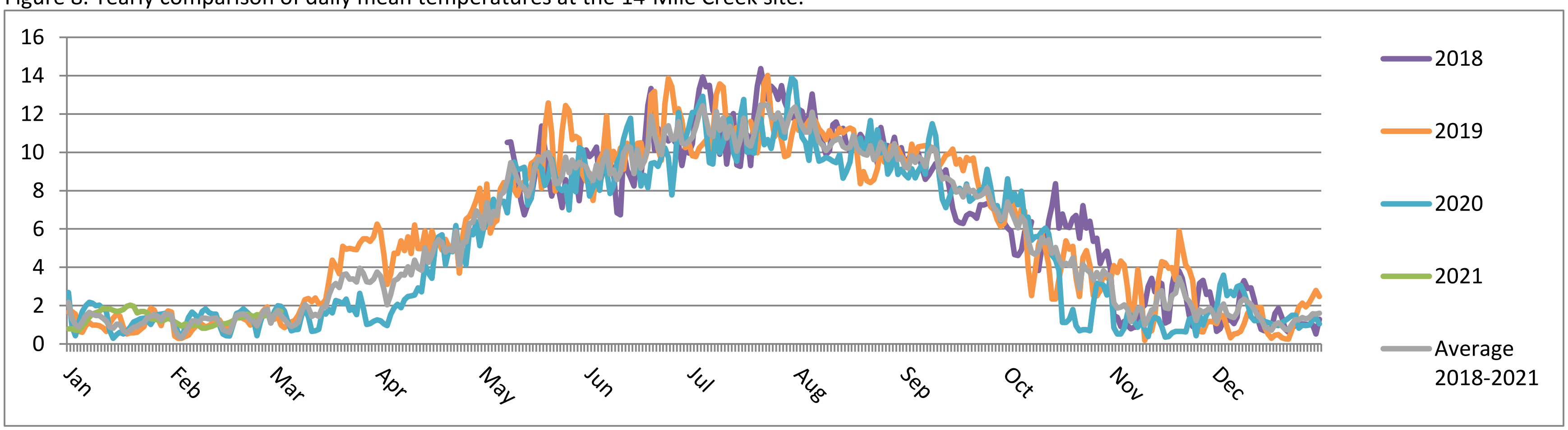
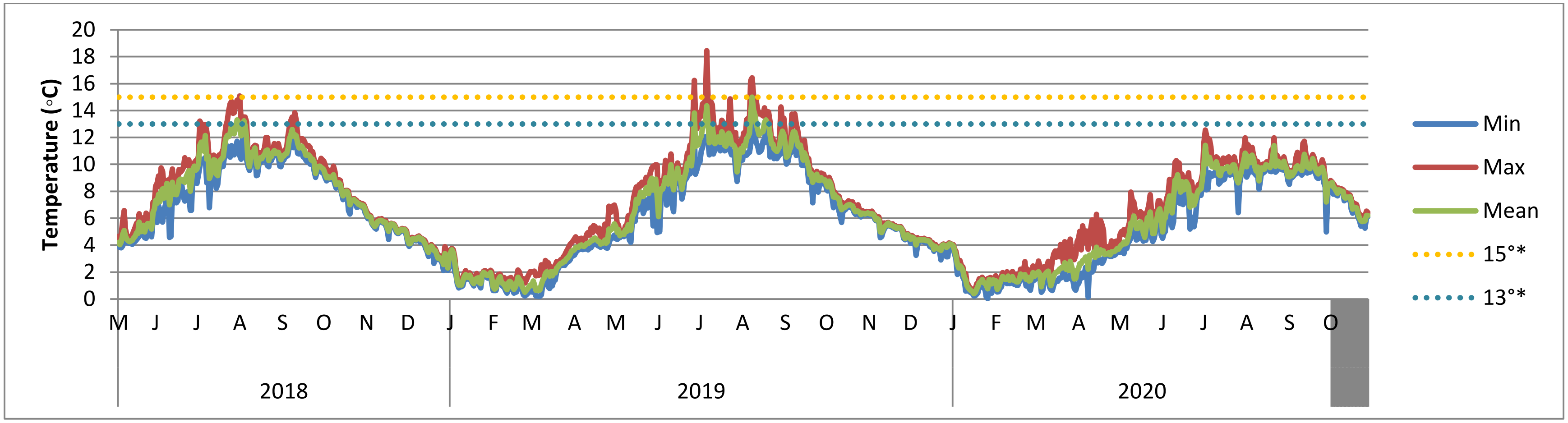


Figure 8. Yearly comparison of daily mean temperatures at the 14-Mile Creek site.



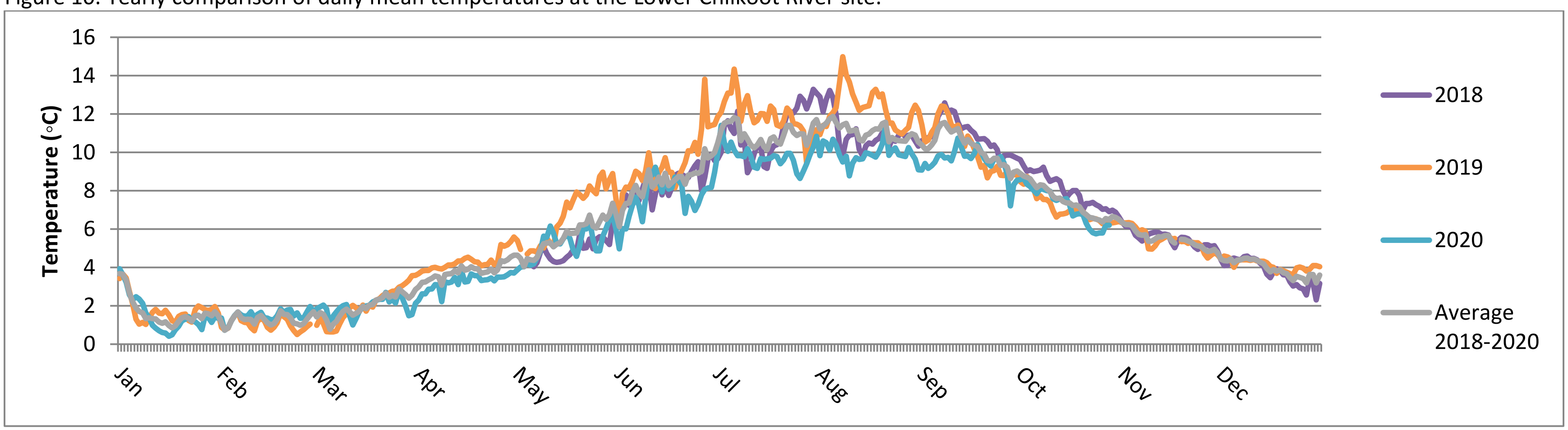
Lower Chilkoot River

Figure 9. Daily minimum, maximum, and mean temperatures at the Lower Chilkoot River site from 11/21/2018 to 10/28/2020.



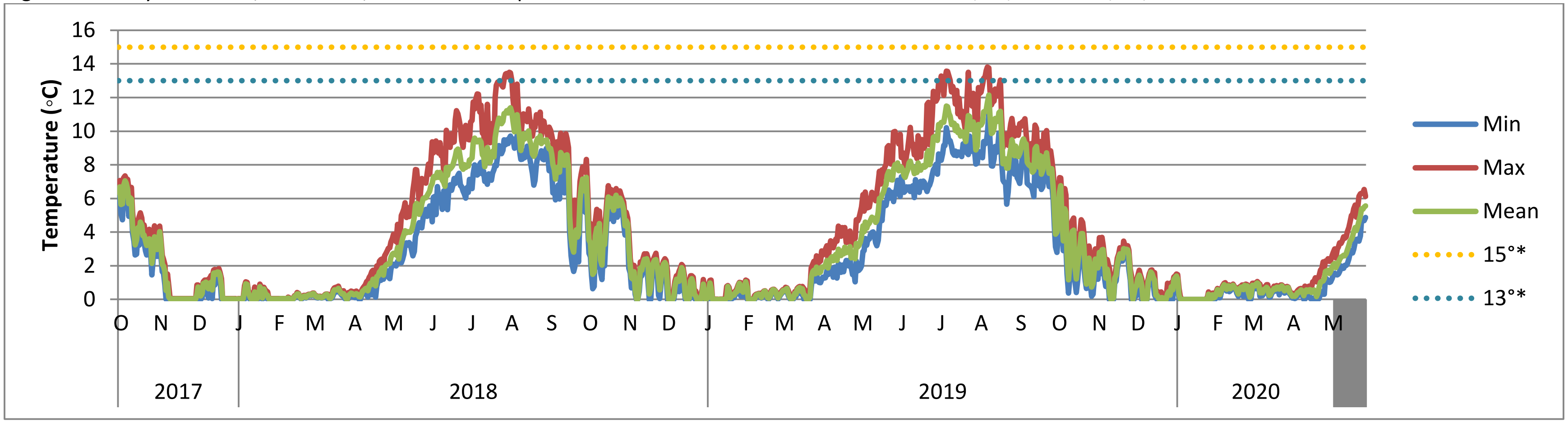
*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

Figure 10. Yearly comparison of daily mean temperatures at the Lower Chilkoot River site.



Little Salmon River

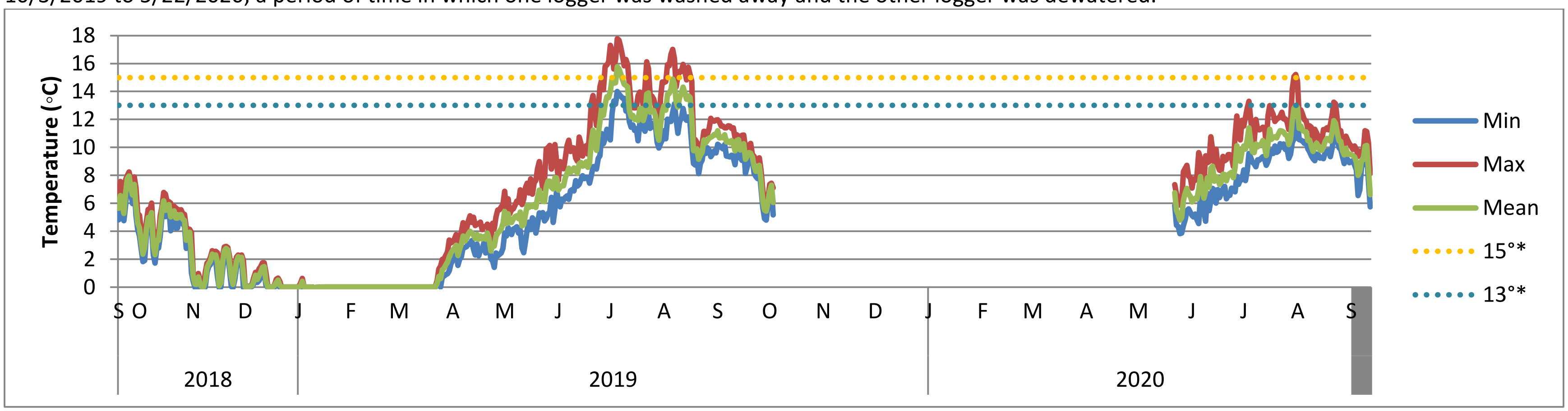
Figure 11. Daily minimum, maximum, and mean temperatures at the Little Salmon River site from 9/29/2017 to 5/26/2020.



*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

Lower Kelsall River

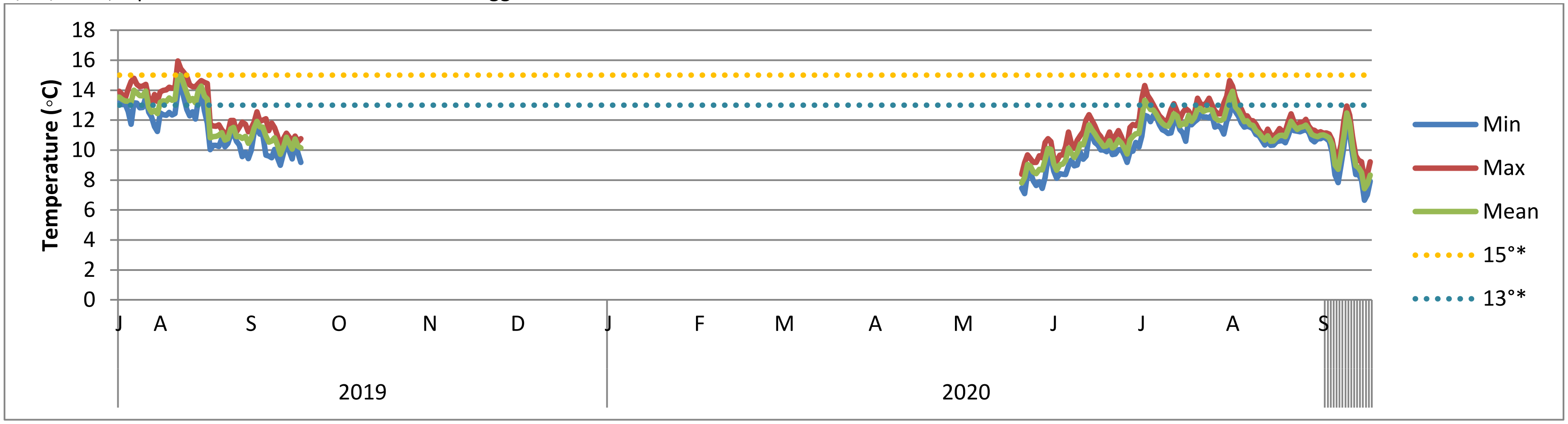
Figure 12. Daily minimum, maximum, and mean temperatures at the Lower Kelsall River site from 9/18/2018 to 9/12/2020. Data are not included from 10/3/2019 to 5/22/2020; a period of time in which one logger was washed away and the other logger was dewatered.



*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

Mink Creek

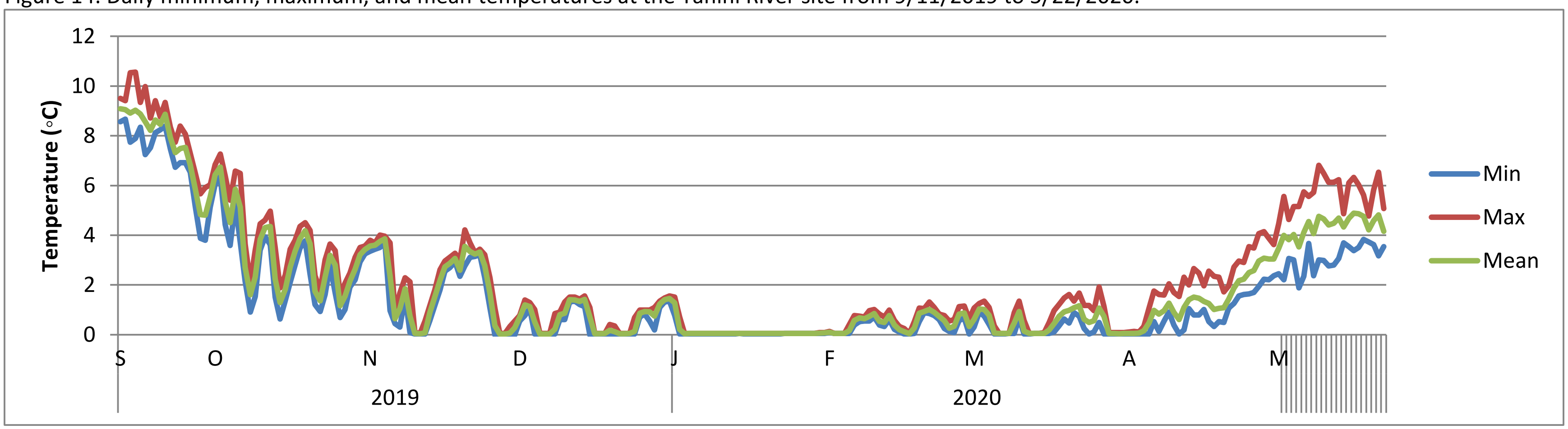
Figure 13. Daily minimum, maximum, and mean temperatures at the Mink Creek site from 7/17/2019 to 9/17/2020. Data are not included from 9/19/2019 to 5/20/2020; a period of time in which both data loggers were buried in sediment.



*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

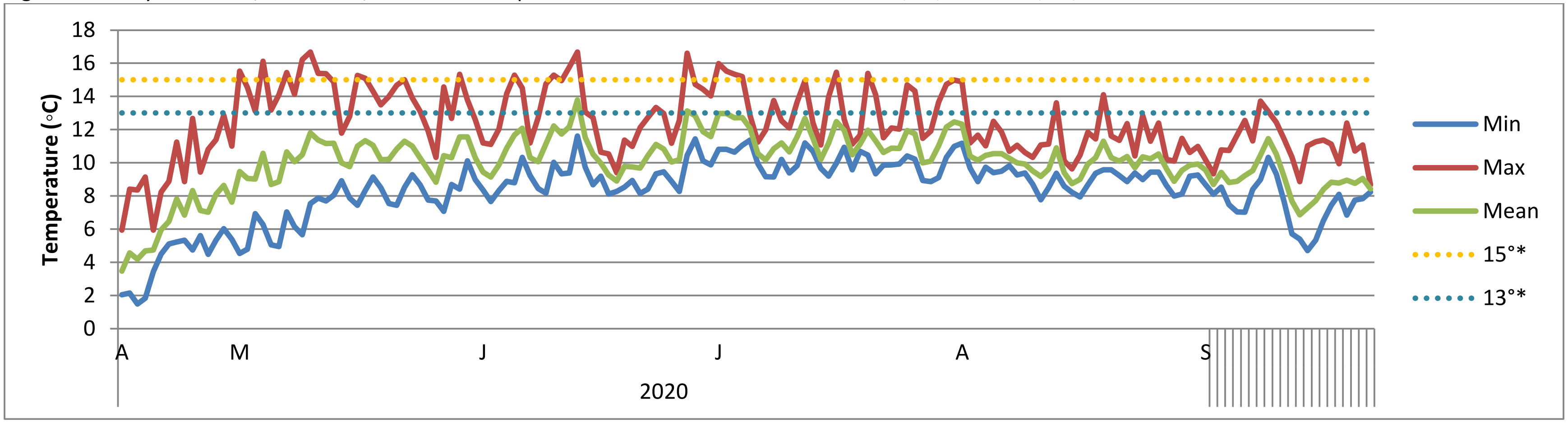
Tahini River

Figure 14. Daily minimum, maximum, and mean temperatures at the Tahini River site from 9/11/2019 to 5/22/2020.



Jones Point (Chilkat River)

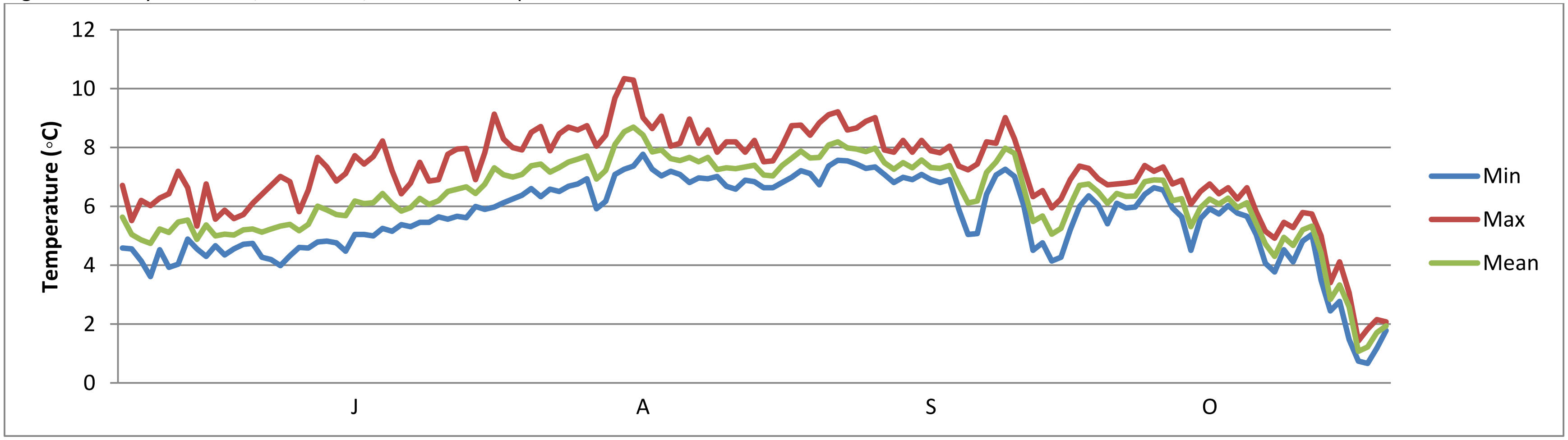
Figure 15. Daily minimum, maximum, and mean temperatures at the Jones Point site from 4/15/2020 to 9/22/2020.



*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

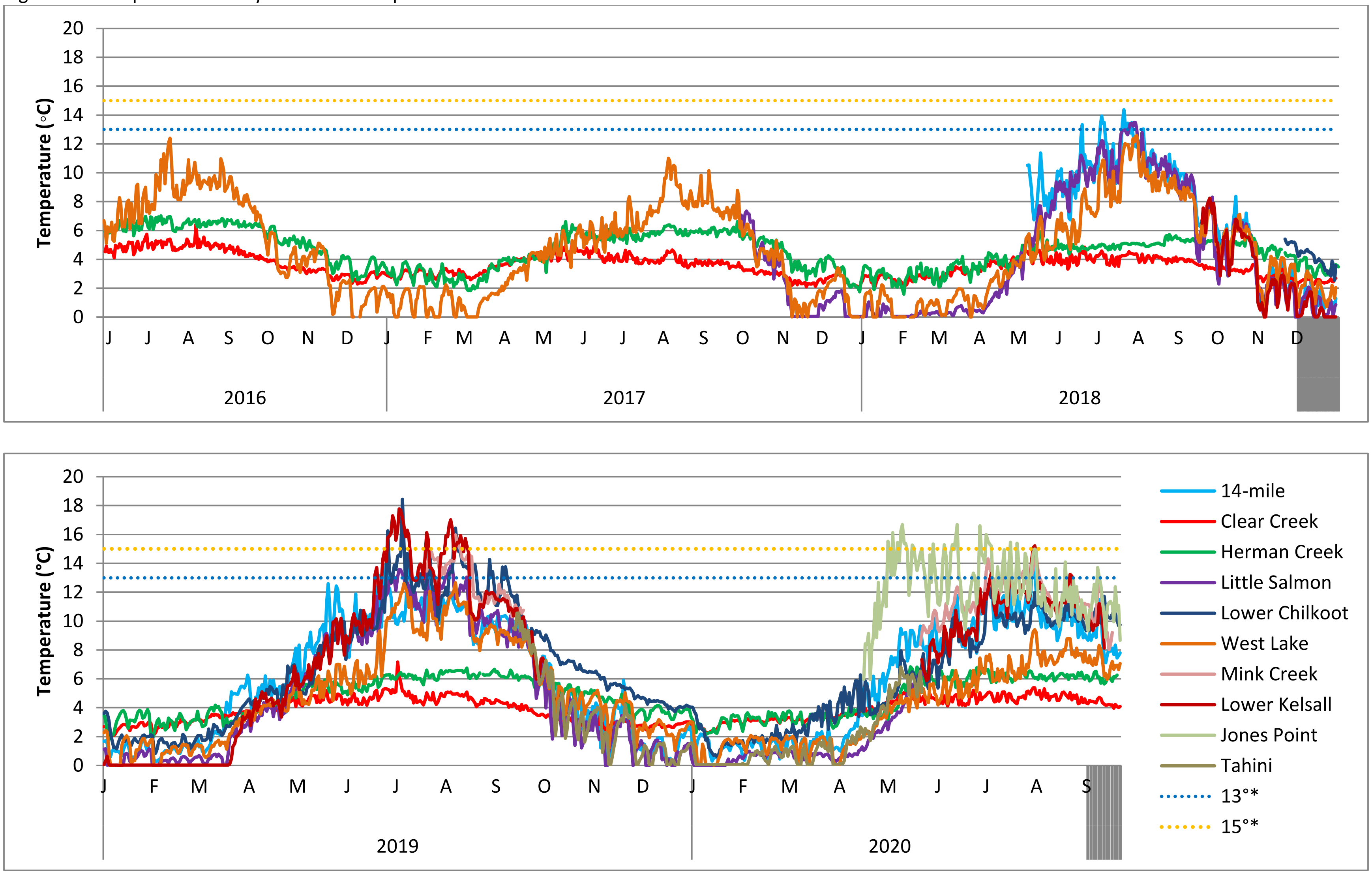
Sarah Creek

Figure 16. Daily minimum, maximum, and mean temperatures at the Sarah Creek site from 6/6/2020 to 10/20/2020.



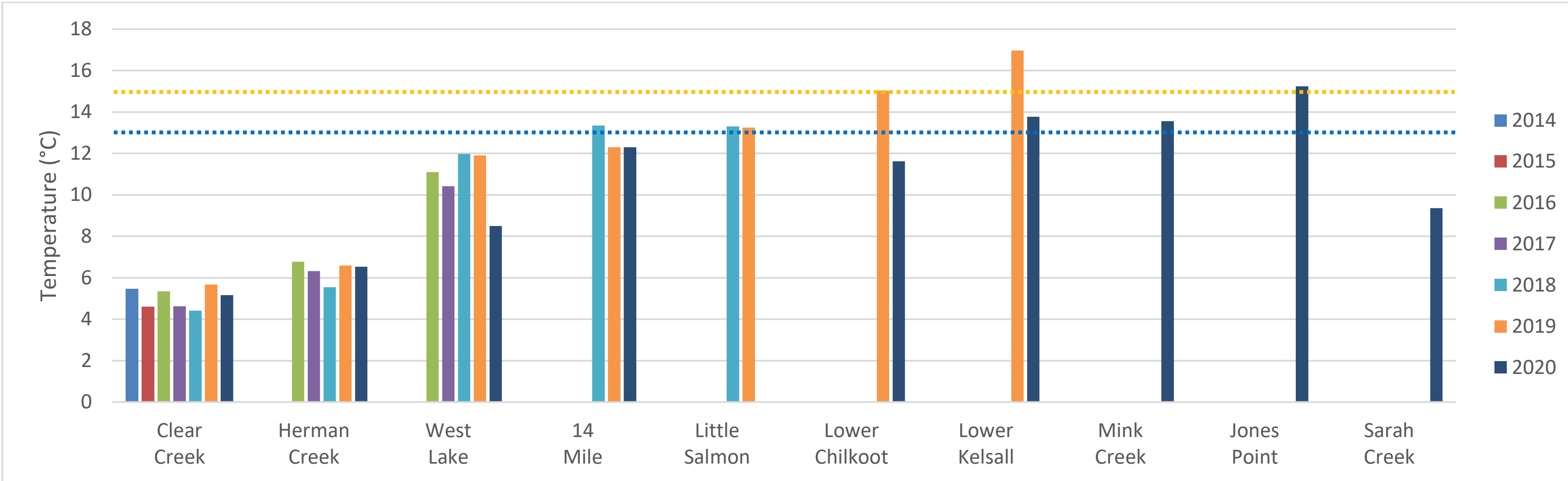
All Sites

Figure 17. Comparison of daily maximum temperatures at all sites.



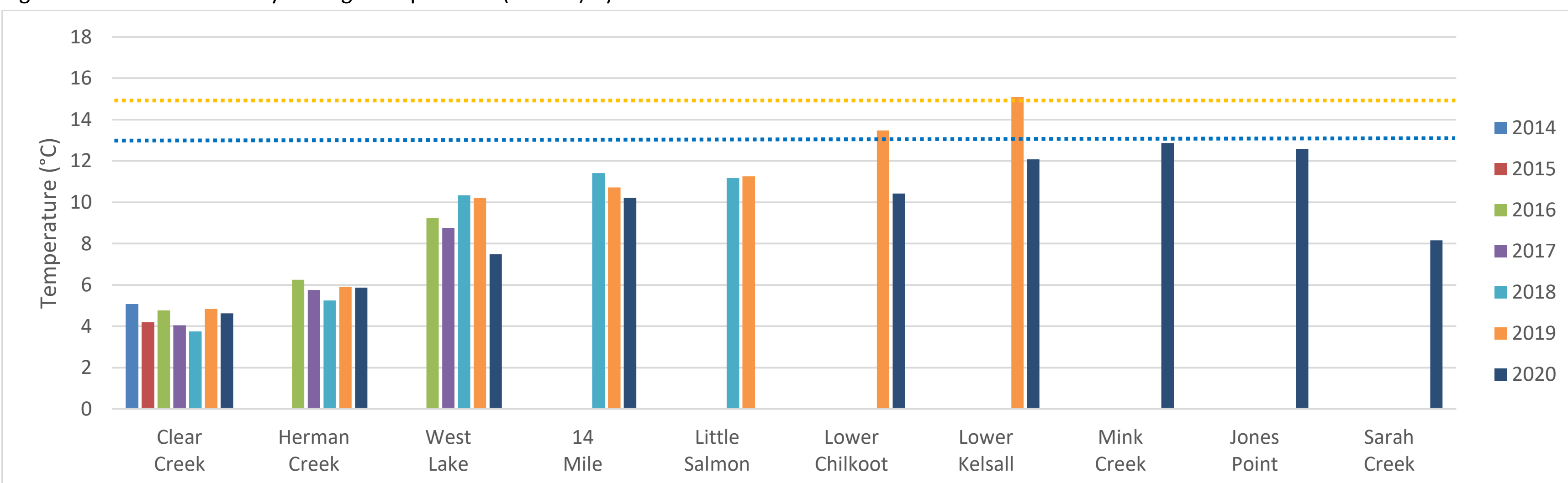
*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

Figure 18. Maximum weekly maximum temperature (MWMT) by site.



*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

Figure 19. Maximum weekly average temperature (MWAT) by site.



*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

Exceedances

Table 2. Maximum temperature recorded at each site. Sites where temperatures exceeded ADEC water temperature limits for aquatic life in freshwater are noted. Dashes indicate that data are not yet available.

Site	Max Temp˚C	Date Max Recorded	Max Temp Exceeded		MWMT Exceeded		MWAT Exceeded		Salmon Species Present[ǂ]
			13°C	15°C	13°C	15°C	13°C	15°C	
West Lake Creek	12.654	8/7/2019							S
Herman Creek	7.015	7/11/2016							CH, CO, P, S
Clear Creek	7.167	7/4/2019							CO, S
Lower Chilkoot	18.438	7/6/2019	X	X	X	X	X		CH, CO, P, S
Tahini River	-	-	-	-	-	-	-	-	CO, K, S
Lower Kelsall River	17.772	7/5/2019	X	X	X	X	X	X	CH, CO, K, P, S
Sarah Creek	10.345	7/30/2020							CO
Little Salmon River	13.810	8/6/2019	X		X				CH, CO, S
14-Mile Creek	14.361	7/21/2018	X		X				CH, CO, P
Jones Point	16.677	5/10&6/13/20	X	X	X	X			CH, CO, K, P, S
Mink Creek	15.963	8/7/2019	X	X	X				CH, CO

[ǂ]According to the Alaska Department of Fish and Game Anadromous Waters Catalogue (ADF&G 2020). CH=Chum, CO=Coho, K=Chinook, P=Pink, S=Sockeye.

The majority of sites exceeded ADEC's lower temperature limits for the protection of fish. Six out of nine sites with available data exceeded the lower limit of 13°C for spawning areas and egg/fry incubation. The MWMT also exceeded 13°C at these sites. Four out of nine sites exceeded the middle limit of 15°C for migration routes and rearing areas and the MWMT exceeded this limit at three of these sites. The MWAT exceeded 13°C at Lower Chilkoot and Lower Kelsall and it also exceeded 15°C at Lower Kelsall. No sites exceeded the upper limit of 20°C, which may not be exceeded at any time (ADEC 2020).

Maximum stream temperatures varied broadly across sites with a low maximum of 7.015°C at Herman Creek and a high maximum of 18.438°C at Lower Chilkoot River. Herman Creek and Clear Creek are largely fed by groundwater, which likely contributes to less temperature fluctuation compared to other sites (Figure 17).

Table 3. Number of days per year in which water temperatures exceeded ADEC limits for aquatic life in freshwater. Dashes indicate that data were not, or have not yet been collected for that year. Data loggers were not deployed before 2018 at sites where exceedances occurred.

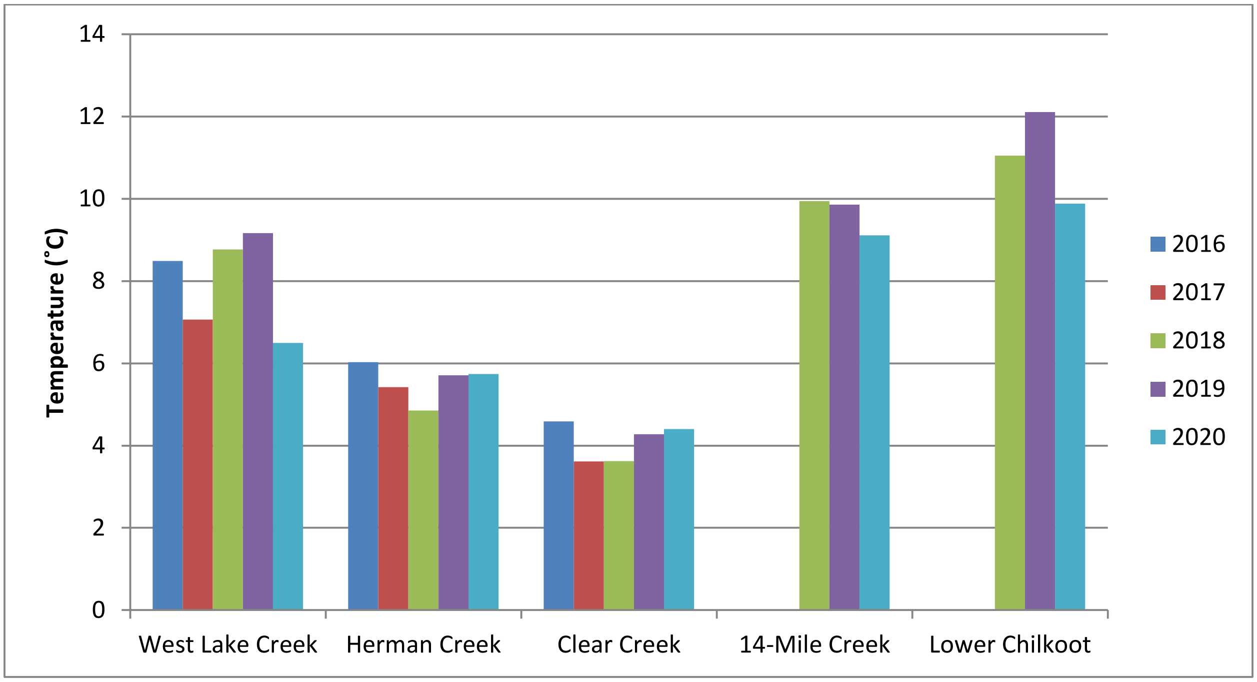
Site	2018		2019		2020	
	#Days Exceeded 13˚C*	# Days Exceeded 15˚C*	#Days Exceeded 13˚C*	# Days Exceeded 15˚C*	#Days Exceeded 13˚C*	# Days Exceeded 15˚C*
Lower Chilkoot	-	-	41	6	0	0
Lower Kelsall River	-	-	49	28	7	2
Little Salmon River	6	0	13	0	-	-
14-Mile Creek	12	0	8	0	2	0
Jones Point	-	-	-	-	60	22
Mink Creek	-	-	30+[ǂ]	3+[ǂ]	17	0

*13°C=ADEC maximum temperature limit for spawning areas and egg/fry incubation. 15°C=ADEC maximum temperature limit for migration and rearing areas.

[ǂ]Data loggers were deployed July 17, 2019. It is likely that additional exceedances occurred at Mink Creek prior to that date in 2019.

Yearly Comparison

Figure 18. Average stream temperature from 1-July to 31-August by site. Only sites with at least three years of data for July and August are included (West Lake Creek, Herman Creek, Clear Creek, 14-Mile Creek, and Lower Chilkoot River).



2019 had the warmest average July and August stream temperature for sites with at least three years of data (West Lake Creek, Herman Creek, Clear Creek, 14-Mile Creek, and Lower Chilkoot River). The overall average July and August stream temperature between these sites was 8.224°C in 2019, 7.646°C in 2018, 7.124°C in 2020, 6.366°C in 2016, and 5.365°C in 2017.

Discussion

This stream temperature monitoring program has initiated a valuable thermal dataset for the Chilkat and Chilkoot watersheds. While no formal analyses were performed for this report, summary statistics indicate that much of the salmon habitat associated with these sites is vulnerable to rising temperatures due to climate change. More descriptive, spatial, and temporal data are necessary to better quantify current effects and predict how changes may occur under likely climate scenarios.

Frequent exceedances of ADEC stream temperature limits under current conditions suggest that salmon habitat is already experiencing degradation due to rising temperatures in the Chilkat and Chilkoot watersheds (Table 3). This is perhaps most concerning at the Lower Chilkoot River, Lower Kelsall River, and Jones Point (Chilkat River); sites where maximum temperatures were the highest, exceedances the most frequent, and most or all species of Pacific salmon are present (Table 2 and 3). On the other hand, these watersheds could be faring better than other regions, such as southcentral Alaska (Mauger et al. 2017), and may provide important refugia for Pacific salmon as temperatures continue to rise.

Chilkat chinook salmon were designated a stock of conservation concern by the Alaska Department of Fish and Game in 2017 due to frequent low returns since 2012 (ADF&G 2017). Although the causes for this decline are not well documented, suitable freshwater habitat will be necessary for the conservation of this species into the future. We therefore recommend that ADEC temperature exceedances at the Lower Kelsall River and Jones Point sites especially be considered when making habitat management decisions in these waterbodies.

Air temperature data are available for each site, but have not yet been summarized for this project. These data will be used in future analyses to determine the sensitivity of stream temperature to local air temperature. This metric is necessary to predict how streams may respond to likely climate scenarios and to determine which sites are at the highest risk. For example, sites that are already warm and also have a high sensitivity to air temperature will be the most vulnerable to impacts due to climate change. Conversely, colder streams with low sensitivity to air temperature are more likely to provide thermal refugia for salmon over time (Mauger et al. 2012).

In addition, characteristic data for each site will be used to determine variables that influence thermal response and to what degree. Predictor variables will help managers focus their response to climate change on specific actions with a high degree of resolution within the watershed. Manageable, small-scale strategies, like restoring riparian vegetation to shade a stream, or improving fish passage to less vulnerable habitat, will contribute to the overall resiliency of salmon populations (Mauger et al. 2017). A targeted approach will similarly allow managers to prioritize limited financial resources and increase efficiency of conservation actions (Isaak and Rieman 2013).

With the help of our partners, TWC will continue to collect temperature and characteristic data at all of our sites, as well as establish multiple new sites within the Chilkat and Chilkoot watersheds. In collaboration with The Southeast Alaska Freshwater Temperature Monitoring Network, we aim to generate a dataset that helps us understand thermal patterns and trends locally as well as regionally in order to help managers make effective decisions in response to climate change.

Literature Cited

Alaska Department of Environmental Conservation (ADEC). 2020. 18 AAC 70, Water Quality Standards. Online: https://dec.alaska.gov/water/water-quality/standards/

Alaska Department of Fish and Game (AGF&G). 2012. Subsistence Harvest and Data Reports. Online: http://www.adfg.alaska.gov/sb/CSIS/index.cfm?ADFG=harvInfo.harvestCommSelComm

Alaska Department of Fish and Game (AGF&G). 2017. State of Alaska Special Status Species: Fish Stock of Concern. Online: http://www.adfg.alaska.gov/index.cfm?adfg=specialstatus.akfishstocks

Alaska Department of Fish and Game (AGF&G). 2020. Anadromous Waters Catalog: Interactive Mapper. Online: https://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=main.interactive

Bellmore R., M. Winfree. Southeast Alaska Freshwater Monitoring Network Implementation Plan. 2019. Online: https://www.alaskawatershedcoalition.org/southeast-alaska-stream-temperature-monitoring-network/.

Isaak D.J. and B.E. Rieman. 2013. Stream isotherm shifts from climate change and implications for distributions of ectothermic organisms. *Global Change Biol.* 19: 742–751.

Kovach, R. P., J.E. Joyce, J.D. Echave, M.S. Lindberg, and D.A. Tallmon. (2013) Earlier Migration Timing, Decreasing Phenotypic Variation, and Biocomplexity in Multiple Salmonid Species, ed S M Carlson, *PLoS ONE*, 8 1–10 Online: http://dx.plos.org/10.1371/journal.pone.0053807.

Mauger, S. 2013. Stream Temperature Monitoring for Cook Inlet Salmon Streams 2008-2012. Final report for the Alaska Department of Environmental Conservation and U.S. Fish and Wildlife Service. Online: https://inletkeeper.org/wp-content/uploads/2017/03/Cook-Inlet-Stream-Temp-Network-Synthesis-Report.pdf

Mauger, S., R. Shaftel, E.J. Trammell, M. Geist, and D. Bogan. 2014. Stream temperature data collection standards and protocol for Alaska: minimum standards to generate data useful for regional-scale analyses. Cook Inletkeeper, Homer, AK and Alaska Natural Heritage Program, UAA, Anchorage, AK. 53 pp.

Mauger, S., R. Shaftel, J.C. Leppi, and D.J. Rinella. 2017. Summer temperature regimes in southcentral Alaska streams: watershed drivers of variation and potential implications for Pacific salmon, *Can. J. Fish. Aquat. Sci.,* 74 702–15 Online: http://www.nrcresearchpress.com/doi/10.1139/cjfas-2016-0076.

Schoen,E.R., M.S. Wipfli, E.J. Trammell, D.J. Rinella, A.J. Floyd, J. Grunblatt, M.D. McCarthy, B.E. Meyer, J. M. Morton, J.E. Powell, A. Prakash, M.N. Reimer, S.L. Stuefer, H. Toniolo, B.M. Wells, and F.D. Witmer. 2017. Future of pacific salmon in the face of environmental change: lessons from one of the World's remaining productive salmon regions. Fisheries, 42 (10) (2017). pp. 538-553

Shanley, C. S., S. Pyare, M.I. Goldstein, P.B. Alaback, D.M. Albert, C.M. Beier, T.J. Brinkman, R.T. Edwards, E. Hood, A. MacKinnon, M.V. McPhee, T.M. Patterson, L.H. Suring, D.A. Tallmon, and M.S. Wipfli. 2015. Climatic Change. 130: 155. Online: https://doi.org/10.1007/s10584-015-1355-9.

Steel, E. A., A. Tillotson, D.A. Larsen, A.H. Fullerton, K.P. Denton, and B.R. Beckman. 2012. Beyond the mean: The role of variability in predicting ecological effects of stream temperature on salmon, *Ecosphere*, 3 1–11 Online: http://doi.wiley.com/10.1890/ES12-00255.1.

Taylor, S. G. 2008. Climate warming causes phenological shift in Pink Salmon, Oncorhynchus gorbuscha, behavior at Auke Creek, Alaska: Climate warming and pink salmon behavior, *Glob. Change Biol.*, 14 229–35 Online: http://doi.wiley.com/10.1111/j.1365-2486.2007.01494.x.

Webb, B. W., D.M. Hannah, R.D. Moore, L.E. Brown, and F. Nobilis. 2008. Recent advances in stream and river temperature research, *Hydrol. Process.*, 22 902–18 Online: http://doi.wiley.com/10.1002/hyp.6994.

Chilkoot Lake. Photo by Derek Poinsette.