McNary Dam Annual Temperature Report, 2021

Prepared by

Wes Stonecypher
Eric Harries

Environmental Assessment Services, LLC

13 September, 2021

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, although smaller numbers of Snake River fall Chinook salmon listed under the Endangered Species Act also navigate the dam.

Typically, the migration of juvenile fall Chinook salmon peak in summer months when water temperatures are highest for the season. High water temperature may have adverse effects on migrating salmonids. In the past, an increase in juvenile salmonid mortality has been associated with high water temperatures at McNary Dam.

Forebay surface water temperatures are warmed by solar radiation and by warm air temperatures, though deeper forebay water may remain cooler. Wind speeds greater than 3 miles per hour (mph) help to decrease the surface temperature by allowing some mixing of the surface with the cool deeper water. Warmer and less windy days are more common during the months of July and August, and this allows the surface water to warm unabated.

A portion (0.5% to 25%) of the juvenile salmonids passing through the Juvenile Collection Channel are sampled. These salmonids are examined to determine species composition and condition and then released back to the tailrace. Fish entering the bypass system from the forebay are guided into turbine gatewells (three 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 2021 Temperature Monitoring Program at McNary Dam was to monitor water temperature patterns in juvenile salmonid passage areas. These areas include the powerhouse, gatewells, collection channel, and the separator and sample tank at the JFF. Temperature readings were taken at 30-minute intervals throughout the day. Daily temperatures were monitored 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, Amber Johnson, 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 Leah Libow for their advice and support over the season.

METHODS

Water temperatures were measured at 0.5-hour intervals (0000 and 0030) from 1200 hours on June 14 to 0700 hours on August 31, 2021. 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 230.5 (0.001%) hours of water temperature data were lost during the 2021 temperature monitoring season due to 9 loggers completely failing in the field, and additional hours were lost 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 (eight 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 August 10 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.

Air temperature was recorded with a temperature logger located below the separator building. All wind velocity and direction data were obtained from the Hermiston Municipal Airport in Hermiston, Oregon, via the MesoWest database, which is managed by the University of Utah and the Department of Atmospheric Sciences[1]. Wind velocity data from each 0.5-hour period 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, 113.1°F, was measured at 1800 hours on June 29 (Figure 1).

Wind velocity was highly variable throughout the day. The highest average wind velocity occurred in July and the lowest average wind velocity occurred in June. The maximum wind velocity was 28.8 mph recorded on July 1 at 0130 hours.

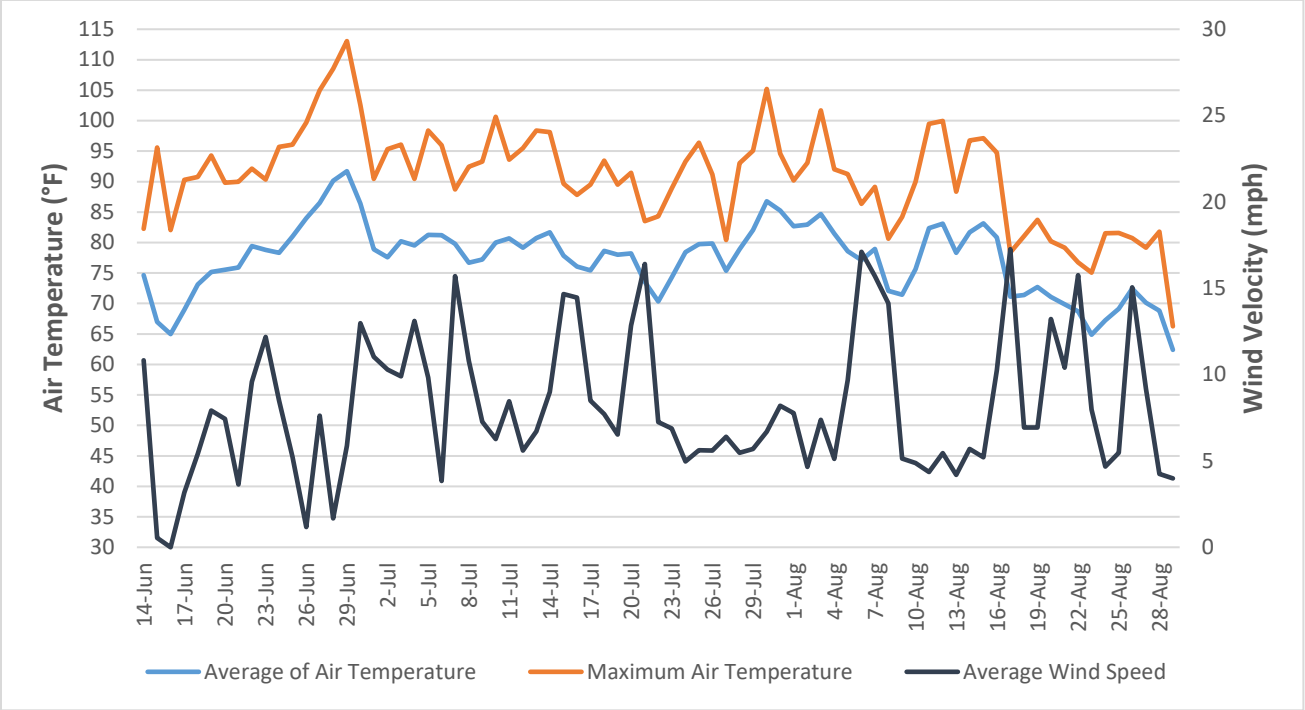
Table 1. Air Temperatures and Wind Velocity at McNary Dam from 1200 on June 14 to 0700 on August 31, 2021

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†	78.3	95.2	65.5	82–113.1	54.3–77.2	13	6.1	16
July	78.8	92.7	68.4	80.4–105.2	60.8–76.4	22	8.9	31
August	78.0	89.5	68.6	67–101.7	54.3–77.1	10	9.2	29

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] MesoWest Database, 2021. MesoWest Weather Observations Database. University of Utah and Department of Atmospheric Sciences. Available at: https://mesowest.utah.edu/.

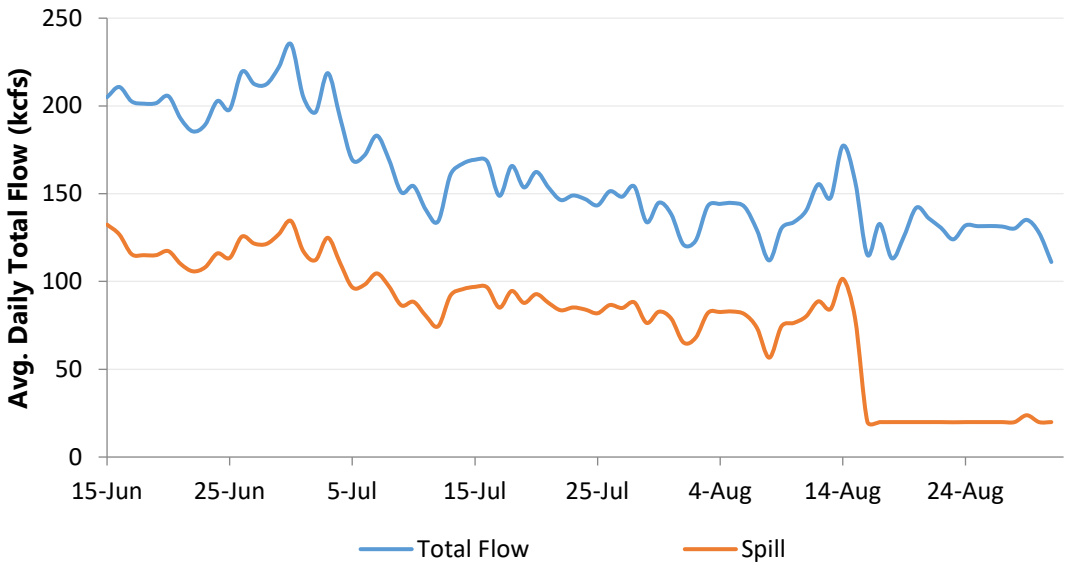
Figure 1. Average and Maximum Daily Air Temperatures and Average Wind Velocity from 1200 on June 14 to 0700 on August 31, 2021



River Flow and Spill

Total river flow during the monitoring period from June 15 to August 31 averaged 159.5 kilo cubic feet per second (kcfs). The peak average daily total river flow (235.2 kcfs) was recorded on June 30. The minimum average daily total river flow (111.1 kcfs) was recorded on August 31 (Figure 2). Monthly average total river flow over the monitoring period in June, July, and August was 206.1, 161.1, and 133.9 kcfs. Monthly average spill for June, July, and August was 119.1, 92.0, and 48.4 kcfs, with spill constituting 57.8%, 57.1%, and 36.1% of the total flow.

Figure 2. Total River Flow and Spill from 0700 on June 14 to 0700 on August 31, 2021



Powerhouse Forebay and Gatewell Temperatures

Daily water temperatures in the forebay and gatewells corresponded to air temperatures and wind velocity. Daily maximum average JFF water temperatures were recorded predominately between 1330 and 0330 and most frequently recorded at 1700 hours. Daily minimum average JFF water temperatures were recorded between 2330 and 1200 hours and most frequently recorded at 0830 hours.

Forebay water temperature reached 68°F for the first time at 1530 hours on June 16 at Unit 10 and averaged 68ºF across the forebay on June 17 for short periods of time (Figure 3). The forebay was consistently above 68°F starting on June 30. McNary Dam began warm water turbine operations, operating Units in a "sawtooth" pattern on June 30. The forebay reached seasonal maximum average water temperatures of 78.5°F at 1630 hours on July 29. The maximum water temperature recorded in the forebay was 83.3°F at 1530 hours on August 11 at Unit 14. The average forebay water temperature was 75.6°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 2.2°F from June 14 to August 31 (Figure 4) and ranged from 0.2°F to 13.6°F. The largest gradients across the forebay formed between 0630 and 0200 hours. The largest water temperature gradient across the forebay was 13.6°F at 1600 hours on June 17.

Figure 3. Average Water Temperatures of Eight Forebay and 14 Gatewell Locations from 1200 on June 14 to 0700 on August 31, 2021

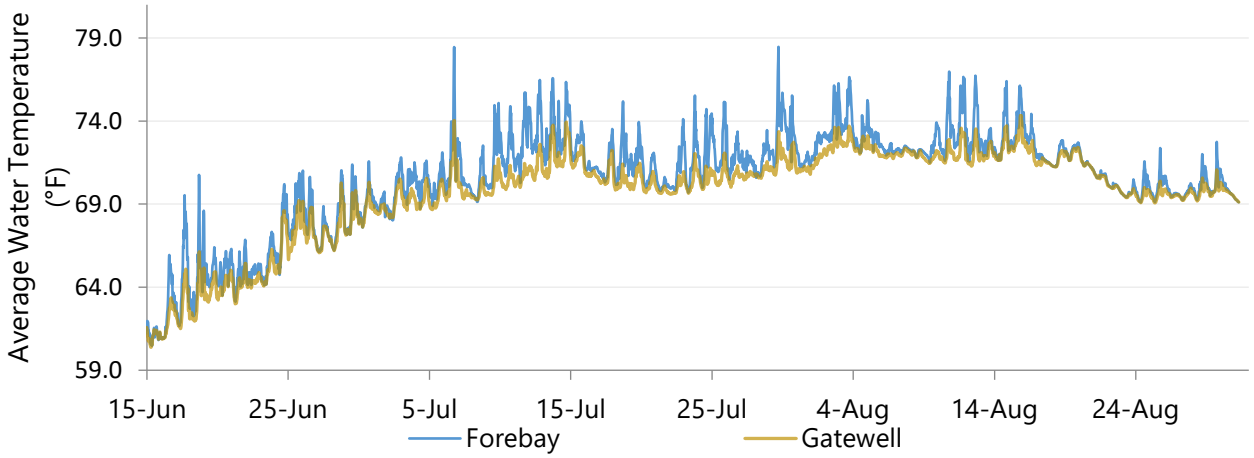
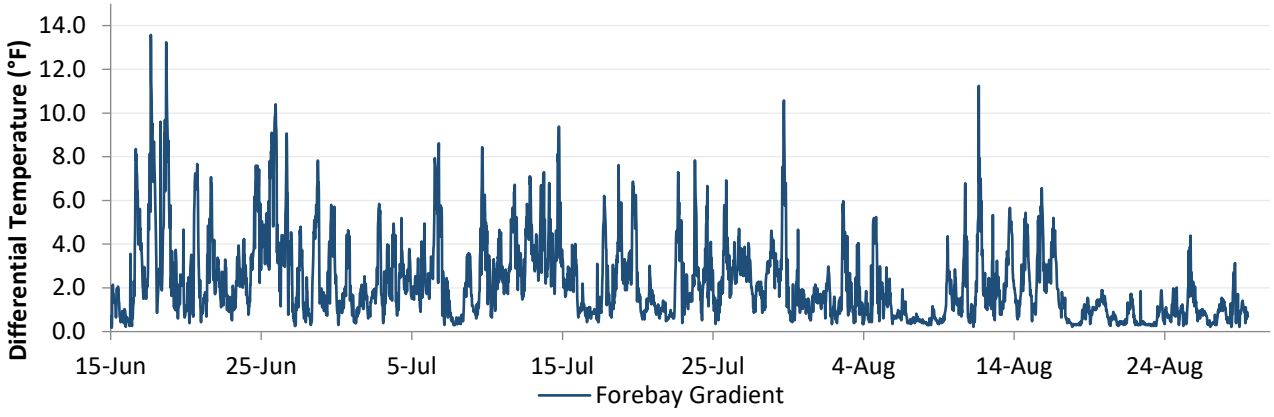


Table 2. Average Forebay and Gatewell Water Temperatures in June, July, and August 2021

Location	June*	July	August
Forebay	65.9°F	71.6°F	71.9°F
Gatewell	65.1°F	70.5°F	71.3°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 1200 on June 14 to 0700 on August 31, 2021



Gatewell water temperatures corresponded to forebay water temperatures but were not as extreme (Figure 3). The average gatewell water temperatures reached 68°F on June 24 for short periods of time, and gatewell water temperatures were consistently above 68°F after June 29. The gatewells reached a seasonal maximum average water temperature of 74.1°F on August 15. The maximum water temperature recorded in the gatewells was 78.7°F at 1730 hours on July 29 at Unit 14. The average temperature gradient across the gatewells was 2.7°F from June 14 to August 31 (Figure 5). The largest temperature gradient across the gatewells was 10.0°F at 1630 hours on June 18.

The water temperature gradient between the forebay and gatewells was 1.1°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 12.1°F at 1630 hours on June 17 at Unit 7. After the June 30 initiation of sawtooth strategy, more units were in stand-by mode.

Figure 5. Temperature Gradient Between Minimum and Maximum Water Temperatures Recorded Across 14 Gatewell Positions for Each 0.5-Hour Period from 1200 on June 14 to 0700 on August 31, 2021

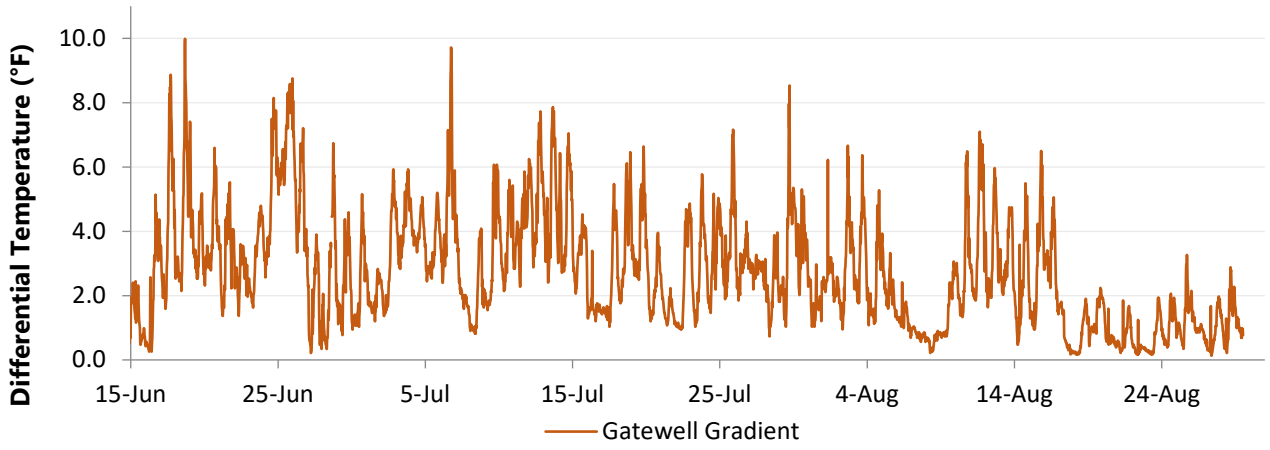
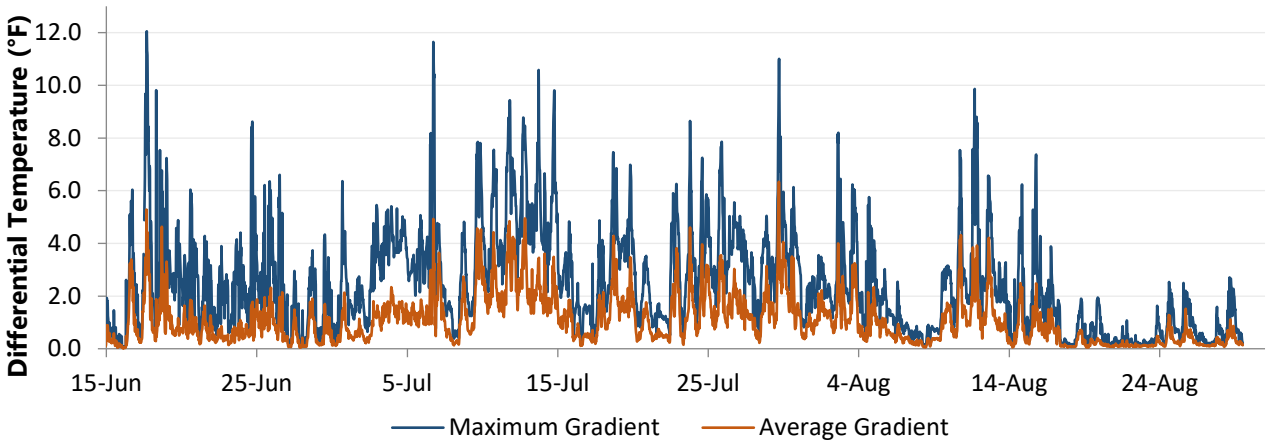


Figure 6. Maximum and Average Water Temperatures Gradient Recorded Between the Forebay and Gatewells for Each 0.5-Hour Period from 1200 on June 14 to 0700 on August 31, 2021



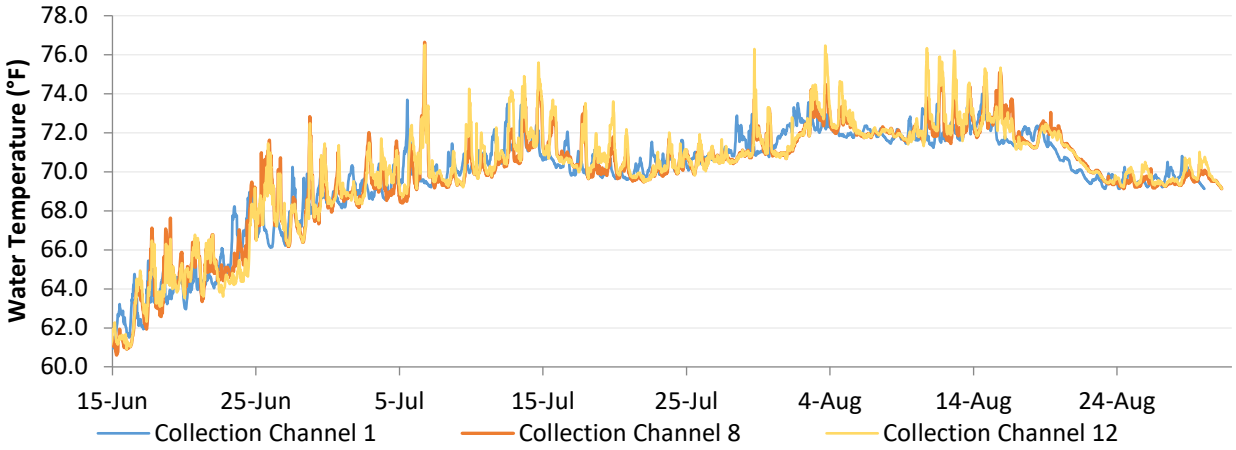
Collection Channel

Water temperatures in the collection channel were less variable than in the forebay and gatewells. Water temperatures across the collection channel averaged 69.8°F from June 14 to August 31 (Table 3). Collection channel water temperatures reached an average of 68°F on June 24 for short periods of time and were continuously exceeding 68°F after June 30 (Figure 7). The maximum water temperature of 76.6°F was measured at 1800 hours on July 6 at Unit 8.

Table 3. Water Temperatures in the Collection Channel from 1200 on June 14 to 0700 on August 31, 2021

Seasonal Average (°F)	Seasonal Maximum (°F)	Date of Maximum
69.8	76.6	July 6

Figure 7. Water Temperatures for Three Collection Channel Locations from 1200 on June 14 to 0700 on August 31, 2021



The average water temperature gradient between the gatewells and the collection channel was 0.3°F from June 14 to August 31 (Figure 8) and ranged from 0°F to 5.6°F. The collection channel was warmer on average than the gatewells at Units 1, 8, and 12. The maximum water temperature gradient was 5.6°F at 1500 hours on June 17 at Unit 1. The average water temperature gradient between the collection channel at Unit 12 and Unit 1 was 0.8°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 3.6°F at 1800 hours on August 10, with Unit 12 being warmer than Unit 1. On average, the collection channel was warmer at Units 8 and 12 than at Unit 1.

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 1200 on June 14 to 0700 on August 31, 2021

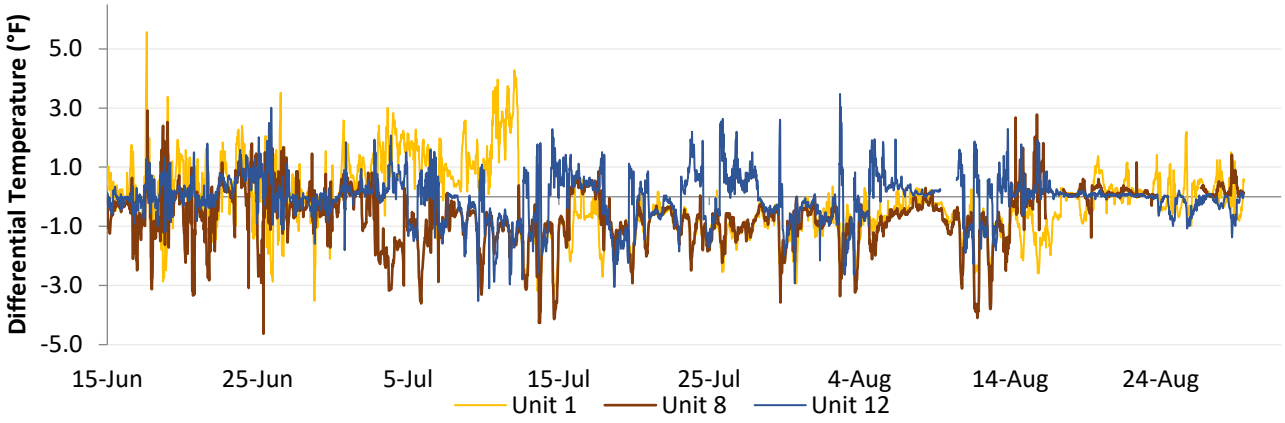
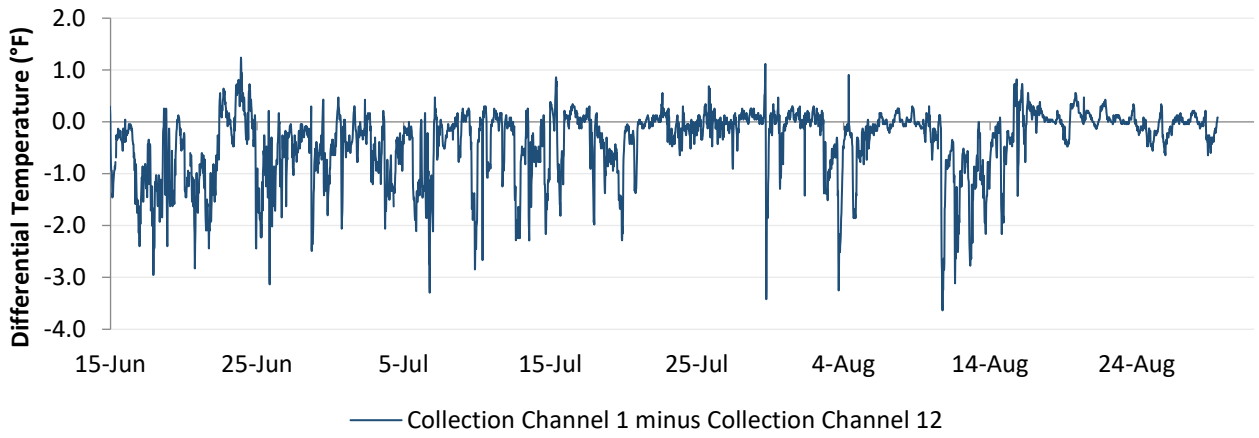


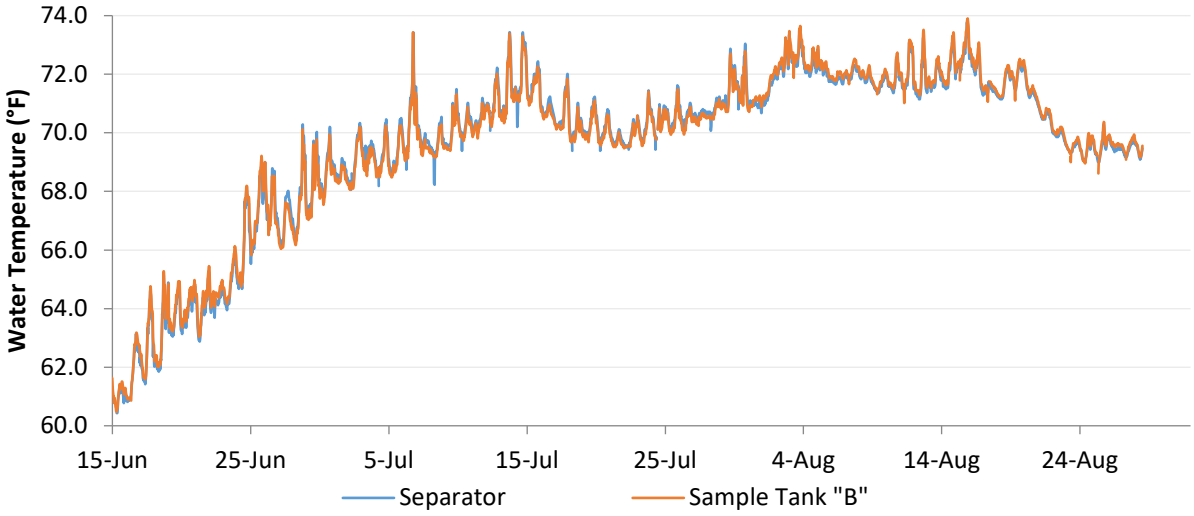
Figure 9. Gradient Recorded Between Water Temperatures at Collection Channel 1 and Collection Channel 12 from 1200 on June 14 to 0700 on August 31, 2021



Juvenile Fish Facility

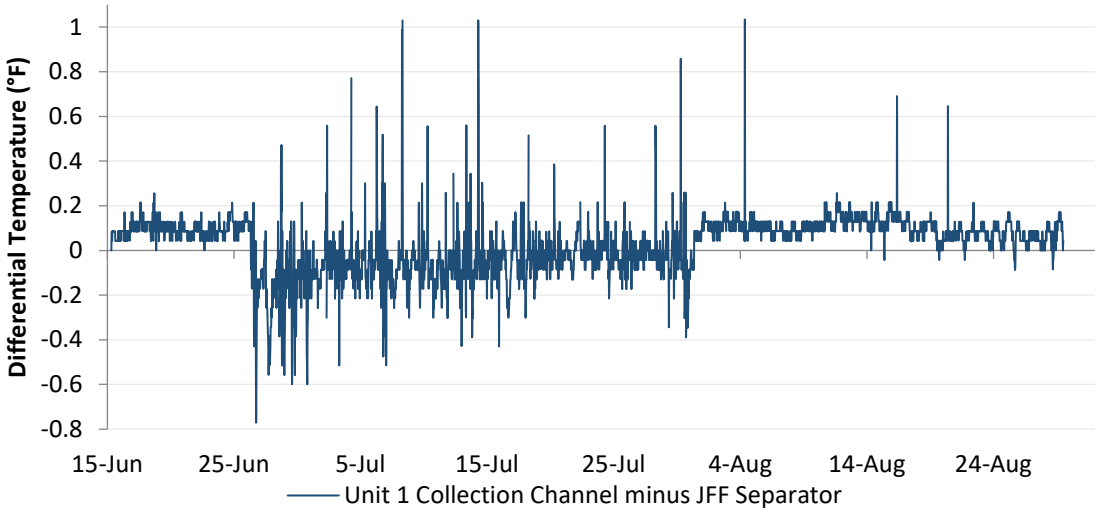
The average water temperature at the JFF from June 14 to August 31 was 69.6°F. Average water temperatures reached 68°F for the first time at 1630 hours on June 24 (Figure 10). Water temperatures continuously exceeded 68°F after June 30. The maximum temperature of 73.9°F was measured at 2100 hours on August 15 at the sample tank "B."

Figure 10. Average Water Temperatures for Two Juvenile Fish Facility Locations from 1200 on June 14 to 0700 on August 31, 2021



The temperature gradient between the collection channel at Unit 1 and the separator at the JFF averaged 0.1°F and ranged from 0°F to 1.0°F (Figure 11). The temperature gradient across the separator and sample tank "B" averaged 0.2°F. The maximum difference between the two JFF locations (1.0°F) occurred at 2130 hours on June 24 when the separator was cooler.

Figure 11. Water Temperature Gradient Recorded Between the Collection Channel at Unit 1 and Juvenile Fish Facility Separator from 1200 on June 14 to 0700 on August 31, 2021



Outfall Pipe

The outfall pipe was inaccessible for the entire 2021 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 306,978 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 were 99.6% of the total during this period. By July 4, 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 0.02% during the monitoring period (subyearling Chinook salmon, 58 mortalities; all species combined, 62 mortalities).

The sample mortality rate may indicate the health status of the total population bypassing the facility because these fish are held for up to 24 hours and then go through the sampling process. The sample mortality rates for subyearling Chinook salmon alone and for all fish combined were both 0.5% during the monitoring period (subyearling Chinook salmon, 35 sample mortalities; all species combined, 38 sample mortalities).

Table 4. Collection, Mortality, and Passage for Juvenile Salmonids in 2020 and 2021

Year	System			Sample			Passage			
	Collection	Mortality	% Mortality	Sample	Sample Mortality	% Mortality	25%	50%	75%	90%
2021	306,978	62	0.02%	7,393	38	0.5%	24-Jun	24-Jun	28-Jun	4-Jul
	Sample Tank "B" Temperature (°F)*						65.1	65.1	66.2	68.6
2020	321,789	128	0.04%	7,962	90	1.1%	20-Jun	6-Jul	12-Jul	22-Jul
	Sample Tank "B" Temperature (°F)*						59.3	62.1	64.1	68.3

Note:
* 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 (sawtooth strategy) 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 the following:

- Continue to deploy temperature data loggers at strategic temperature monitoring sites.
- Continue to use temperature data logger to monitor air temperatures at separator of the JFF throughout the monitoring season.
- Continue to obtain wind data from a local National Oceanic and Atmospheric Administration based weather station.

Appendix A
Temperature Logger Problems

APPENDIX A: TEMPERATURE LOGGER PROBLEMS

At the beginning of the 2021 temperature monitoring season, 26 new data loggers were purchased. Of these, nine were deployed as replacements for failed loggers. Failed loggers were replaced the same day as downloading (usually less than 26 hours of disrupted data recording). Short disruption in data recording (usually less than 1 hour) occurred sporadically throughout the season with some loggers. A total of 230.5 hours of data were lost this year due to logger failure (Table A-1).

Table A-1. 2021 Season monitoring hours lost due to failure of Onset Computer Corporation HOBO U22-001 data Loggers (HOBO U22-001)

Dates	Time Period	HOBO Logger Location						
		G4	G8	G10	G12	F7	F12	F14
6/25–6/26	0900–0630			22.5				
6/27	0000–0730			7.5				
7/3–7/4	0800–0730							23.5
7/6–7/7	0830–1000					25.5		
7/29–7/30	0730–1130	28						
8/9–8/10	0830–1000				25.5			
8/16–8/17	0900–1130		25.5					
8/21–8/22	0930–1030						25	
8/22–8/23	1000–1030			24.5				
8/30–8/31	0800–0700					23		
Total hours	**230.5**							