Thermal Gradients, Collection and Mortality at the McNary Project, 2015

Water temperatures and the effect on salmonids

This report is prepared for the Army Corp of Engineers, Walla Walla District

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Executive Summary

Water temperatures at the McNary Project are influenced by air temperature and wind velocity. Project operations (turbine unit operations, number and location of operating and non-operating turbine units) and spill (magnitude and more importantly percent) have an effect on the movements and creation of thermal gradients. Total project discharge during the temperature monitoring period (June 15 – August 31) averaged 143.7kcfs in 2015. The percentage of project discharge diverted through the spill June 15 – August 31, 2015 was 49.9%. There was no spring run-off. The Fish Operation Plan mandates that there will be 40% flow from April 10 until June 15. June 16 through August 31, 50% of the flow will go to spill. The Fish Operation Plan is agreed upon by the fish managers who use the current Biological Opinion as reference.

The month of June had temperatures that were an average of ten degrees Fahrenheit warmer than recorded last year. Historically, there have been gradients that occur at the southern end of the powerhouse during days with elevated air temperatures and light winds. In the 2015 season, McNary Dam saw the worst gradients on June 26. There were differences between the forebay and the gatewell of 11.7°F, 10:00 p.m. at Unit 3 and 5.

Fish passage timing can be critical to the mortality equation but earlier passage does not necessarily correspond to cooler river temperatures and decreased mortality. The forebay was consistently reaching 70°F by June 16*. The Corp of Engineers initiated a "sawtooth" pattern for operation of the powerhouse on June 24th. This is an every-other-unit pattern which allows for a larger volume of cooler water to be drawn into the system. By June 30, 50% of the Hanford Reach Fall Chinook fish were at McNary. Without collection in the raceways for transport the volume of mortalities cannot be accounted for. Therefore, the only indicator of mortality is from the sample holding tanks. The largest day of mortality, 8.5%, was July 8. July 7 saw differentials between the forebay and gatewell as large as 6.7°F. The ambient air temperature that day had a maximum of 98.5°F

Standard operational mode for the McNary fish facility is bypass with fish being sampled every-other-day. Therefore, the only reliable accounting for mortality is from the sample holding tank. From June 15 through August 31, sample tank mortality was 2.2%, 90 of 4,093 fish sampled. System mortality was 0.16%, 1,085 for the 684,846 fish estimated for passage.

* This is the justification for changing the parameters for the contract dates.

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ACKNOWLEDGMENTS

This report was accomplished only with aid from the McNary staff. Thomas VanNice and the PSMFC crew are always available for any technical advice required by the Blue Leaf Environmental staff, who were responsible for downloading probes and compiling data. Bobby Johnson and the Corp of Engineers at the Juvenile Fish Facility were always available for anything that was needed.

INTRODUCTION

McNary Dam, located at river mile 292 of the Columbia River, is the first hydroelectric project downstream of the confluence of the Snake and Columbia Rivers. McNary Dam is 7,365 feet long, and rises approximately 183 feet above the streambed. It consists of a 14 turbine Unit powerhouse, a 22 bay spillway, a navigation lock, and an earthen fill embankment at the Oregon (south) abutment. The dam raises the water surface approximately 85 feet creating Lake Wallula, which extends 64 miles upstream to the Hanford Reach on the Columbia River and to Ice Harbor Dam on the Snake River. Lake Wallula has a water surface area of 38,800 acres with 242 miles of shoreline.

The McNary powerhouse is equipped with extended-length submersible bar screens (ESBS) to guide fish into the gatewells of each turbine Unit. There are three vertical gatewell slots (A, B, and C) for each turbine Unit. From the gatewells, water and fish enter the collection channel through 12-inch orifices that leads to a wet separator at the juvenile fish facility (JFF) for separation of fish by size and return of adults to the river. The juvenile fish can be routed back to the river or held in raceways for transport by barge or truck to release locations below Bonneville Dam.

Since 1987, Washington Department of Fish & Wildlife (WDFW/PSMFC) has recorded water temperatures across the powerhouse from June 15 through August 31 of each year. In 2015, the Corp of Engineers (COE) separated this work with the biological oversight contract to be awarded to a small business. Blue Leaf Environmental, Inc. was awarded the contract.

This work has been conducted to identify thermal gradients at the McNary Project that might be detrimental to juvenile fish entering the project and fish facility. Water temperatures were recorded from the scrollcase of all 14 turbine Units. Prior to 1998, water temperatures were recorded with a dissolved oxygen meter in the B gatewell slot of each turbine Unit, and the forebay surface at odd numbered turbine Units at 1:00 p.m. each day. Since 1998, temperature monitoring efforts have been expanded over the full 24 hours of each day to recover temperature information using electronic temperature probes. In 2015, all 37 probes were MadgeTech Temp1000®.

Objectives

The specific objectives at McNary Dam for 2015 were to:

1) Monitor typical temperature patterns in the forebay, tailrace, collection channel, and juvenile fish facility of McNary Dam.
2) Monitor the effects of forebay temperatures on turbine Unit gatewell water temperatures.
3) Monitor the effects of wind speed and air temperature on water temperatures and the creation of thermal gradients at the McNary Dam.
4) Locate areas where thermal gradients are present at McNary Dam and within the juvenile fish facility.
5) Monitor water temperatures in the raceways and the separator.
6) Monitor increased temperature gradients at McNary Dam that might pose a threat to increased mortality at the JFF.

Methods

MadgeTech Temp1000® temperature data loggers were installed at 37 locations throughout the McNary Project and Juvenile Fish Facility (JFF). It is accurate to +/- 0.5°C at any temperature. The range is -40 ~ +80°C. Probes located at the Project and JFF were set to record temperatures at 30-minute intervals.

Temperature probes were downloaded each day for in-season evaluation of thermal gradients at the Project. A weather station is located on top of the JFF building to record air temperatures and wind speed. The weather station recorded temperatures on 30-minute intervals to correspond to water temperature information. Weather information was downloaded every day. All data presented in this report, unless stated otherwise, was from June 15 through August 31, 2015.

MadgeTech Temp1000® data recorders were positioned in the following locations at McNary Dam in 2014 (Figure 1):

1) In front of spillbay 22, 17, 12, 7 and 2 approximately 5 feet below the surface. These probes were hung in the center of the spillbay, on the tailrace side.
2) Forebay, near elevation 335 approximately 5 feet below the surface. These are attached to the pier noses of the "B" slot in front of turbine Units 1, 3, 5, 7, 8, 10, 12 and 14.
3) Attached to the handrail in the center of the "B" turbine gatewell slots, approximately 2 to 3 feet below the surface, in turbine Units 1, through 14.
4) The collection channel had probes installed at turbine Units 12, 8 and past Unit 1 at the beginning of the transition screen.
5) Fish separator, between the bars nearest the side of the "B" side. It is impossible to float the canister and have it out of the way for the technicians to work. Therefore, it lays on the bottom.
6) Sample holding tank, side "B", 2 feet below surface.
7) Recovery raceway #9W at a depth of 2 – 3 feet.
8) The barge transportation dock, 5 feet below the surface.
9) The wingwall of the navigation lock on the tailrace side of the dam. This was placed 5 feet below the water surface.
10) Tailwater locations were at turbine Unit 1 and 14 (tailrace). These were placed 5 feet below the water surface.

Figure 1. Placement of temperature data devices at McNary Dam, 2015*
*Picture was taken July 4, 2013

WEATHER

Air temperature and wind velocity have been identified as critical components impacting thermal gradients at McNary Dam (Hoffarth 1999). Mild (3–5 mph) to moderate (6–10 mph) wind velocities help to break up major temperature differences that may appear between the forebay and the gatewell. When ambient air temperature exceeds 90 °F, thermal gradients may occur. Light winds (>3 mph), can break up these gradients (Figure 2).

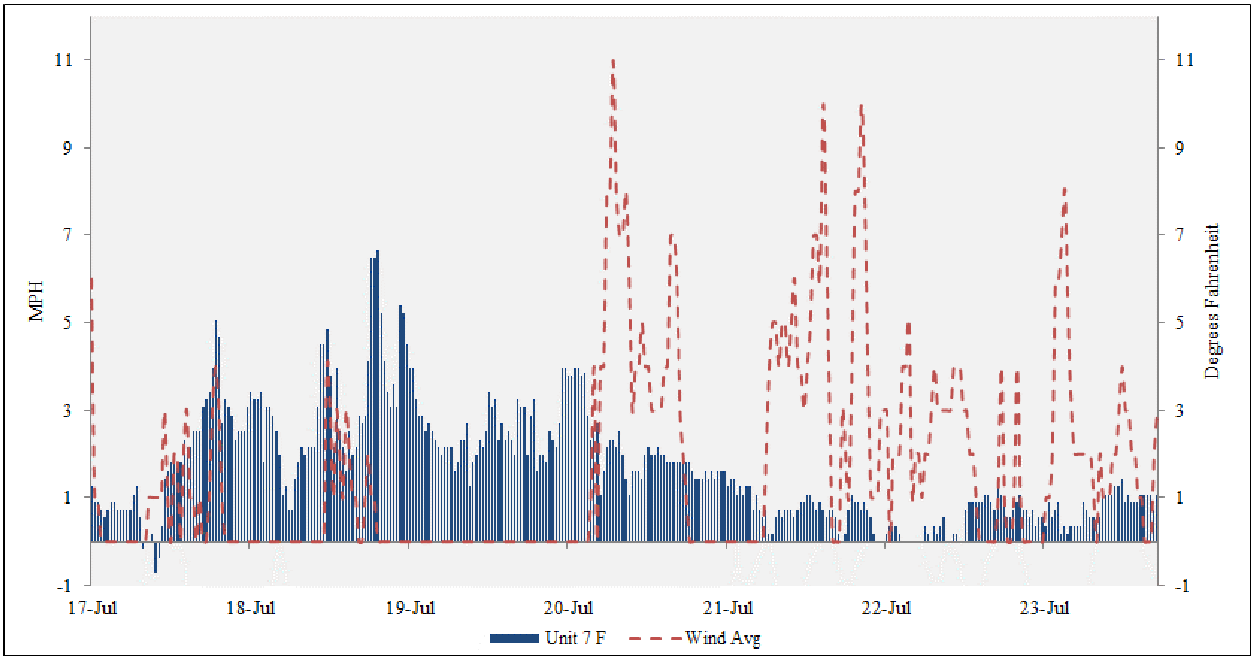

Figure 2. Differences in degrees Fahrenheit between forebay & gatewell, with wind, at McNary Dam, July 17 – 23, 2015

The 2015 season was the 17th year that complete and accurate weather information at McNary Dam. The weather station was located at the JFF immediately below the powerhouse on the Oregon shore.

Mean daily air temperatures in June, July and August were 77.4, 78.1 and 74.7°F respectively. The month of June was 10°F higher on average than June of 2014. The highs were 104.1, 102.8 and 102.3°F (Table 1). June had 8 days above 90°F, July had 15 and August had 9. Of those days, there were 10, 25 and 18 where there was a sustainable three mile an hour breeze to accompany the heat to break up thermal gradients.

Table 1. Monthly air temperatures (°F) & wind velocity (mph) at McNary Dam, 2011 – 2015

Month	Daily Average	Maximum Average	Minimum Average	Maximum Range	Minimum Range	Days >90°F	Wind Average
June*							
2015	77.4	92.5	64.8	81.1-104.1	54.4-76.0	8	0.8
2014	67.4	79.4	56.3	65.8-89.0	50.5-63.5	0	3.3
2013	68.4	79.5	58.9	67.6-96.8	52.5-67.6	4	3.3
2012	66.4	78.2	55.6	70.3–88.6	49.1–64.3	0	4.1
2011	65.6	78.1	55.1	70.6-89.3	48.0-62.0	0	4.1
July							
2015	78.1	92.0	66.0	78.6-102.8	55.7-74.2	15	1.6
2014	78.2	92.8	65.2	77.6-102.5	54.7-73.2	24	2.4
2013	76.9	92.5	64.5	82.2-105.1	53.8-73.2	20	2.2
2012	73.6	88.4	61.7	72.1–98.7	49.5-69.6	12	2.9
2011	70.1	84.1	58.5	74.7-94.7	50.8-66.0	6	2.8
August							
2015	74.7	87.1	63.4	66.6-102.3	54.8-72.3	9	1.4
2014	75.4	88.6	64.9	77.2-98.5	57.6-78.5	14	1.5
2013	75.4	88.9	64.5	79.2-98.0	57.5-74.6	14	1.5
2012	74.5	90.1	61.6	77.6-103.6	49.1-72.1	18	2.2
2011	74.0	88.6	62.6	74.2-97.5	53.9-73.0	13	2.2

*Report period begins June 15

PROJECT DISCHARGE & SPILL

Total project discharge during the temperature monitoring period (June 15 – August 31) averaged 143.7kcfs in 2015. In 2014, the flow averaged 206.7kcfs (Figure 3). The target flows set by National Marine Fisheries Service Biological Opinion states that during the spring (April 20 - June 30) will be 220 – 260kcfs. McNary flows for the period averaged 173.5.0kcfs. From June 15 to June 30, flows averaged 145.5kcfs. According to the Biological Opinion, ideal target flows for July 1 through August 31 should average 200kcfs. Flows for this period were 143.2kcfs. The average percentage of project discharge diverted through the spill in 2015 was 49.9%, compared to 49.9% in 2014 (Figure 4).

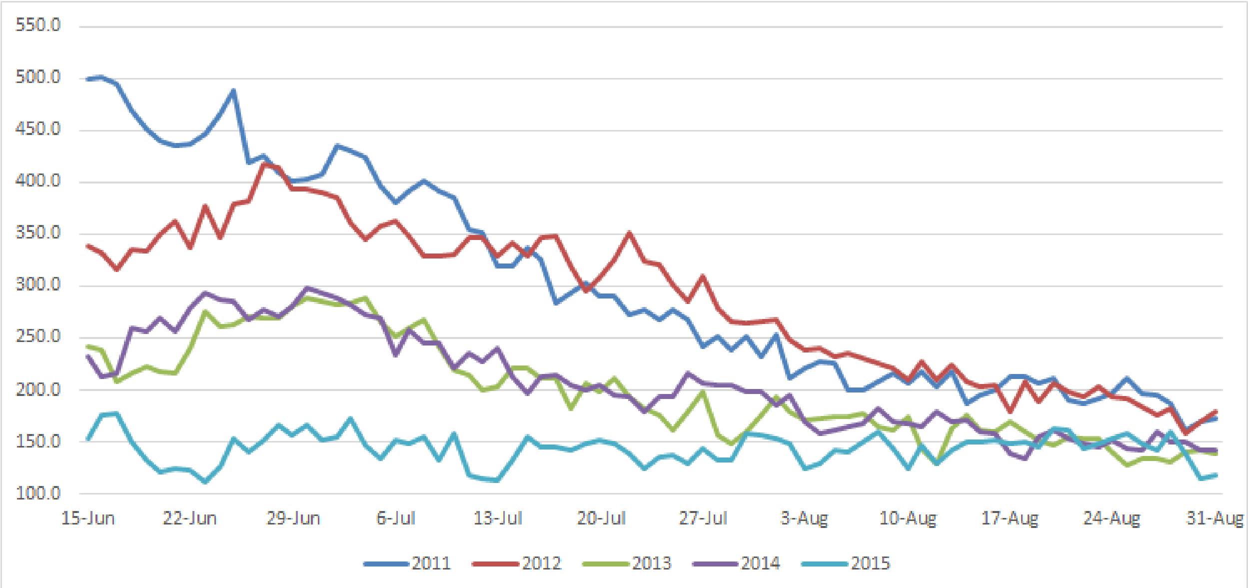

Figure 3. Project discharge for McNary Dam, 2011 - 2015

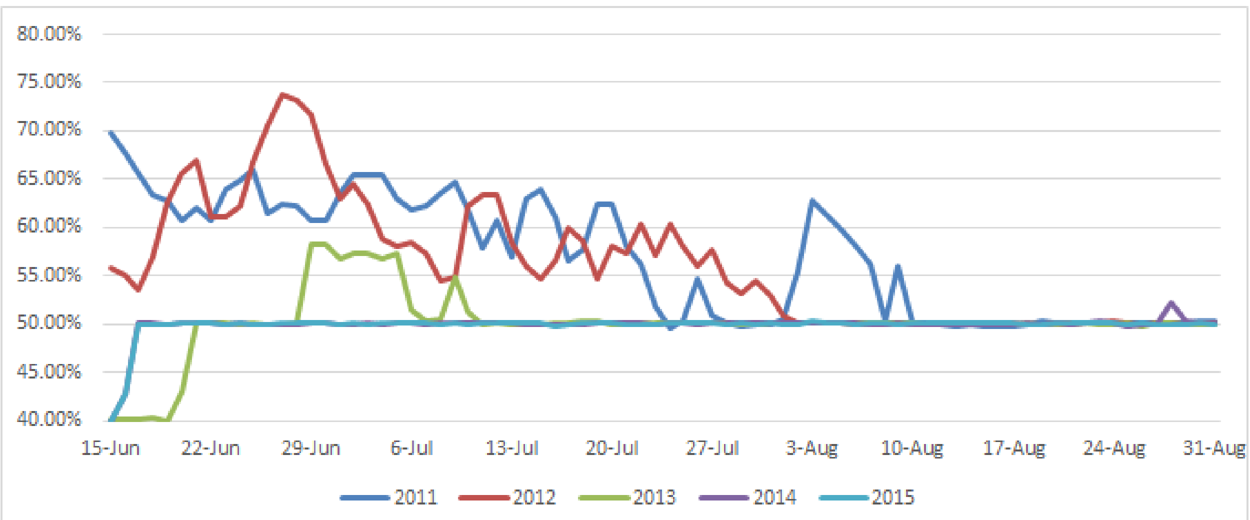

Figure 4. Percent spill at McNary Dam, 2011 – 2015

Thermal Profiles at the Powerhouse

Forebay and gatewell water temperatures were recorded every half hour using MadgeTech Temp1000® temperature data loggers. This data was recorded in the "B" gatewell slot of all 14 turbine Units and the forebay surface water in front of turbine Units numbered 1, 3, 5, 7, 8, 10, 12 and 14. Temperatures are also recorded from the mercury thermometers on the scrollcase of each turbine Unit. Using this data, a daily cross sectional thermal profile of water temperatures at the powerhouse was constructed. This information was then used to identify thermal gradients at the project. The temperature profiles are relatively good indicators of thermal stratification. They also reveal the dynamics of water temperature movements at the powerhouse, peak daily temperatures and identify locations of critical thermal gradients. This data enables the generation of temperature profiles across the powerhouse during a full 24-hour period.

It has been shown in previous years that surface water temperatures in the forebay at McNary Dam increases during the day and peaks in the late afternoon or evening (Figure 5). The trend for river water temperatures in the gatewells and in the forebay across the McNary powerhouse on warm days is cooler river water temperatures at the northern end of the powerhouse (turbine Unit 14) and warmer temperatures toward the southern end (turbine Unit 1). Turbine Unit operations influence temperature patterns as well.

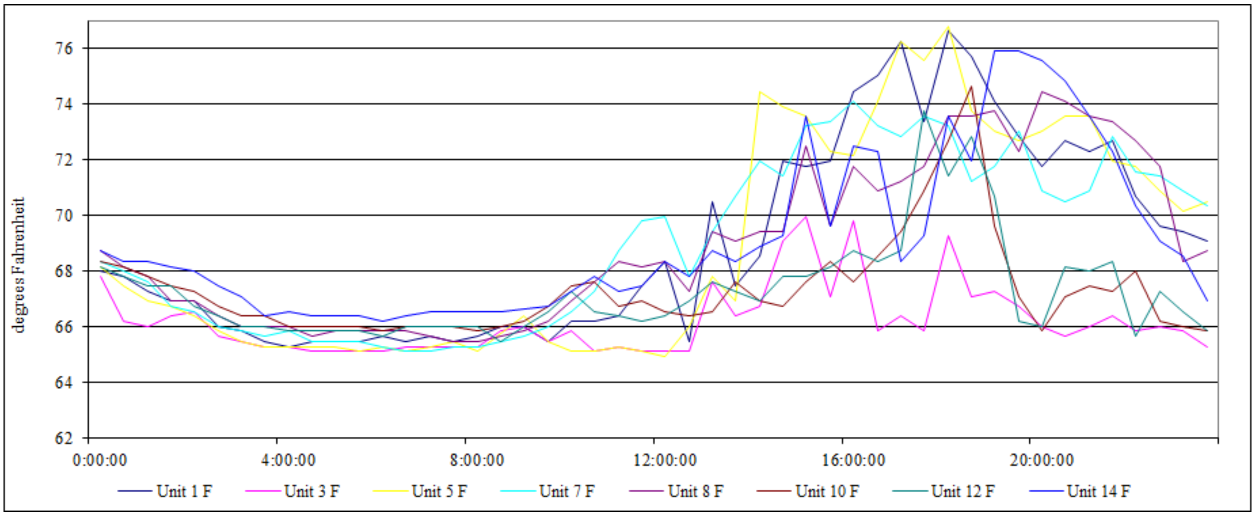

Figure 5. Forebay temperatures at McNary Dam, June 16, 2015

Figure 6 was made by taking the gatewell water temperature in the turbine unit and subtracting the gatewell water temperature of Unit 14 from it. This was done for every turbine starting with Unit 1 and continuing down through turbine Unit 13. The differences for five of the units are graphed below. A negative number indicates that gatewell water temperatures in turbine Unit 14 were warmer. It is possible to have the differences in a unit go from positive to negative in one day.

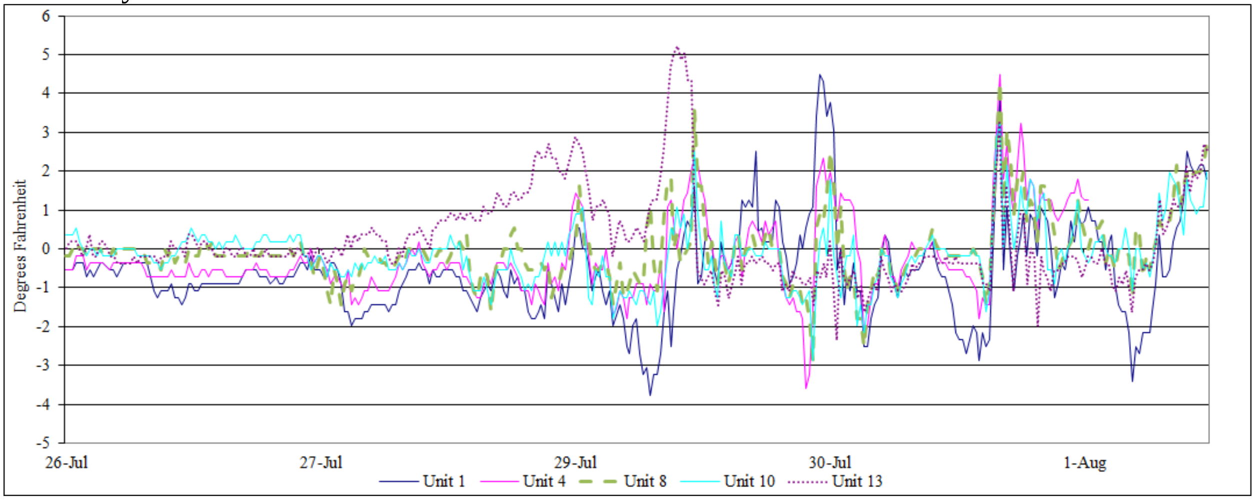

Figure 6. Temperature differences, in degrees Fahrenheit, in 5 gatewells across the McNary powerhouse, July 26 – August 1, 2015

Forebay & Gatewell Temperature Profiles

Temperatures were recorded every half hour in the forebay at powerhouse turbine Units 1, 3, 5, 7, 8, 10, 12, 14, and spillbays 22, 17, 12, 7, and 2 during 2015. Temperature probes were located at elevation 335, up to five feet below the surface. In the spillbays, the probes were deployed on the leafgate side between the gate and the side of the roadway. Gatewell probes were located in the center of the "B" slot of each turbine Unit, approximately three feet down. They also recorded temperatures every half hour. Average forebay temperatures in 2015 were: June 69.9, July 72.8 and August 71.6°F (Table 2). The actual temperatures are graphed in figure 7,

Table 2. Monthly Forebay water temperature averages at McNary Dam, 2011 - 2015

Year	June*	July	August
2015	69.9	72.8	71.6
2014	60.2	66.9	70.7
2013	61.6	68.9	71.7
2012	59.2	62.4	69.2
2011	58.2	63.3	69.3

***June 15 - 30**

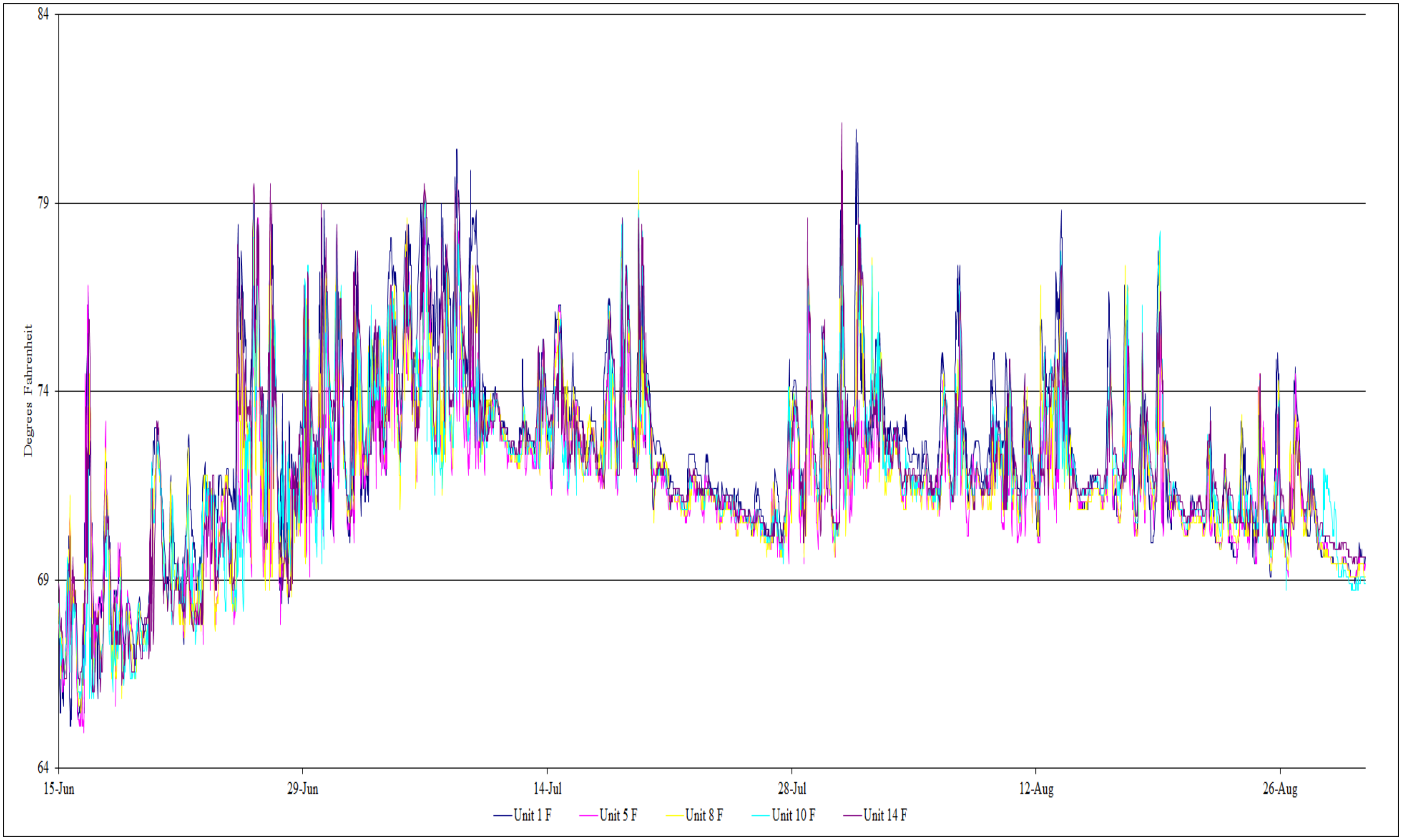

Figure 7. McNary Dam forebay temperatures in degrees Fahrenheit, June 15 – Aug. 31, 2015

The powerhouse turbines draw the warmer surface water from the forebay toward the fish screens and gatewell slots when in operation (Meyer 1989). Therefore, gatewell temperatures do follow the same trend as the corresponding forebay temperatures (Figure 8), climbing during the day and into the evening hours. What has normally been seen in past seasons is that around midnight temperatures take a significant drop, cooling down during the morning hours. This is the coolest portion of the day, just before dawn. There is still a cooler portion in the morning, but it appears the forebay heats up and stays hot for a significant portion of the time (Figure 9).

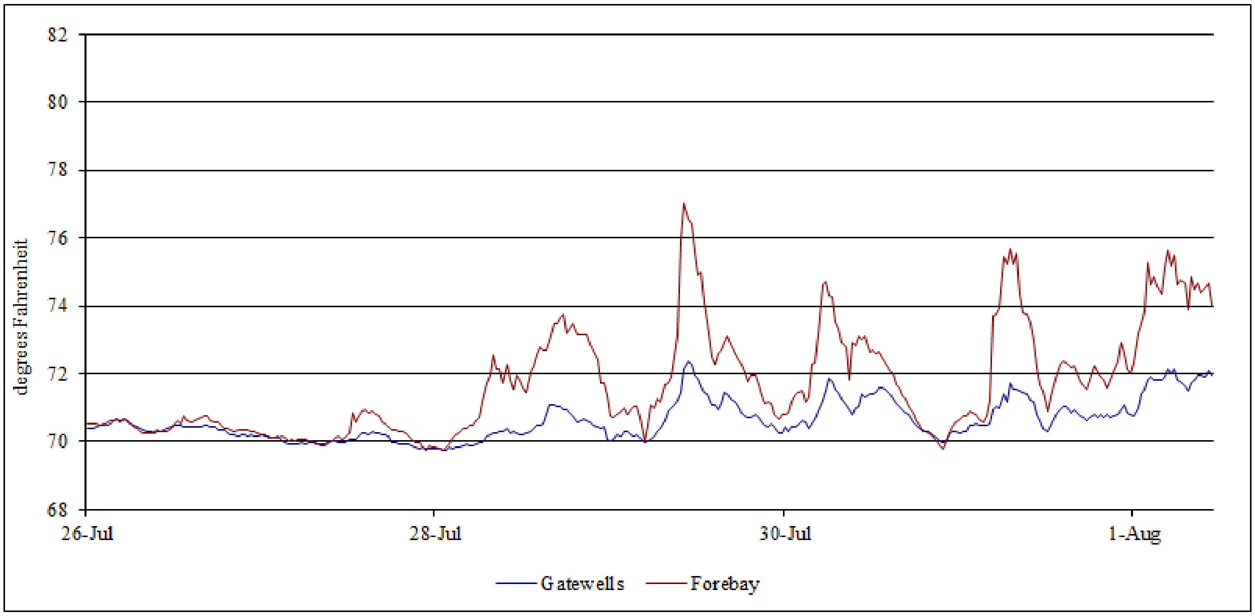

Figure 8. An average of temperatures across all 14 turbine Units at McNary Dam, July 26 - August 1, 2015

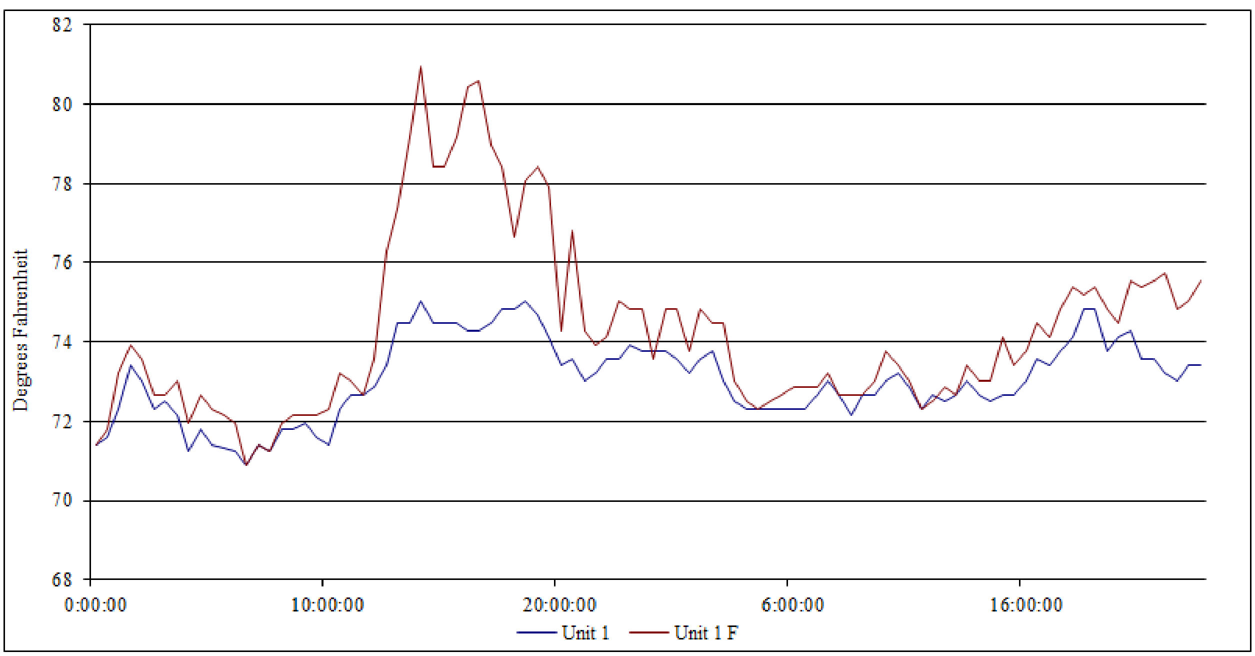

Figure 9. Forebay & Gatewell Temperatures at Unit 1 at McNary Dam, August 1 – 2, 2015

Effects of Forebay Water Temperatures on Project Temperatures and Thermal Gradients

Historically, water temperatures in the gatewells were similar to temperatures in the adjacent forebay, even though the gatewell temperatures typically did not elevate to the extremes recorded in the forebay (Figure 10). The high in the forebay was 81.1°F at 5:30pm on July 31 in front of turbine Unit 14. The high in the gatewell was 78.6°F in turbine Unit 1 July 6 and 8. Both at 8:30pm. With the onset of warming weather, there can be large water temperature gradients between the forebay and the gatewell. The gradients that are 8, 10, 12°F between forebay and gatewell are the significant factor that stress fish, and can cause mortality. The largest gradient was 11.7°F in Unit 3 and Unit 5, and the corresponding forebay in front of the unit. This occurred June 26 at 10:00 p.m. Fish were not being held in the sampling tanks and there was no increase in mortality rate in the following days. In 2014 the high in the forebay was 80.6°F and the high in the gatewells was 75.6°F.

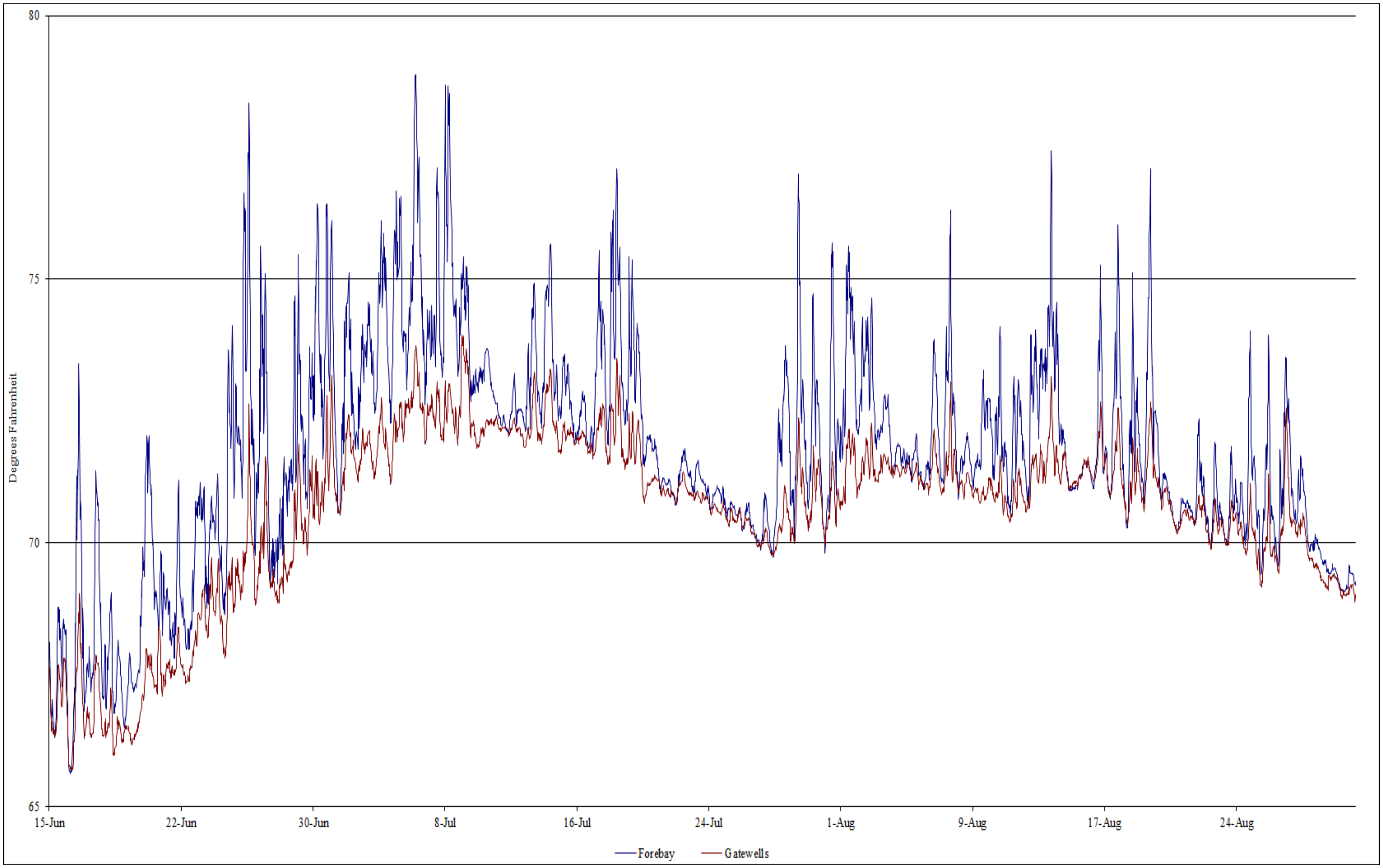

Figure 10. Average Gatewell & Forebay temperatures at McNary Dam, June 15 – August 31, 2015

Collection Channel

Each turbine unit has three gatewells (A, B, and C) and each gatewell has a north and south orifice which discharge into the collection channel. In order to not overflow the collection channel, only one orifice per gatewell is open. Temperature probes are installed at three locations in the collection channel, downstream of turbine gatewell orifice marked 12B south, 8B south and upstream of the incline dewatering screen, Unit 1 (Figure 11).

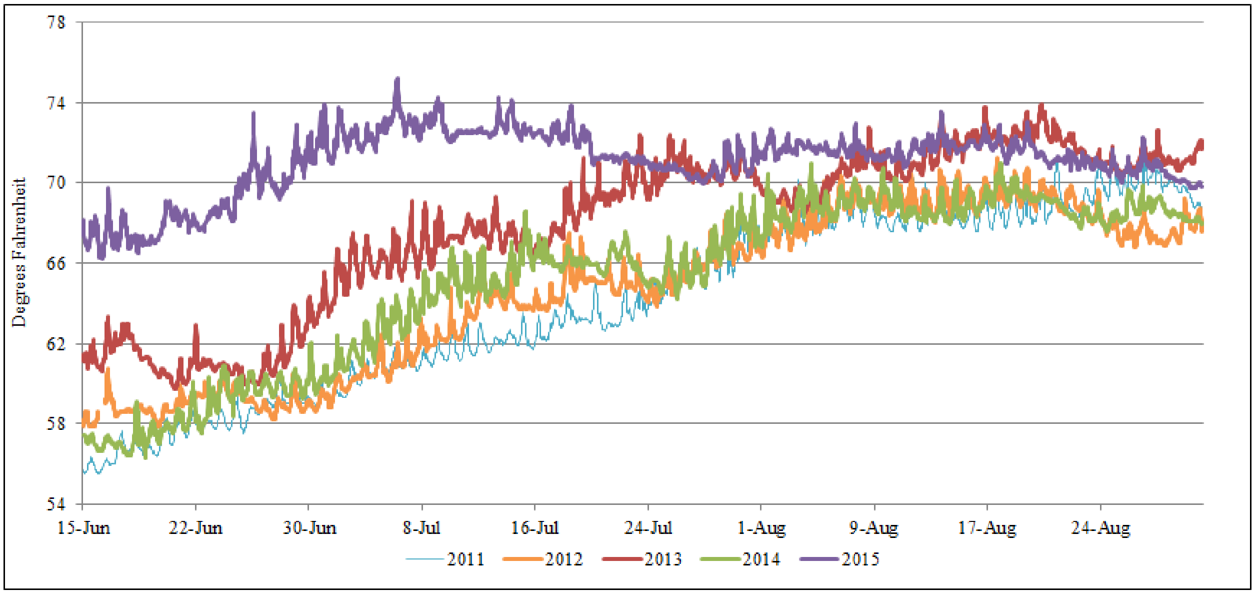

Figure 11. Average collection channel temperatures at McNary Dam, 2011- 2015

Water temperatures averaged 71.1°F in the collection channel from June 15 through August 31, compared to 65.5 in 2014. Collection channel water temperature reached 70°F on June 24; a full month before last year. The warmest temperature recorded this season was 75.9°F, on July 6, 9:30pm below turbine Unit 12 (Figure 13).

Table 3. Collection Channel water temperatures at McNary Dam, 2011 - 2015

Year	Average	High	Date
2015	71.1	75.9	6-Jul
2014	65.5	73.2	17-Aug
2013	68.0	75.0	20-Aug
2012	64.8	71.8	17-Aug
2011	64.1	72.7	27-Aug

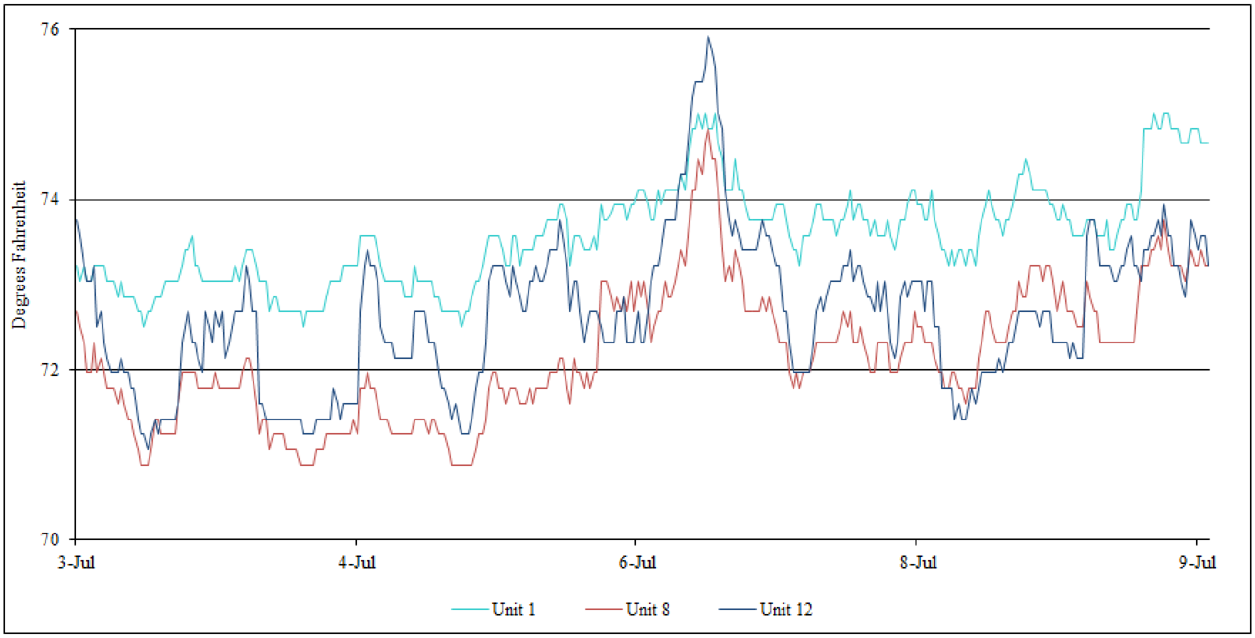

Figure 12. McNary Dam collection channel temperatures, July 3 – 9, 2015

Temperature gradients between turbine Unit 1 and turbine Unit 12 within the collection channel averaged 1.4°F (range 3.8 to –1.3) during the monitoring period (Figure 13). A negative number indicates that turbine Unit 12 was warmer. Temperature differences in the collection channel between Unit 12 on the northern end and Unit 1 on the southern end exceeded 2.0°F on 31 days. Of those days, 2 had hours where the temperature exceeded 3.0°F. The maximum temperature gradient recorded between turbine Unit 1 and 12, was 3.4°F on August 27, from 6:30pm until 9:30pm, Unit 1 was warmer than Unit 12. The differences in water temperatures between turbine Unit 1 and Unit 12 can be compared to last year (Figure 14).

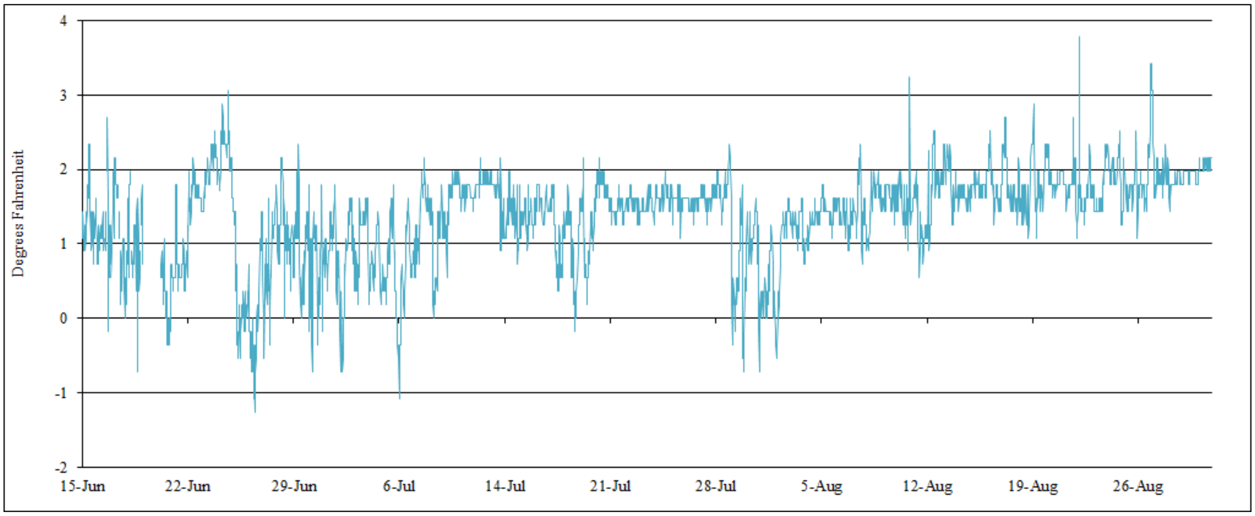

Figure 13. Differences in temperatures between Unit 1 and Unit 12 in the collection channel at McNary Dam, June 15 – August 31, 2015

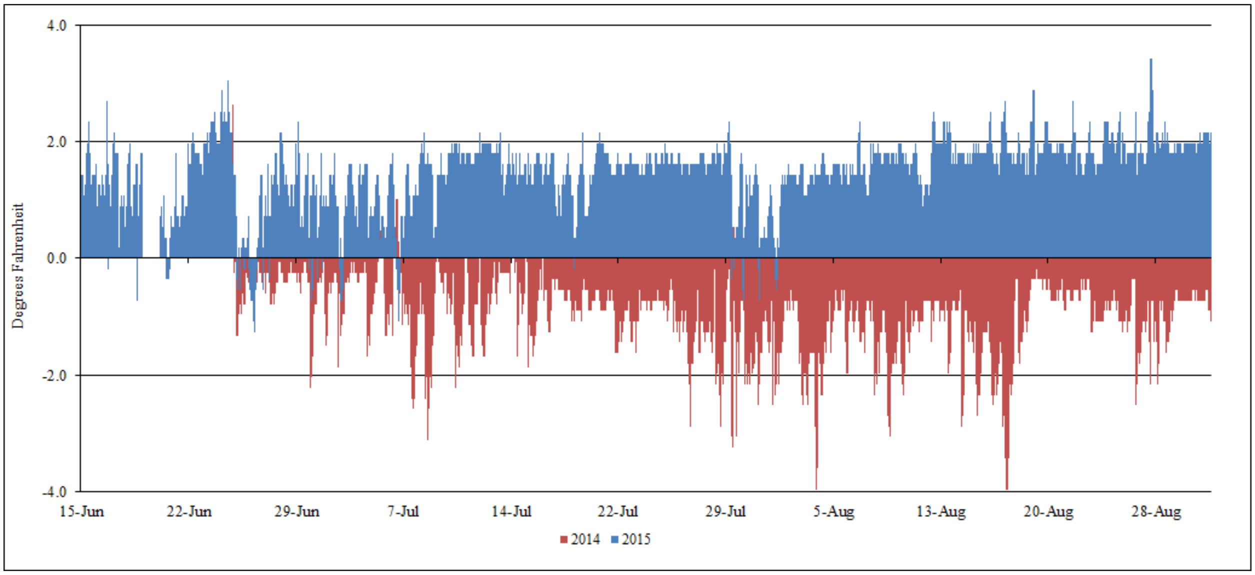

Figure 14. Differences in temperatures between Unit 1 and Unit 12 in the collection channel at McNary Dam, 2014 vs. 2015

Temperature Gradients at the Orifice Discharge

Previous temperature profiling identified water temperature gradients between the turbine unit gatewells and the collection channel (Hoffarth 1999). Water temperatures in the gatewells vary depending on turbine unit location, operation and weather. As previously described, temperature probes were placed at three locations in the collection channel. The water temperature within the collection channel at any one point reflects the mixture of water drawn in from the upstream gatewell orifices. Thermal gradients developed frequently when air temperatures exceeded 90°F. This was especially true when there was no wind and one or more turbine units were operating. Water temperatures in the gatewells and collection channel at the northern end of the powerhouse were usually similar (Figure 15). But, figure 15 also shows what happens when the two units, Unit 13 and 14, where turned on. At Unit 1 the gradients ranged from 3.1 to -4.1°F (Figure 16). A negative number would indicate that the gatewell was warmer. The gradients between the gatewell and collection channel at Turbine Unit 8 ranged from 4.3 to –4.5ºF (Figure 18). At Unit 12, gradients were from 7.2 to –3.2 (Figure 19).

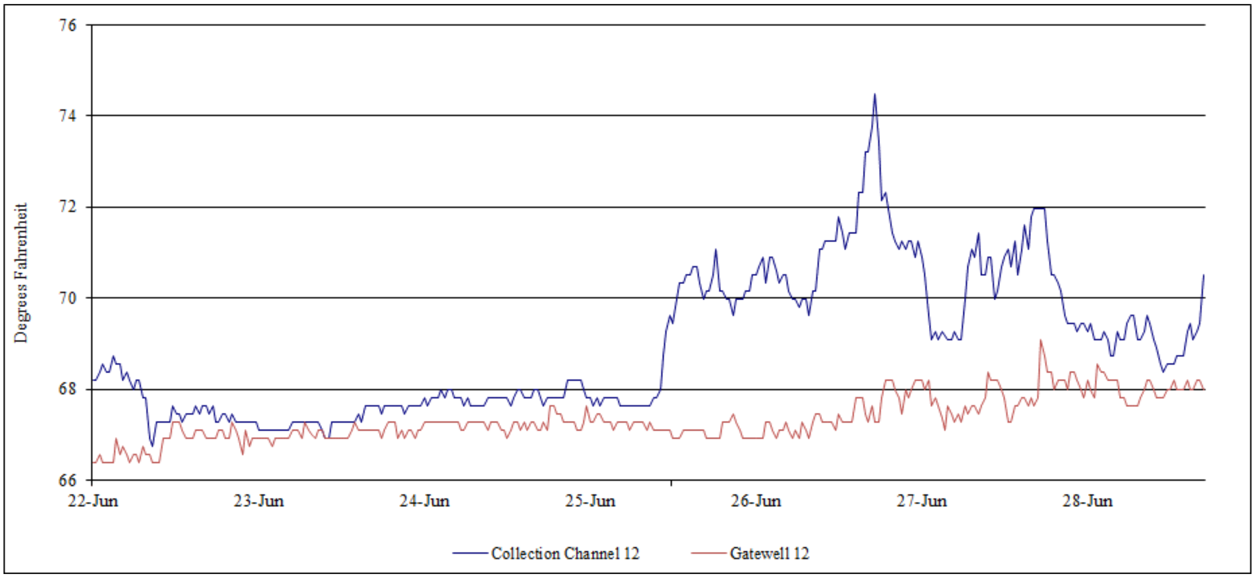

Figure 15. McNary Dam gatewell & collection channel temperatures at turbine Unit 12, June 22 - 28, 2015

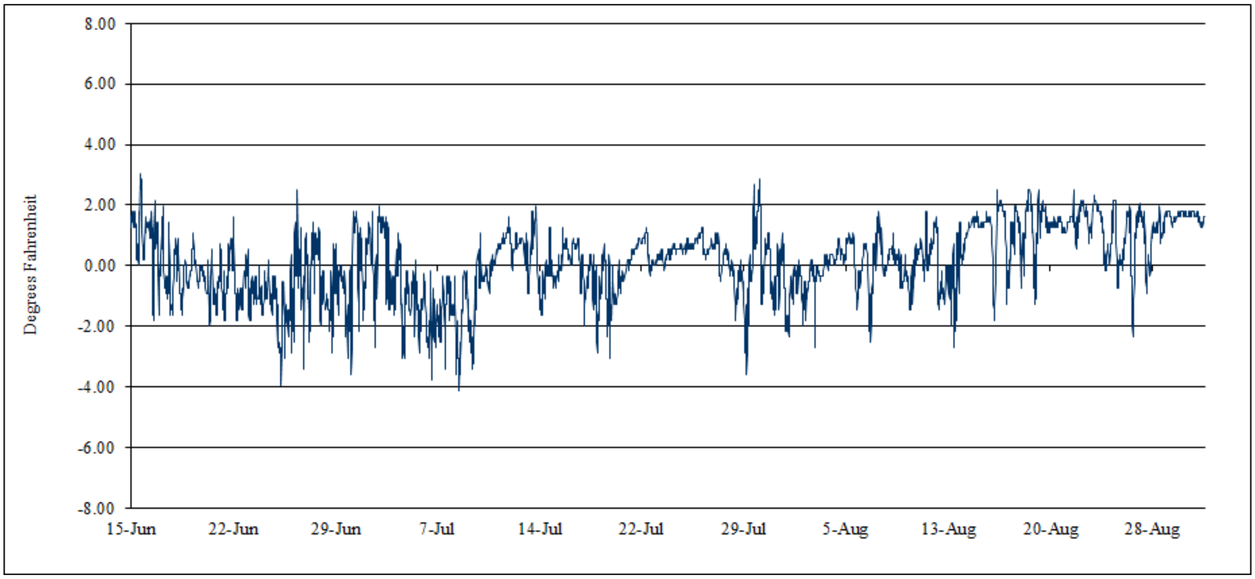

Figure 16. Temperature differentials between gatewell & collection channel at McNary Dam, turbine Unit 1, June 15 – August 31, 2015

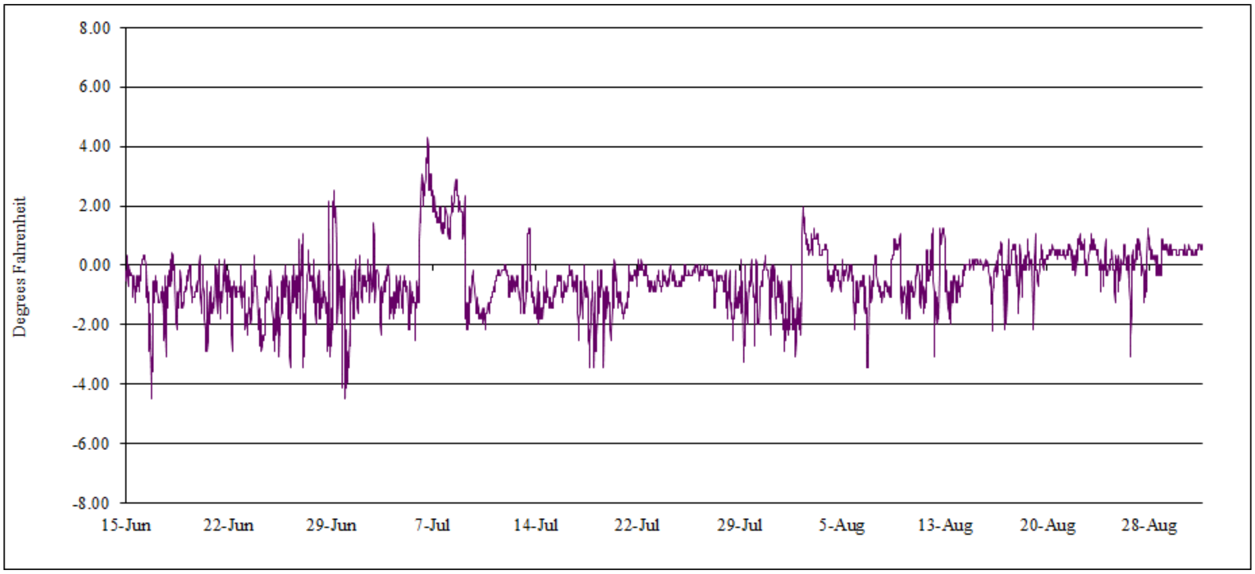

Figure 17. Temperature differentials between gatewell & collection channel at McNary Dam, turbine Unit 8, June 15 – August 31, 2015

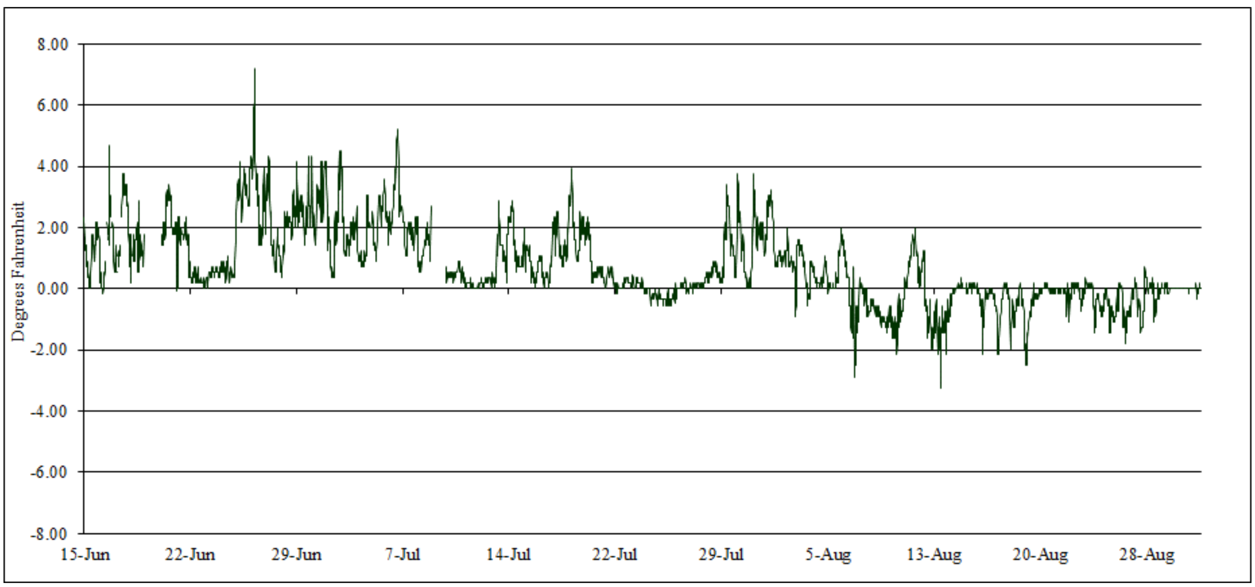

Figure 18. Temperature differentials between gatewell & collection channel at McNary Dam, turbine Unit 12, June 15 – August 31, 2015

Juvenile Fish Facility

The McNary Juvenile Fish Facility (JFF) had temperature loggers installed in the separator, the sample holding tank “B” and recovery raceway 9W to monitor the water temperature that would directly affect fish that are being held for sampling. Water for the JFF comes directly from the collection channel. The temperatures that these probes record can be compared to the temperatures recorded from the probes located in the collection channel at the beginning of the inclined dewatering screen which is directly down from Unit 1.

Collection Channel vs. Separator

The dewatering structure at the wet separator of the McNary JFF eliminates most of the water from the 36-inch transport pipe allowing only the fish and a small amount of water to reach the separator. Water in the separator is maintained by a series of upwells supplied by water from the collection channel. Temperature differentials between the collection channel and the separator ranged from -1.0 to -2.5°F (Figure 19). All of these numbers were below zero which indicates that the collection channel was consistently warmer than the separator.

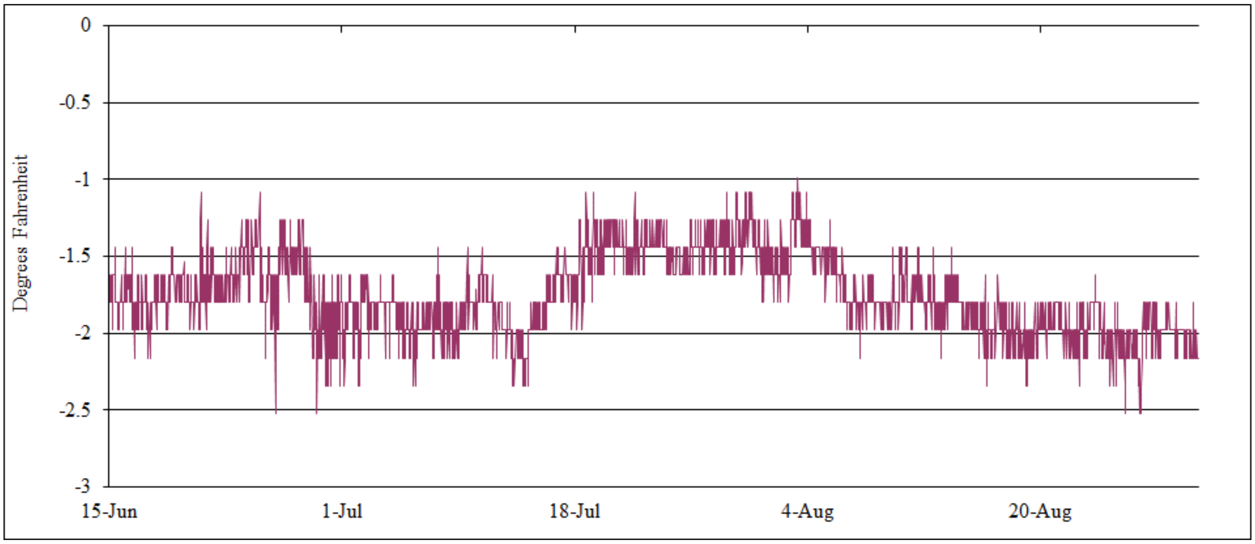

Figure 19. Temperature differentials between collection channel & separator at McNary Dam, June 15 - August 31, 2015

Separator vs. Raceway

Excess water in the collection channel is removed by the inclined dewatering screen and a portion of it is used for operation of the JFF, providing inflow for the separator and holding raceways. Most of the raceways are covered, but those on the far west side are exposed to direct sunlight especially during the late afternoon. A temperature logger was located in the separator and in raceway 9W, the raceway where the sampled fish recover from anesthetics. The water exchange rate in a raceway with normal diffuser inflow was about 15 to 20 minutes. Temperature differential ranged from -0.5 to 0.9°F (Figure 20).

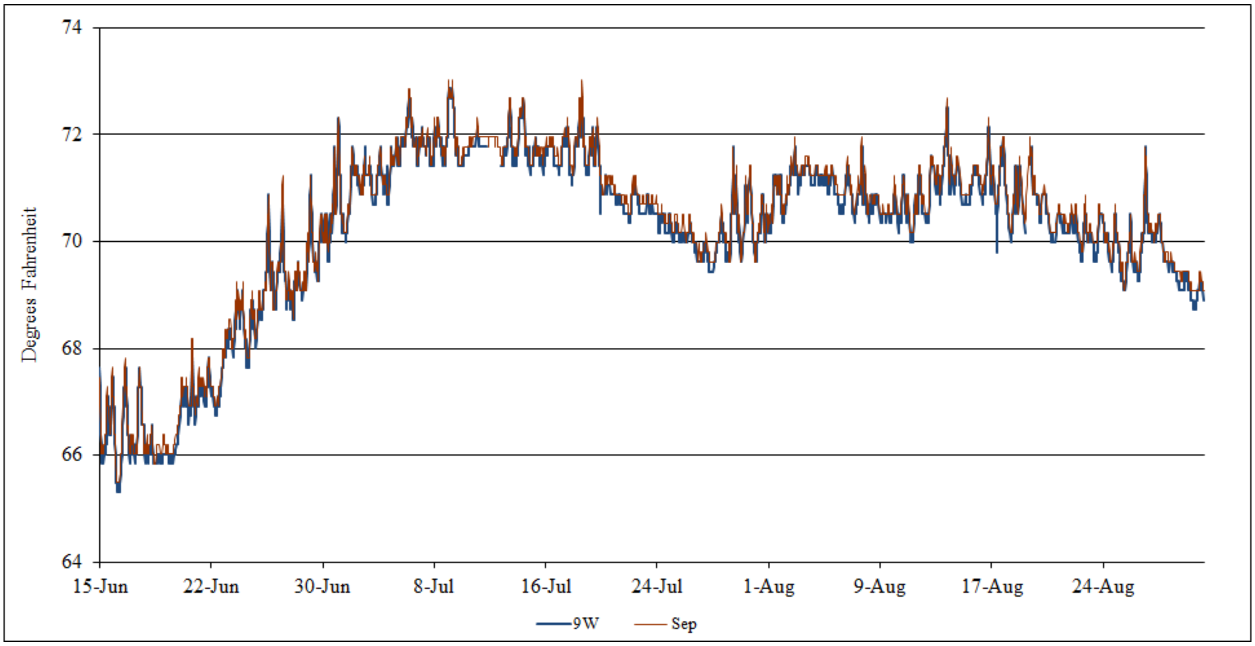

Figure 20. Separator temperatures vs. raceway 9W temperatures at McNary Juvenile Fish Facility, June 15 - August 31, 2015

Tailrace

Temperature loggers were installed in the tailrace below the project at four locations: the barge loading dock, below turbine Unit 1 and 14 and at the wingwall downstream of spillbay 1. Tailrace temperatures averaged 69.8°F, with a peak temperature of 72.7°F on July 6 from 3:00pm until 5:30pm, at the tailwater of Unit 1, adjacent to the Oregon ladder entrance. With the advent of a new primary bypass pipe, fish no longer exit directly in front of the turbine units. They now exit the flume just above the boat restricted zone line. A comparison of the water temperature at the end of the collection channel and the navigation lock wingwall in the tailrace shows a differential range from 0.7°F to 4.7°F. Because this range is above zero, it indicates that the collection channel was warmer (Figure 21).

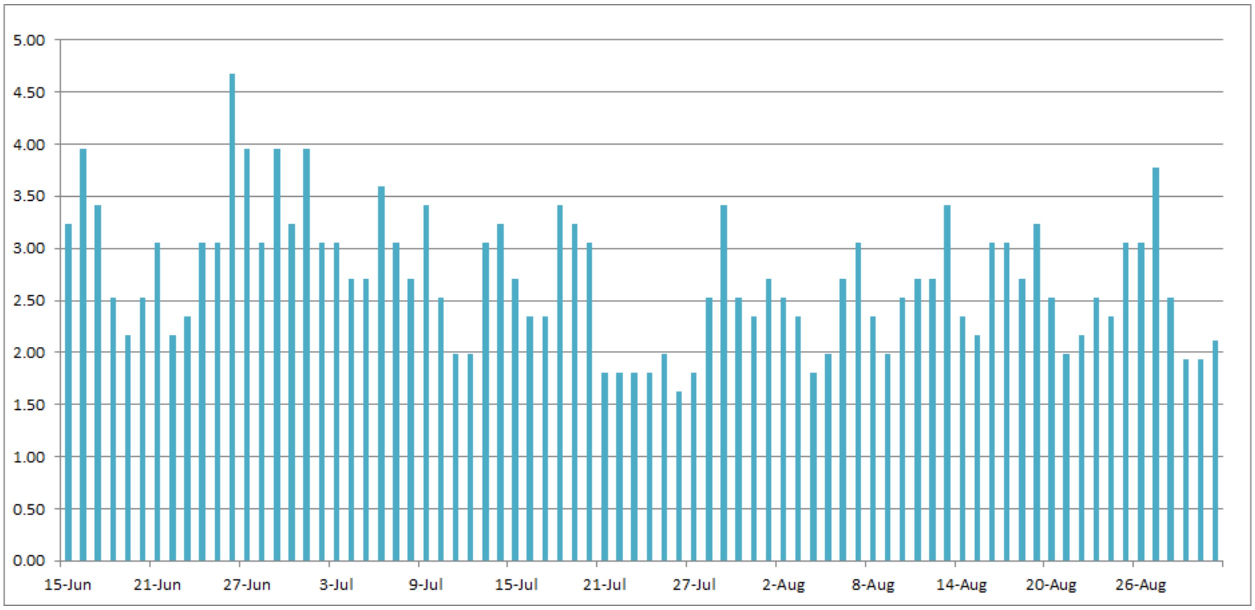

Figure 21. Collection Channel at Unit 1 and Navigation Wingwall Differential at McNary Dam, June 15 – August 31, 2015

River Temperature and Fish Passage Timing

Water temperatures are recorded at 7:00am in the wet lab and reported to the Corps of Engineers (COE) on a daily basis. These temperatures reflect the temperature at the time of sampling in the fish sampling lab at the Juvenile Fish Facility (JFF). The water in the lab is fed from water removed by the inclined dewatering screen in the collection channel. Water temperatures at 7:00am are typically the coolest temperatures encountered at the JFF each day. Therefore, these water temperatures reported should be considered minimum temperatures. They do not provide information on daily maximum, minimum or fluctuations of water temperatures at the project. Water temperatures recorded in the wet lab during the temperature profiling season were warmer than the recorded averages (Table 4) with July being the warmest beyond the 5-year average. Wet lab water temperatures reached the 70°F mark on July 1.

Table 4. McNary Juvenile Fish Facility Average laboratory water temperatures, June 15 - August 31, 2010 - 2015

	2010	2011	2012	2013	2014	5-yr. Avg.	2015
June*	58.7	57.1	58.3	61.0	60.4	59.1	67.5
July	65.4	61.9	62.9	67.4	66.7	64.8	71.1
August	69.8	67.7	67.8	70.6	70.8	69.3	70.5

*The month of June is the 15th through the 30th.

Migration of juvenile fall Chinook, particularly wild fall Chinook from the Hanford Reach to McNary Dam is strongly tied to temperature. During cooler water years fall Chinook rear for a longer period and migrate later. During warm water years, the fish grow faster and begin the downstream migration sooner. Both of these scenarios typically have the same result; fish arrive at McNary during critical temperature periods.

Comparison of water temperatures and mortality rates for juvenile salmonids at the McNary fish facility from previous years suggests that temperature was related to mortality. Previously, years with warmer water and large thermal gradients corresponded to the highest mortality rates for subyearling fall Chinook at the McNary JFF. Lower mortality was often associated with cooler water years and gradients that were not as severe. The critical migration period in regards to thermal gradients occurs from mid-June to early August. At this time river temperatures at depth in the McNary forebay are in the tolerance zone for salmonids, 58°F to 66°F (Brett, 1952), but increased air temperatures elevate water temperatures at the surface during the afternoon creating thermal gradients in the forebay. Project operation, air temperature and wind combine to determine the movements and interactions of these cool and warm areas of water.

Fish passage timing can be critical to the mortality equation but earlier passage does not necessarily correspond to cooler river temperatures and decreased mortality (Table 5). The outmigration this year was effected by early hot weather conditions. This triggered an early outmigration of fall Chinook from the Hanford Reach. The forebay was consistently reaching 70°F by June 15, at the beginning of the monitoring season. The COE initiated a "sawtooth" pattern for operation of the powerhouse beginning June 25. This is an every-other-unit pattern which allows for a larger volume of cooler water to be drawn into the system. By June 30, 50% of these fish were at McNary. Without collection in the raceways for transport the volume of mortalities cannot be accounted for. Therefore, the only indicator of mortality is from the sample holding tanks. The largest day of mortality, 8.5%, was July 8. July7, while fish were being collected, saw differentials between the forebay and gatewell as large as 6.7°F.

Table 5. McNary Dam collection, mortality, and passage of fall Chinook, June 15 – August 31, 2011 – 2015[1]

		System			Passage		
Year	**Collection**	**Mortality**	**% Mortality**	**25%**	**50%**	**75%**	**90%**
2015	678,828	1,083	0.2	22-Jun	30-Jun	6-Jul	8/Jul
2014	2,306,928	661	<0.1	1-Jul	8-Jul	16-Jul	2-Aug
2013[2]	1,616,623	538	<0.1	28-Jun	6-Jul	12-Jul	26-Jul
2012	1,238,437	1,156	<0.1	3-Jul	20-Jul	8-Aug	21-Aug
2011	2,173,108	40,776	1.9	12-Jul	24-Jul	31-Jul	11-Aug

[1]These numbers are reflective of only the dates of this report, not the whole season.
[2]2013 is the first season without any transportation.

Fish Condition

The migration of juvenile salmonids June 15 – August 31, through the McNary fish facility was dominated by subyearling fall Chinook (99.1%). The condition of fish prior to arrival at McNary may determine their ability to cope with the added stresses, thermal and physical, during passage through the fish collection system. Although the overall health of a fish cannot be determined as far as assessing disease and internal issues, external injuries and descaling can. The percentage of subyearling fall Chinook that were descaled by either concrete structures or predators during the 2015 temperature monitoring period was 1.9%. In 2014, it was 1.7%. In

2015, there were 2,258 subyearling Chinook examined between June 15 and August 31 for detailed injuries. Of those, 532 fish, 23.6%, had injuries, descaling, diseases or parasites, 12.0% had more than one malady. This season the most common malady was the group called parasites. Black spot was the most common ailment, 15.6%.

Passage

All fish guided into the McNary JFF are bypassed into the tailrace below the dam from the start of fish facility operation in the spring until October 1 when sampling is concluded (Fish Passage Plan, 2015). Collection and holding of fish in raceways for the juvenile fish transportation is no longer part of the FPP since the outfall pipe has been extended and moved.

A portion of the daily collection is diverted to the sample holding tanks for examination of fish condition and extrapolation of species passage through the project. Every-other-day sampling is the standard mode of operation. According to sampling guidelines, 300 – 500 fish are to be sampled. Although, during the fall Chinook out-migration and because the water temperatures were warm, the sampling was reduced to 100 fish. The sample rate ranged from 0.25% to 25.0% from June 15 through August 31 in 2015. A total of 684,846 juvenile salmonids were collected during the temperature monitoring period (Table 6). Of those 678,828 were subyearling fall Chinook

Table 6. McNary Dam Collection Fall Chinook, June 15 – August 31, 2011 - 2015

	Collection	Subyearling Chinook	Peak Collection	Date
2015	684,846	678,828	151,601	6-Jul
2014	2,306,928	2,294,411	265,064	2-Jul
2013	1,616,623	1,601,329	175,208	10-Jul
2012	1,238,437	1,229,268	89,405	20-Jul
2011	2,173,108	2,161,211	111,300	24-Jul

Mortality

Sample tank mortality is the best indicator of mortality when in bypass mode. Sample tank mortality includes fish mortalities removed from the sample holding tank prior to sampling and mortality due to sampling activities. During bypass operation, mortality rates are only available from the daily sample as all other fish are returned directly to the tailrace. System mortality includes all mortalities recovered from the recovery raceway, the sample holding tank and the separator.

A total of 90 sampling mortalities were recovered from June 15 through August 31. This was 2.2% of the 4,093 fish sampled. The highest one-day sample tank mortality percentage was 8.5% on July 8.

Recommendations

Powerhouse Operations

Turbine unit loading should be kept as uniform as possible across the powerhouse. Computer modeling has shown that a “saw tooth” pattern of operations where every-other unit is on, is the best way to operate. This mode of operations allows for a larger volume of cooler water to be drawn into the system. “Saw tooth” pattern loading should be implemented on 15 June. This would be a preventative measure that could be taken in advance of hot weather. Starting and stopping of turbine Units during critical temperature periods should be conducted from 12:00 midnight to 12:00 noon, 4:00 a.m. to 10:00 a.m. being the most preferred times. Trashracks should be raked as often as possible.

Over the years it has been observed that there are some very large thermal gradients that appear in the first two weeks of June. During a low flow year such as this season was, this is a timeframe that should be included in the contract. Simply shifting the dates would be acceptable as by the time August arrives, everything is uniformly hot.

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