McNary Dam Annual Temperature Report, 2020

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

INTRODUCTION

McNary Dam, located at river mile 292, is the first dam encountered by Columbia River fall Chinook salmon originating from the Hanford Reach and Priest Rapids Hatchery. These fish comprise the largest component of subyearling fall Chinook salmon migrating through McNary Dam, though smaller numbers of Endangered Species Act-listed Snake River fall Chinook salmon also navigate the dam. The migration of juvenile fall Chinook salmon typically peaks in summer months when water temperatures are the highest of the season. High water temperatures may have adverse effects on migrating salmonids. High rates of juvenile salmonid mortality have been associated with high water temperatures at McNary Dam in the past.

Forebay surface temperatures are warmed by solar radiation and warm air temperatures, though deeper forebay water may remain cooler. Moderate wind speeds (greater than 3 miles per hour [mph]) can mix water in the forebay and decrease surface water temperature. Warm, windless days are typically experienced in July and August and allow surface water to warm unabated.

A portion (0.5% to 25%) of the juvenile salmonids passing McNary Dam are collected and held for examination to determine species composition and condition, and then released to the tailrace. Fish entering the bypass system from the forebay are guided into turbine gatewells (3 gatewells for each of the 14 turbines, totaling 42 gatewells) and away from turbine intakes by extended-length submersible bar screens. In the gatewells, 12-inch orifices lead into the collection channel and the full-flow bypass system that delivers fish to the Juvenile Fish Facility (JFF) during sampling under secondary bypass operations. Water from the collection channel is diverted over the wet separator at the JFF where smolts and smaller fish are separated from adults and larger fish. While in secondary bypass, most of the separated fish are passed through the JFF system and returned to the river via the JFF outfall pipe.

High water temperatures in the juvenile bypass system can be mitigated through powerhouse operations. Using a turbine operational strategy that balances the turbines in operation and those in standby across the powerhouse can decrease the magnitude of the temperature and temperature gradients. Operating turbines draw in warmer surface water while standby turbines allow cooler, deeper water at orifice depth to passively enter the gatewells. This warm water turbine management pattern can decrease the temperature of water along bypass routes.

The objective of the 2020 Temperature Monitoring Program at McNary Dam was to monitor water temperature patterns in juvenile salmonid passage areas, including the powerhouse, gatewells, collection channel, and the JFF. Daily temperatures were monitored in these areas to identify temperature conditions that might contribute to increased mortality for fish passing through the juvenile bypass system.

Thank you to the staff at the McNary Dam JFF for their advice and support. Bobby Johnson, Denise Griffith, and the U.S. Army Corps of Engineers staff at the JFF provided invaluable assistance during each phase of this work. Thank you to Thomas VanNice, Josh Hubbard, and Kathleen Carter of Pacific States Marine Fisheries Commission for providing suggestions, assisting with equipment deployment, and drafting this document. Thank you also to Anchor QEA, LLC, staff Kristi Geris and Celia Baker for their advice and support over the season.

METHODS

Water temperatures were measured at 0.5-hour intervals (0000 and 0030) from 0700 hours on June 14 to 0700 hours on August 31, 2020. Measurements were taken using Onset Computer Corporation HOBO U22-001 data loggers with an accuracy of ±0.38°F and a precision of 0.04°F. A total of 642 (0.7%) hours of water temperature data were lost during the 2020 temperature monitoring season due to 17 loggers completely failing in the field and additional lost hours due to slight logger malfunctions (Appendix A).

The loggers were deployed at 27 locations throughout the McNary Dam Project including the forebay, gatewells, collection channel, and the JFF as follows:

- Powerhouse forebay (referred to herein as forebay), near elevation 335 feet in the trolley pipes fitted to the "C" pier nose of Units 1, 3, 5, 7, 8, 10, 12, and 14 (8 total): submerged to a depth of approximately 10 feet below the forebay water surface.

- Gatewells, in the center of each "B" slot at each unit (14 total): submerged to a depth of approximately 3 feet below the water surface in the gatewell. The temperature logger for Gatewell 5 was deployed at 1030 hours on July 29 after the fish diversion screen was operational.

- Collection channel, downstream of gatewell orifices 12B and 8B, and upstream of the incline dewatering screen south of Unit 1: submerged to a depth of approximately 2 feet below the water surface in the collection channel.

- JFF, in the fish separator underneath the bars in the "B" section and in the "B" sample tank: submerged to a depth of 2 feet below the water surface.

Prior to 2017, water temperature loggers were deployed along the spillway and in the tailrace at Units 1 and 14, on the transportation barge dock, and the tailrace navigation lock wing wall. A logger placed at the JFF outfall pipe has replaced the tailrace navigation lock wing wall logger since 2016; however, the JFF outfall pipe was not accessible this year due to damage from high flows in 2019. The spillway has not been monitored since 2016.

Daily water temperatures were also recorded at 0700 hours in sample tank "B" using a Fluke 52-2 digital thermometer with a precision of 0.1°F and an accuracy of ±0.54°F. The daily temperature value was reported to McNary Dam biologists as part of the Smolt Monitoring Program. The temperatures recorded at 0700 hours are considered a minimum daily temperature and do not reflect any diurnal fluctuation.

In previous years, weather data was obtained from a Davis Vantage Vue data station positioned at the JFF near the separator. Early in the season this station became unreliable and repair was unsuccessful. A replacement station was purchased but operation could not be established. In coordination with the manufacturer's IT department, a warranty replacement of the station data logger, followed by a warranty

replacement of the station console, were tried, but connectivity with the on-site computer could not be established by the end of the monitoring period. Air temperature was recorded with a temperature logger below the separator building and was downloaded for daily and weekly reports. For this report, all weather data were obtained from the Hermiston Airport in Hermiston, Oregon via the MesoWest database managed by the University of Utah and the Department of Atmospheric Sciences[1]. Air Temperature and Wind velocity from each hour and half hour were averaged and summarized in this report.

Daily temperature reports were compiled using water temperatures and weather data collected from 0700 hours of the previous day to 0700 hours of the current day. This time frame coincided with sampling activities at the JFF.

RESULTS

Weather Conditions

Maximum air temperatures occurred between 1300 and 2030 hours and minimum air temperatures occurred between 2000 and 1000 hours (Table 1). The maximum air temperature for the monitoring season, 109.4°F, was measured at 1630 to 1800 hours on July 30 (Figure 1).

Wind velocity was highly variable throughout the day. The highest average wind velocity occurred in June and the lowest average wind velocity occurred in August. The highest average daily wind velocity was 22.7 mph at 1430 hours on June 30.

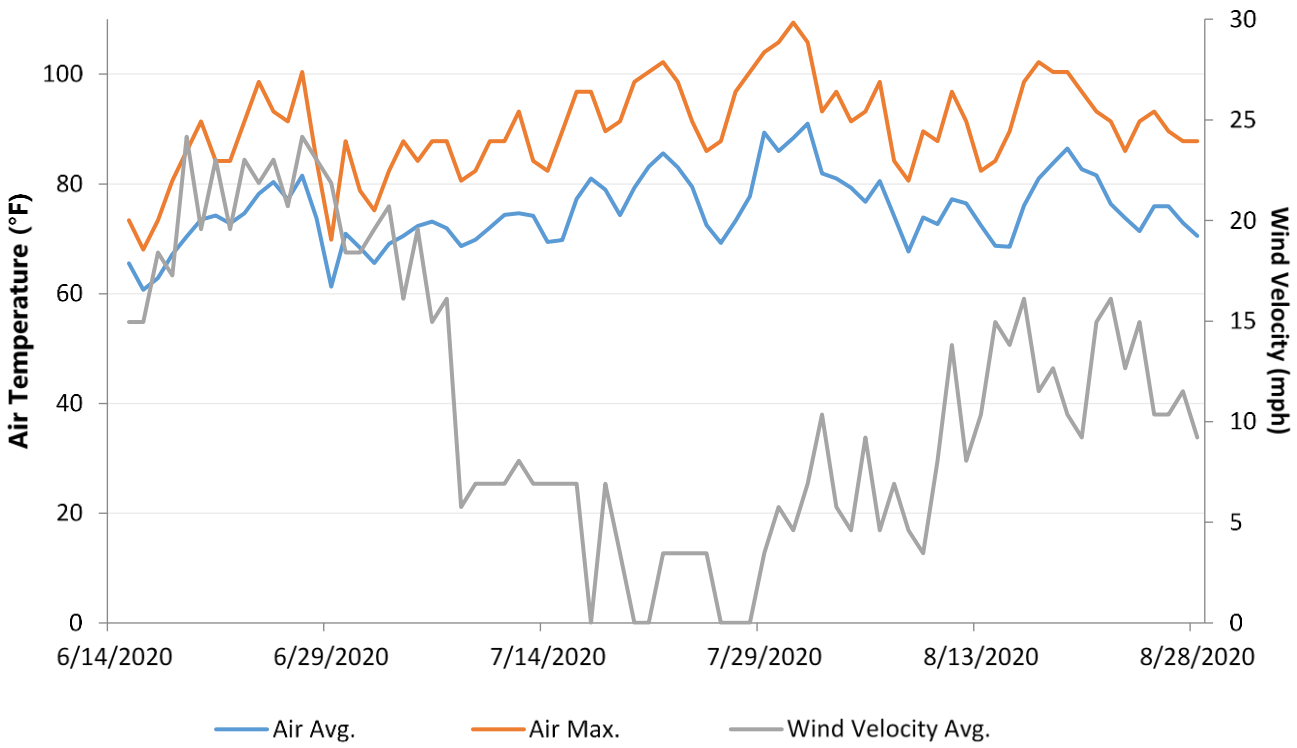
Table 1. Air Temperatures and Wind Velocity at McNary Dam from 0700 on June 14 to 0700 on August 31, 2020

Month	Daily Avg. (°F)	Daily Max. Avg. (°F)	Daily Min. Avg. (°F)	Max. Range (°F)	Min. Range (°F)	Days >90°F*	Wind Avg. (mph)	Days >3 mph**
June†	71.4	84.5	57.3	68.0–100.4	50.0–66.2	6	10.7	17
July	76.3	92.1	59.3	75.2–109.4	46.4–77.0	15	9.3	31
August	75.3	90.5	60.0	69.8–102.2	44.6–73.4	16	7.8	31

Notes:
* Count of days with highs exceeding 90°F
** Days with at least one 0.5-hour period with wind velocity exceeding 3 mph
† Monitoring occurred June 14 to June 30
mph: miles per hour

[1] https://mesowest.utah.edu/

Figure 1. Average and Maximum Daily Air Temperatures and Average Wind Velocity from 0700 on June 14 to 0700 on August 31, 2020



River Flow and Spill

Total river flow during the monitoring period from June 15 to August 31 averaged 214.3 kilo cubic feet per second (kcfs). The peak average daily total river flow (320.2 kcfs) was recorded on June 29. The minimum average daily total river flow (124.9 kcfs) was recorded on August 26 (Figure 2). Monthly average total river flow over the monitoring period in June, July, and August was 299.6, 225.7, and 158.8 kcfs respectively. Monthly average spill for June, July, and August was 173.3, 128.9, and 56.9 kcfs, with spill constituting 57.9%, 57.1%, and 35.8% of the total flow for June, July, and August.

Figure 2. Total River Flow and Spill from 0700 on June 14 to 0700 on August 31, 2020

Powerhouse Forebay and Gatewell Temperatures

Daily water temperature patterns in the forebay and gatewells trended with air temperatures and wind velocity. Daily maximum average forebay water temperatures were recorded between 1300 and 2230 hours and most frequently recorded at 1630 hours. Daily minimum average forebay water temperatures were recorded between 0030 and 1400 hours and most frequently recorded at 0730 hours.

Forebay water temperature reached 68°F for the first time at 1800 hours on June 22 at Unit 7 and averaged 68ºF across the forebay on July 10 for short periods of time (Figure 3). The forebay was consistently above 68°F starting on July 27. McNary Dam began warm water turbine operations on July 22. The forebay reached seasonal maximum average water temperatures of 77.5°F at 1800 hours on August 4. The maximum water temperature recorded in the forebay was 80.1°F at 1700 hours on August 4 at Unit 1. The average forebay water temperature was 76.8°F at that time. Average monthly forebay and gatewell water temperatures are provided in Table 2.

The average water temperature gradient across the forebay was 1.8°F from June 14 to August 31 (Figure 4) and ranged from 0°F to 11.8°F. The largest gradients across the forebay formed between 1630 and 2030 hours. The largest water temperature gradient across the forebay was 11.8°F at 1630 hours on July 19.

Figure 3. Average Water Temperatures of 8 Forebay and 14 Gatewell Locations from 0700 on June 14 to 0700 on August 31, 2020

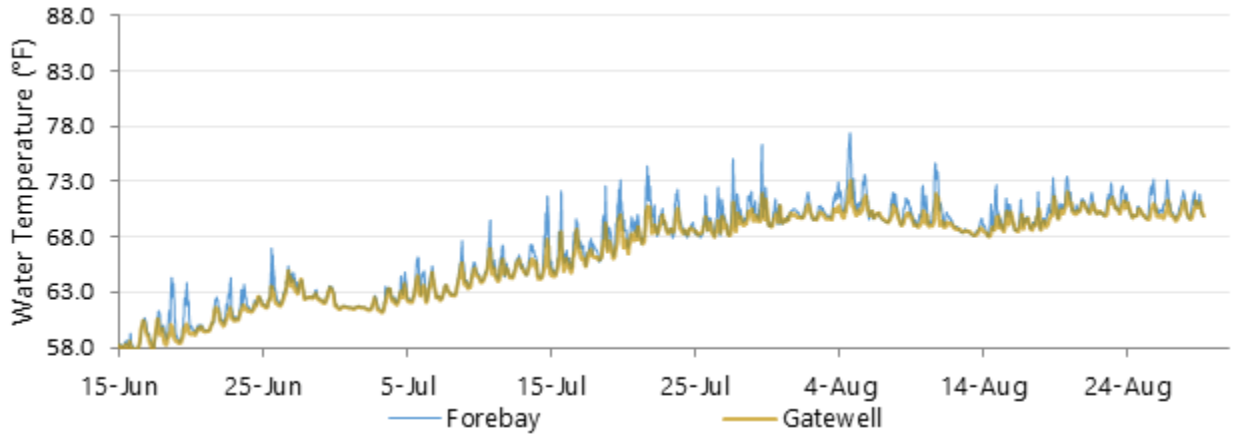
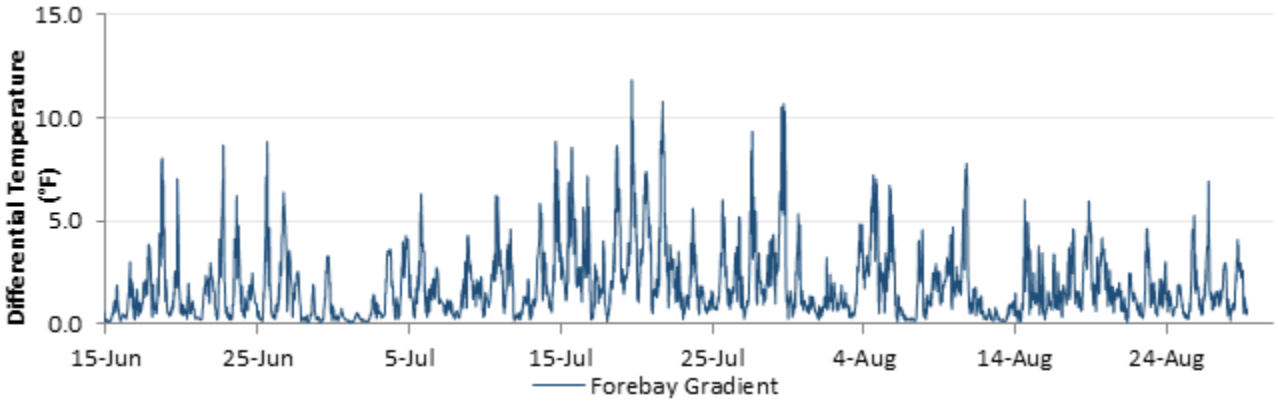


Table 2. Average Forebay and Gatewell Water Temperatures in June, July, and August 2020

Location	June*	July	August
Forebay	61.1°F	66.5 °F	70.4 °F
Gatewell	60.8 °F	65.9°F	69.8 °F

Note:
* June 14 to June 30

Figure 4. Temperature Gradient Between Minimum and Maximum Water Temperatures Recorded Across Eight Forebay Positions for Each 0.5-Hour Period from 0700 on June 14 to 0700 on August 31, 2020



Gatewell water temperatures trended with forebay water temperatures but did not reach the same extremes observed in the forebay. The average gatewell water temperatures reached 68°F on July 15 for short periods of time, and gatewell water temperatures were consistently above 68°F after July 21. The gatewells reached a seasonal maximum average water temperature of 73.1°F on August 4. The

maximum water temperature recorded in the gatewells was 77.5°F at 1830 hours on August 4 at Unit 2. The average temperature gradient across the gatewells was 2.0°F from June 14 to August 31 (Figure 5). The largest temperature gradient across the gatewells was 9.3°F at 1500 hours on July 29.

The water temperature gradient between the forebay and gatewells was 0.5 °F on average (Figure 6). The forebay was warmer than the corresponding gatewell on average for each unit from June 14 to August 31. The maximum water temperature gradient was 11.3°F at 1700 hours on August 4 at Unit 1. The number of units in stand-by increased once warm water turbine operation began on July 22.

Figure 5. Temperature Gradient Between Minimum and Maximum Water Temperatures Recorded Across 14 Gatewell Positions for Each 0.5-Hour Period from 0700 on June 14 to 0700 on August 31, 2020

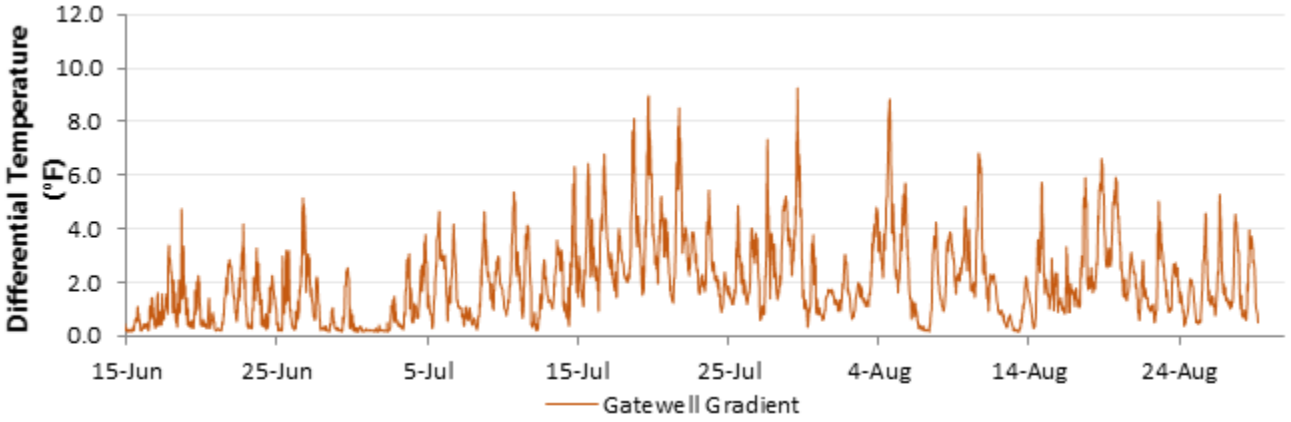
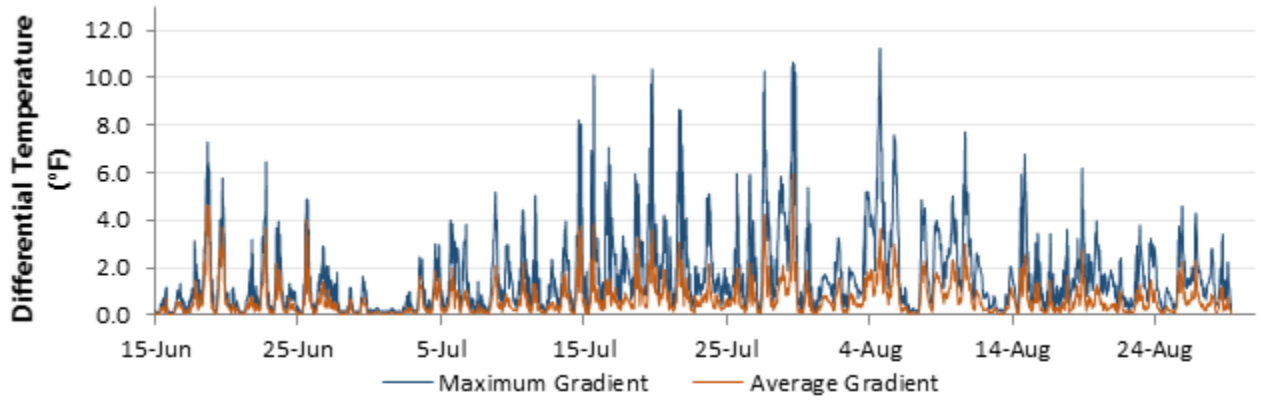


Figure 6. Maximum and Average Water Temperatures Gradient Recorded Between the Forebay and Gatewells for Each 0.5-Hour Period from 0700 on June 14 to 0700 on August 31, 2020



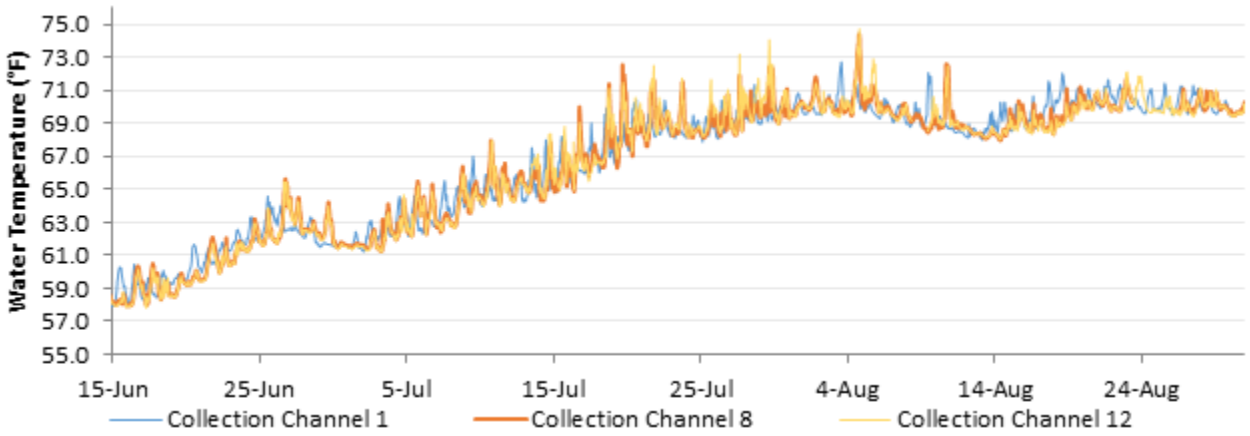
Collection Channel

Water temperatures in the collection channel were less variable than in the forebay and gatewells. Water temperatures across the collection channel averaged 66.5°F from June 14 to August 31 (Table 3). Collection channel water temperatures reached an average of 68°F on July 15 for short periods of time and were continuously exceeding 68°F after July 21(Figure 7). The maximum water temperature of 74.7°F was measured at 1900 hours on August 4 at Unit 12.

Table 3. Water Temperatures in the Collection Channel from 0700 on June 14 to 0700 on August 31, 2020

Seasonal Average (°F)	Seasonal Maximum (°F)	Date of Maximum
66.5	74.7	August 4

Figure 7. Water Temperatures for Three Collection Channel Locations from 0700 on June 14 to 0700 on August 31, 2020



The average water temperature gradient between the gatewells and the collection channel was 0.5°F from June 14 to August 31 (Figure 8) and ranged from 0°F to 4.3°F. The gatewell was warmer on average than the collection channel at Unit 12 but cooler at Units 1 and 8. The maximum water temperature gradient was 4.3°F at 1830 hours on August 10 at Unit 12 and the gatewell was cooler. The average water temperature gradient between the collection channel at Unit 12 and Unit 1 was 0.23°F from June 14 to August 31 (Figure 9). The maximum water temperature gradient between the collection channel at Unit 12 and Unit 1 was 3.7°F at 1600 hours on July 29 with Unit 12 being warmer than Unit 1. On average, the collection channel was warmer at Units 1 and 12 than at Unit 8.

Figure 8. Water Temperature Gradient Recorded Between Three Gatewells and Corresponding Collection Channel Locations (Gatewell Minus Collection Channel) for Each 0.5-Hour Period from 0700 on June 14 to 0700 on August 31, 2020

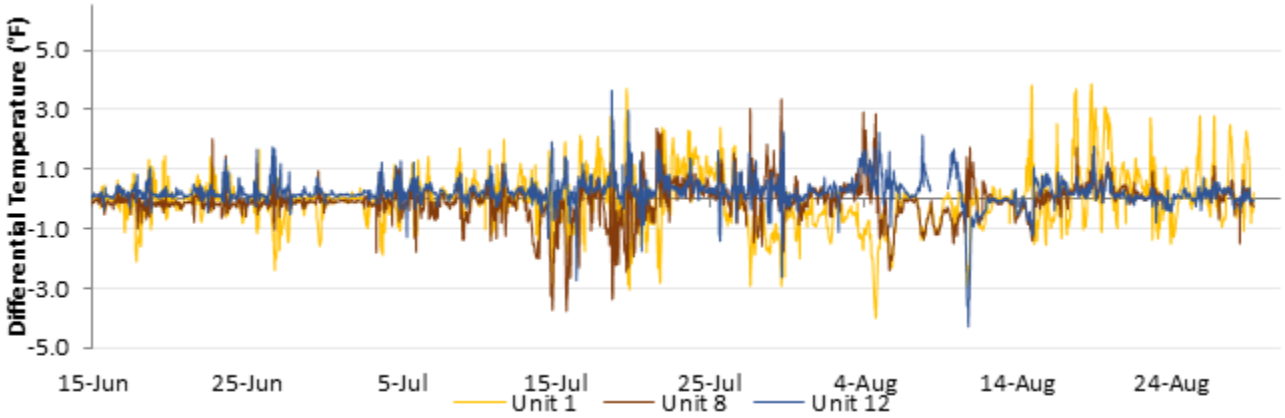
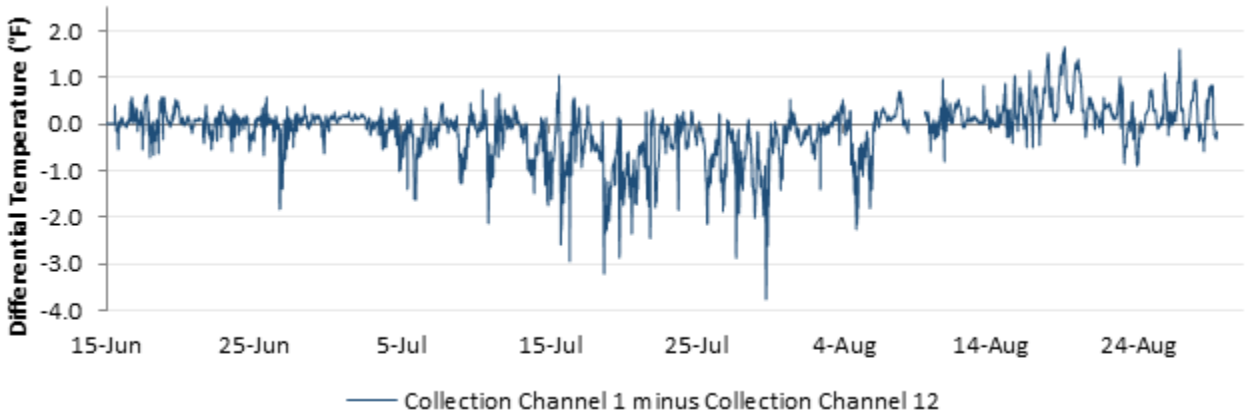


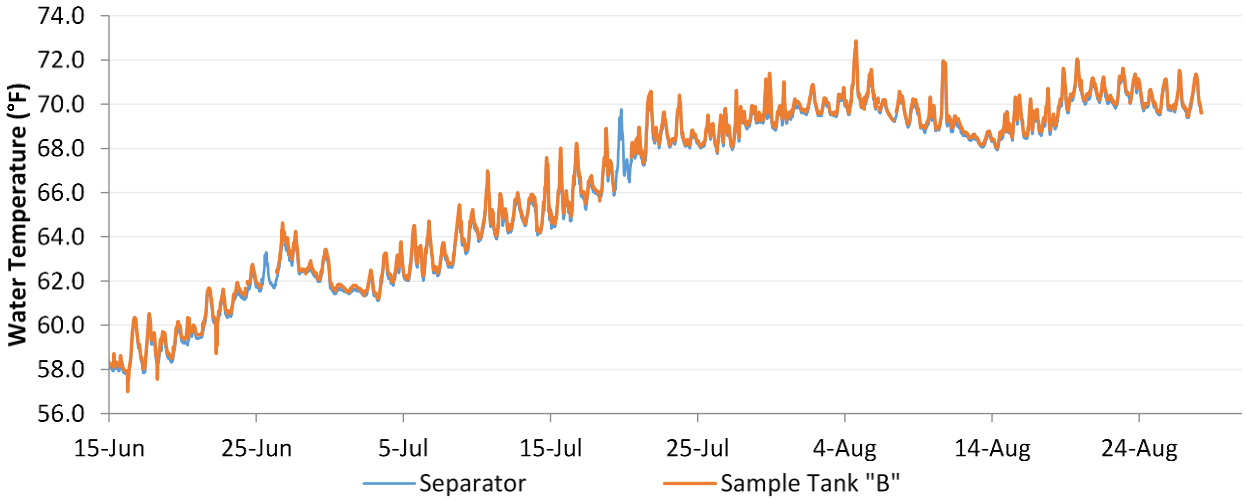
Figure 9. Gradient Recorded Between Water Temperatures at Collection Channel 1 and Collection Channel 12 from 0700 on June 14 to 0700 on August 31, 2020



Juvenile Fish Facility

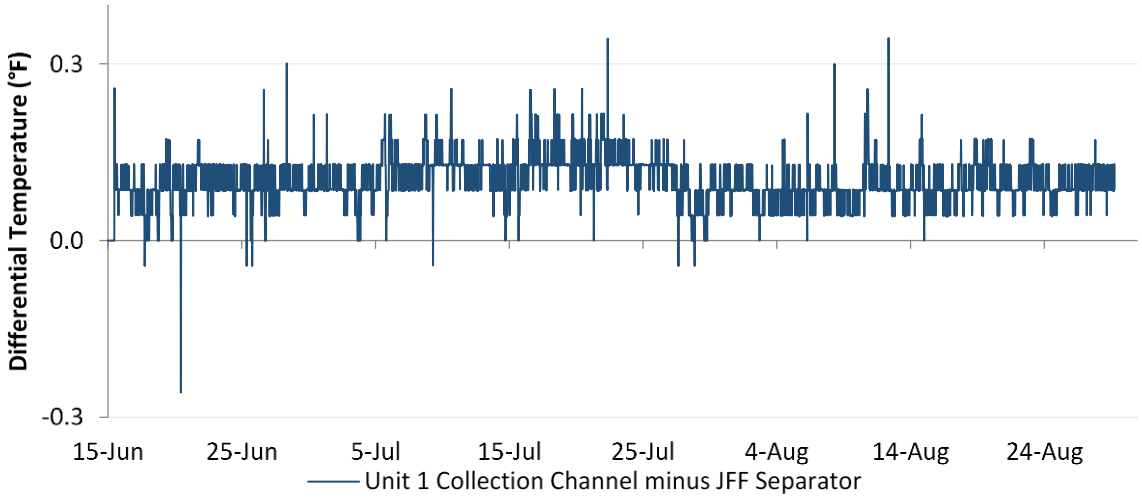
The average water temperature at the JFF from June 14 to August 31 was 66.4°F. Average water temperatures reached 68°F for the first time at 1700 hours on July 15 (Figure 10). Water temperatures continuously exceeded 68°F after July 21. The maximum temperature of 72.9°F was measured at 1830 hours on August 4 at the sample tank "B."

Figure 10. Average Water Temperatures for Two Juvenile Fish Facility Locations from 0700 on June 14 to 0700 on August 31, 2020



The temperature gradient between the collection channel at Unit 1 and the separator at the JFF averaged 0.2°F and ranged from 0°F to 0.3°F (Figure 11). The collection channel was typically warmer than the separator. The temperature gradient across the separator and sample tank "B" averaged 0.2°F. The maximum difference between the two JFF locations (1.2°F) occurred at 0700 hours on June 22 when the separator was cooler.

Figure 11. Water Temperature Gradient Recorded Between the Collection Channel at Unit 1 and Juvenile Fish Facility Separator from 0700 on June 14 to 0700 on August 31, 2020



Outfall Pipe

The outfall pipe was inaccessible for the entire 2020 temperature monitoring season.

Fish Passage and Mortality

At the McNary Dam JFF, fish sampling occurs every other day and collection estimates are derived from these sample counts. These estimates do not account for fish that pass the project on non-sample days. A total of 321,789 juvenile salmonids were estimated to have been collected at McNary Dam during the June 15 to August 31 temperature monitoring period (Table 4). Subyearling Chinook salmon was 99.2% of the total during this period. By July 22, 90% of fish migrating during the monitoring period had bypassed the dam. In previous years, high juvenile mortality at McNary Dam has been correlated with high water temperatures and large temperature gradients along juvenile bypass routes through the powerhouse and JFF. Mortality was low during this monitoring period. Total facility mortality for subyearling Chinook salmon alone, and for all salmon species combined, was estimated at 0.04% of bypassed fish over the monitoring period (subyearling Chinook salmon, 127 mortalities; all species combined, 128 mortalities).

The sample mortality rate may indicate the health status of the total population bypassing the facility since these fish are held for up to 24 hours and then go through the sampling process. The sample mortality rate for subyearling Chinook salmon alone was 1.1% of all fish sampled during the monitoring period (subyearling Chinook salmon, 90 sample mortalities; all other species no mortality).

Table 4. Collection, Mortality, and Passage for Juvenile Salmonids in 2019 and 2020

Year	System			Sample			Passage			
	Collection	Mortality	% Mortality	Sample	Sample Mortality	% Mortality	25%	50%	75%	90%
2020	321,789	128	0.04%	7,962	90	1.1%	20-June	6-July	12-July	22-July
						Sample Tank "B" Temperature (°F)*	59.3	62.1	64.1	68.3
2019	162,401	43	0.03%	3,125	31	1.0%	21-June	25-June	29-June	17-July
						Sample Tank "B" Temperature (°F)*	63.0	63.4	64.5	68.7

Notes:
* Sample tank temperature was taken at 0700 daily.

RECOMMENDATIONS

High water temperature at McNary Dam is managed through modification of turbine operation. Turbines operating in alternating standby pattern reduces high water temperatures and temperature gradients in fish passage routes through the powerhouse and the JFF. This operation plan is most effective in reducing high water temperatures from the forebay in the early season because deeper forebay water has not been warmed by prolonged high air temperatures. McNary Dam should continue to employ this program.

Additional recommendations include:

- Continue to deploy temperature data loggers at strategic temperature monitoring sites.
- Work to establish full operation of the new weather station. Connectivity of this station with the on-site computer should be completed as soon as possible in the off-season. If this cannot be accomplished, then alternative sources of local atmospheric condition data will need to be established.
- Continue to use temperature data logger to monitor air temperatures at separator of the JFF throughout the monitoring season, either to replace the weather station or to provide backup data in the event of an in-season weather station failure.
- Obtain wind data from a local National Oceanic and Atmospheric Administration based weather station.
- Implement and assess (in 2021) additional protective measures, such as weighting or armoring of loggers deployed in gatewells, as records from 2020 suggest data loggers may be subjected to more damage in gatewell locations.

Appendix A
Temperature Logger Problems

APPENDIX A: TEMPERATURE LOGGER PROBLEMS

At the beginning of the 2020 temperature-monitoring season, 18 new data loggers were purchased. Of these, 14 were deployed as replacements for failed loggers. Failed loggers were replaced the same day as downloading (usually less than 24 hours of disrupted data recording). Short disruption in data recording (usually less than one hour) occurred sporadically throughout the season with most loggers.

Table A-1. 2020 Season monitoring hours lost due to temperature logger failures with Water Temperature Loggers (HOBO U22-001)

								HOBO Logger Location						
Date	**Time**	**G2**	**G6**	**G7**	**G9**	**G10**	**G13**	**G14**	**F8**	**F14**	**C1**	**C8**	**C12**	**Sample**
6/14–6/15	1000–1130										26			
6/15–6/16	0900–1200				27									
6/16–6/18	0730–1030						51.5							
6/17–6/18	0900–1500					30								
6/19–6/20	0700–1200					29.5								
6/21–6/22	0430–1130			19.5										
6/23–6/24	0800–1130				28									
6/23–6/24	0800–1200						28.5							
6/25–6/27	0830–0730			47.5										
6/25–6/26	0900–0900													24
6/27–6/28	0800–1400									30				
7/12–7/13	1000–1030					25								
7/14–7/15	0900–0730					22.5								
7/14–7/15	0930–0700							22						
7/19–7/20	0800–1130													27.5
7/22–7/23	0830–0930	25.5												
7/27–7/28	0830–1130								27.5					
7/31–8/1	0730–1230								29.5					
8/8–8/9	0830–1000												26	
8/23–8/26	1000–0930											72		
8/30–8/31	0800–0630		23											
Total Hours	**642**													