# LOWER MOKELUMNE RIVER
# UPSTREAM FISH MIGRATION MONITORING
# Conducted at Woodbridge Irrigation District Dam
# August 2014 through July 2015

**August 2015**

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Key words: lower Mokelumne River, fall-run Chinook salmon, steelhead, escapement

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***Abstract*: This report summarizes data collected below Woodbridge Irrigation District Dam (WIDD) on the lower Mokelumne River (LMR) from August 1, 2014 through July 31, 2015. An estimated 12,117 fall-run Chinook salmon (*Oncorhynchus tshawytscha*) passed the WIDD fish ladder between September 30, 2014 and February 2, 2015. Fifty percent of the run passed WIDD by November 11, 2014. Ninety percent of the run passed WIDD by December 2, 2014. Highest daily passage was 994 Chinook salmon on November 6, 2014 which is the fourth highest daily count of fish passage since video monitoring began. The sex and life stage was positively determined for 12,107 fish including 3,386 (28%) adult females, 3,004 (25%) adult males, 1,085 (9%) grilse females, and 4,632 (38%) grilse males. Management actions, such as pulse flows and Delta Cross Channel closures, were followed by peaks in daily passage and contributed to the high overall returns. One hundred and fifty-two adult steelhead (*O. mykiss*) passed WIDD between September 2014 and March 2015. Peak steelhead passage occurred in December (n=64).**

## INTRODUCTION

East Bay Municipal Utility District (EBMUD) has been monitoring adult fall-run Chinook salmon (*Oncorhynchus tshawytscha*) escapement in the lower Mokelumne River (LMR) using video monitoring and trapping at the Woodbridge Irrigation District Dam (WIDD) at river kilometer (Rkm) 64 since fall 1990. Beginning in 2010, through coordination between EBMUD and Woodbridge Irrigation District, Lodi Lake remained full of water throughout the Chinook salmon run. This facilitated continuous video monitoring of Chinook salmon passage in the high stage ladder at WIDD. WIDD operations remained the same during the upstream migration of fall-run Chinook salmon from 2010/2011 through 2014/2015. Therefore, total Mokelumne River fall-run Chinook salmon escapement during these years was based on video monitoring of fish passage at WIDD.

## OBJECTIVES

The objectives of this study are to 1) develop an escapement estimate for fall-run Chinook salmon in the LMR, 2) summarize sex and age composition, run timing, and coded wire tag component of the 2014 LMR fall-run Chinook salmon population, 3) describe the relationship of fall-run Chinook salmon movements to environmental conditions and management actions in the LMR and Sacramento-San Joaquin Delta, 4) enumerate steelhead passage, and 5) monitor presence of native and non-native fishes in the WIDD high stage fish ladder.

## METHODS

*Video*

EBMUD's video monitoring in the high stage ladder at WIDD is conducted year round, with the exception of a short period of time when the dam is lowered for annual maintenance. Woodbridge Irrigation District lowered the dam on February 2, 2015. As water was routed through the low stage ladder, video monitoring operations were suspended. After the air bladders of WIDD were reinflated on March 4, 2015, monitoring in the high stage ladder resumed and continued through July 31, 2015.

All other monitoring, data collection, and storage methods for video monitoring were consistent with prior year's monitoring efforts (Marine and Vogel 2000, Workman 2004).

## RESULTS AND DISCUSSION

*Fall-Run Chinook Salmon*

The fall-run Chinook salmon escapement estimate in the LMR for 2014/2015 is 12,117 spawners entering the river between September 2014 and February 2015 (Figure 1). Fifty percent of the run passed WIDD by November 11$^{th}$ (Table 1). Highest daily passage of 994 fish occurred on November 6, 2014. This was the fourth highest daily fish passage count since video monitoring began. Sex and life stage were positively determined for 12,107 fish including 3,386 (28%) adult (≥70 cm FL) females, 3,004 (25%) adult males, 1,085 (9%) grilse (<70 cm FL) females, and 4,632 (38%) grilse males (Figure 2).

**Table 1. Dates when 10%, 50%, and 90% of fall-run Chinook salmon passed the Woodbridge Irrigation District Dam, 1990-2004; 2010-2014.**

| Year | 10% | 50% | 90% |
|---|---|---|---|
| 1990 | Oct. 23 | Nov. 18 | Dec. 12 |
| 1991 | n/a | n/a | n/a |
| 1992 | Oct. 28 | Nov. 13 | Dec. 2 |
| 1993 | Oct. 22 | Nov. 3 | Nov. 21 |
| 1994 | Oct. 21 | Nov. 7 | Dec. 2 |
| 1995 | Sept. 28 | Oct. 30 | Nov. 23 |
| 1996 | Oct. 18 | Oct. 31 | Nov. 20 |
| 1997 | Oct. 15 | Nov. 8 | Nov. 22 |
| 1998 | Oct. 11 | Nov. 4 | Nov. 24 |
| 1999 | Oct. 16 | Nov. 3 | Nov. 20 |
| 2000 | Oct. 12 | Oct. 30 | Nov. 16 |
| 2001 | Oct. 29 | Nov. 11 | Nov. 25 |
| 2002 | Oct. 24 | Nov. 7 | Nov. 24 |
| 2003 | Sep. 4 | Nov. 13 | Dec. 4 |
| 2004 | Oct. 23 | Nov. 12 | Nov. 29 |
| 2010 | Oct. 9 | Oct. 24 | Nov. 24 |
| 2011 | Oct. 9 | Oct. 24 | Nov. 13 |
| 2012 | Oct. 17 | Nov. 3 | Nov. 22 |
| 2013 | Oct. 23 | Nov. 6 | Nov. 22 |
| 2014 | Oct. 22 | Nov. 11 | Dec. 2 |

From 1990 to 2003 and in 2010, approximately a 1:3 grilse to adult ratio was observed on the LMR. In 2004 and 2012, the grilse ratio was considerably higher with a grilse to adult ratio closer to 1:2. Conversely, the grilse to adult ratio in 2011 was reversed with an approximate grilse to adult ratio of 3:1. In 2014, the grilse to adult ratio was closer to 1:1 (47% GR; 53% AD) (Figure 3).

In the 2014/2015 monitoring season, 72% of fish passed the video monitor during the day and 28% during the night. Day is defined as ½ hour before sunrise to ½ hour after sunset. Daytime passage has been consistently higher than nighttime passage (Table 2). Peak passage occurred between 1000hrs and 1200hrs (Figure 4).

**Table 2. Percent of annual fall-run Chinook salmon passing WIDD during day and night, 1990-2004; 2010-2014.**

| *Year* | *1990* | *1991* | *1992* | *1993* | *1994* | *1995* | *1996* | *1997* | *1998* | *1999* | *2000* | *2001* | *2002* | *2003* | *2004* | *2010* | *2011* | *2012* | *2013* | *2014* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day | 57 | 64 | 69 | 59 | 61 | 68 | 52 | 56 | 56 | 62 | 68 | 58 | 55 | 73 | 79 | 87 | 82 | 68 | 72 | 72 |
| Night | 43 | 36 | 31 | 41 | 39 | 32 | 48 | 44 | 44 | 38 | 32 | 42 | 45 | 27 | 21 | 13 | 18 | 32 | 28 | 28 |

Clipped adipose fins were evident on 2,890 (24%) of the observed fall-run Chinook salmon (Table 3). The sex and life stage were positively determined for 2,887 adipose fin clipped fish. Of the fish identified with an adipose fin clip, 816 (28%) were adult (≥70 cm FL) females, 727 (25%) were adult males, 309 (11%) were grilse (<70 cm FL) females,

and 1,035 (36%) were grilse males. Twenty-four percent of the returning adult females were adipose fin clipped, 24% of the adult males were adipose fin clipped, 28% of the grilse females were adipose fin clipped, and 22% of the grilse males were adipose fin clipped. Between 2010 and 2012, approximately 25% of hatchery reared Chinook salmon at the Mokelumne River Fish Hatchery were coded wire tagged and adclipped.

**Table 3. Incidence of adipose fin clips on fall-run Chinook salmon passing Woodbridge Irrigation District Dam, 1992-2004; 2010-2014.**

| | Adults | | Grilse | |
|---|---|---|---|---|
| Year | Number | Percent | Number | Percent |
| 1992 | 10 | 1.4 | 35 | 3.8 |
| 1993 | 11 | 0.9 | 8 | 1.7 |
| 1994 | 244 | 10.3 | 22 | 4 |
| 1995 | 161 | 7.8 | 55 | 15.2 |
| 1996 | 169 | 9.2 | 47 | 3.5 |
| 1997/1998 | 152 | 2.9 | 7 | 1.7 |
| 1998/1999 | 427 | 7.4 | 175 | 12 |
| 1999/2000 | 327 | 10.8 | 139 | 6.1 |
| 2000/2001 | 225 | 4.0 | 83 | 8 |
| 2001/2002 | 326 | 8.5 | 188 | 18.6 |
| 2002/2003 | 1,228 | 14.4 | 363 | 16.2 |
| 2003/2004 | 996 | 13.4 | 319 | 12.7 |
| 2004/2005 | 614 | 9.7 | 129 | 3.7 |
| 2010/2011 | 1,978 | 38.3 | 1,708 | 84.1 |
| 2011/2012 | 3,508 | 80.1 | 13,449 | 94.6 |
| 2012/2013 | 7,656 | 92.8 | 1,152 | 30.0 |
| 2013/2014 | 2,921 | 30.8 | 666 | 24.2 |
| 2014/2015 | 1,543 | 24.1 | 1,347 | 23.5 |

Mokelumne River Flow, Water Temperature, and Rainfall

During the 2014/2015 Chinook salmon migration period, Camanche Dam daily average releases ranged from 215 – 485 cfs (Figure 5). Average daily flow was 248 cfs. Average daily flow below WIDD ranged from 29 – 445 cfs and averaged 125 cfs (Figure 6). Daily average water temperatures from the August through the February monitoring period ranged from 10.1 – 17.7 C° below Camanche Dam (Figure 7) and 7.7 – 25.7 C° below WIDD (Figure 8). Total rainfall, collected at the Camanche North station, was 11 inches (Figure 9). Peak daily rainfall was 2.35 inches.

River flow, temperature, and rainfall have been investigated for their relationship to salmon returns. Regression analyses comparing these factors to the number of fish that passed WIDD were run for the 2014/2015 escapement. Flow ($P$=0.004) and temperature ($P$=0.005) had a significant relationship with daily salmon passage. However, due to variability in the response timing of fish passage at WIDD to management actions and environmental variables, the relationship between flow, temperature, and fish counts do not represent a strong correlation.

Management Actions and Migration Response

Expected flow below WIDD during August and September was based on the Joint Settlement Agreement (JSA) Dry water year type. In accordance with the October through March JSA Dry water year designation, flow was increased below WIDD on September 30, 2014 in order to maintain the minimum JSA flow requirement of 80 cfs. This increase in flow corresponded with the first Chinook salmon observed moving passed WIDD.

EBMUD conducted 6 planned pulse flow events during October and November. This was the fifth year in a row that EBMUD released fall attraction flows in the LMR. Woodbridge Irrigation District also supported the implementation of fall attraction flows by the re-regulation of Camanche Reservoir releases. Woodbridge Irrigation District was able to surcharge Lodi Lake by building up the lake elevation to approximately 40 feet and then dropping the lake level by 1 - 2 feet thereby augmenting 4 of the EBMUD planned pulses. WIDD also conducted 4 additional pulses which extended the implementation of fall attraction flow events into December. EBMUD did not release any additional water above and beyond typical flow releases in order to surcharge Lodi Lake. In addition to the pulse flow events, multiple Delta Cross Channel (DCC) closures occurred from October through February in order to meet Rio Vista flow standards and implement winter-run Chinook salmon protection measures.

As in previous years, peaks in Chinook salmon passage corresponded with pulse flow events and DCC closures (Figure 6). Table 4 summarizes each pulse flow event and concurrent DCC closure conducted during the immigration of fall-run Chinook salmon to the Mokelumne River.

**Table 4 Summary of management actions, including pulse flow events and corresponding DCC closures, implemented during the 2014/2015 Mokelumne River Chinook salmon run.**

| Pulse Flow | Date of Peak Flow | Peak Flow (cfs)[1] | Peak Passage Event | Chinook Salmon Count | DCC Operations |
|---|---|---|---|---|---|
| 1 | 10/7/2014 | 692 | 10/9/2014 | 133 | Open |
| 2 | 10/14/2014 | 557 | 10/16/2014 | 144 | Open |
| 3 | 10/21/2014 | 969 | 10/22/2014 | 313 | Open |
| 4 | 10/29/2014 | 757 | 10/30/2014 | 798 | Closed |
| 5 | 11/5/2014 | 940 | 11/6/2014 | 994[2] | Closed |
| 6 | 11/11/2014 | 806 | 11/11/2014 | 640 | Open |
| 7 | 11/19/2014 | 761 | 11/19/2014 | 548 | Open |
| 8 | 11/25/2014 | 757 | 11/25/2014 | 446 | Open |
| 9 | 12/1/2014 | 759 | 12/1/2014 | 412 | Closed |
| 10 | 12/11/2014 | 740 | 12/11/2014 | 157 | Closed |

[1]Flow is based on raw 15 minute instantaneous measurements recorded at the Golf gauge located downstream of WIDD. Flow data are preliminary and subject to change.
[2]Highest daily passage of fall-run Chinook salmon recorded during the 2014/2015 monitoring period.

*Steelhead*

Steelhead (*O. mykiss*) have been observed since monitoring began in 1990 (Table 5). In all years prior to 1997, adult monitoring ended in December. Spawning, however, typically occurs between January and March for winter steelhead in the Central Valley (IEP Steelhead PWT 1999).

**Table 5. Steelhead observed moving upstream during video monitoring at Woodbridge Irrigation District Dam.**

| *Monitoring Period* | *Number* | *Monitoring Period* | *Number* |
|---|---|---|---|
| Oct. - Dec. 1990 | 4 | Aug. 2000 – Apr. 2001 | 48 |
| Oct. - Dec. 1991 | n/a | Aug. 2001 – July 2002 | 91 |
| Oct. - Dec. 1992 | 7 | Aug. 2002 – July 2003 | 62 |
| Oct. - Dec. 1993 | 8 | Aug. 2003 – July 2004 | 39 |
| Oct. - Dec. 1994 | 19 | Aug. 2004 – Apr. 2005 | 44 |
| Sept. - Dec. 1995 | 76 | Aug. 2010 – July 2011 | 100 |
| Sept. - Dec. 1996 | 12 | Aug. 2011 – July 2012 | 257* |
| Sept. 1997 – Feb. 1998 | 6 | Aug. 2012 – March 2013 | 74 |
| Aug. 1998 – Mar. 1999 | 12 | Aug. 2013 – July 2014 | 124 |
| Aug. 1999 – Mar. 2000 | 80 | Aug. 2014 – July 2015 | 152 |

* Count may include hatchery-origin Age 1+ steelhead released during the monitoring period at the Feist Ranch and/or New Hope.

One hundred and fifty-two adult steelhead (≥380 mm FL) were observed moving upstream through WIDD from September 7, 2014 through March 26, 2015. The highest monthly abundance of steelhead was in December (n=64). Of the 152 fish observed, 45 were males, 41 were females, and 66 were not distinguishable to sex. Ninety-seven percent (n=147) were adipose fin clipped (Table 6).

**Table 6. Monthly sex composition and adipose fin clip totals of steelhead passing Woodbridge Irrigation District Dam, August 1, 2014 – July 31, 2015.**

| *Monitoring Period* | *Male Count* | *Female Count* | *Unknown Sex Count* | *Total Count* | *Adclip Total* |
|---|---|---|---|---|---|
| August | - | - | - | - | - |
| September | - | 1 | - | 1 | 1 |
| October | 6 | 6 | 4 | 16 | 15 |
| November | 7 | 11 | 9 | 27 | 25 |
| December | 12 | 14 | 38 | 64 | 62 |
| January | 16 | 9 | 10 | 35 | 35 |
| February* | 3 | - | 2 | 5 | 5 |
| March* | 1 | - | 3 | 4 | 4 |
| Totals | 45 | 41 | 66 | 152 | 147 |

* No video monitoring occurred between February 3, 2015 and March 3, 2015 as fish passage at WIDD was diverted to the low stage ladder.

Yearling steelhead (FL <200mm) and subadult steelhead (FL ≤350mm) were not counted due to their ability to pass through the bars which guide fish in front of the video monitoring vault and their tendency to hold within the high stage ladder.

*Incidental Species*

Presence and absence data for native and non-native species are presented in Table 7. Native fishes observed using the ladder include Pacific lamprey, Sacramento pikeminnow, Sacramento sucker, and tule perch. In addition, 24 adult and 3 grilse Chinook salmon were observed moving upstream past WIDD between June 12, 2015 and July 2, 2015. Clipped adipose fins were evident on 23 (85%) of the observed Chinook salmon. Non-native fish using the fish ladders at WIDD include black bass, carp, goldfish, largemouth bass, redear sunfish, striped bass, unidentified centrarchids, and unidentified ictalurid.

**Table 7. Native and non-native fish observed in the Woodbridge Irrigation District Dam fish ladder, August 1, 2014 - July 31, 2015. Species names in bold represent native species.**

| | August | September | October | November | December | January | February | March | April | May | June | July |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pacific Lamprey** | | | | | | | | X | X | X | X | X |
| **Sacramento Pikeminnow** | X | X | X | X | X | X | | X | X | X | X | |
| **Sacramento Sucker** | | X | X | X | X | X | X | X | X | X | X | X |
| **Tule Perch** | X | | | | | | | X | | | X | X |
| **Chinook Salmon** | | | | | | | | | | | X | X |
| Black Bass | X | X | | | | | | X | X | X | X | |
| Common Carp | | | X | | | | | | X | | X | |
| Goldfish | | | | | X | | | | | | | X |
| Largemouth Bass | X | X | X | | | | | X | | X | | |
| Redear Sunfish | | X | | | | | | | | | | |
| Striped Bass | | | | | | | | | | | X | X |
| Unidentified Centrarchid | X | X | X | | X | | | | X | X | X | |
| Unidentified Ictalurid | | | | | | | | X | | | | |


## Acknowledgements

We would like to thank the field crew of Jason Shillam, Ed Rible, Charles Hunter, and Henry Kei for their hard work and dedication to accurate data collection, data storage, and data retrieval. Thanks to Woodbridge Irrigation District for their continued coordination, fish ladder maintenance, and access to the site. We would also like to thank EBMUD Fisheries and Wildlife Division staff for assistance on the project as needed.

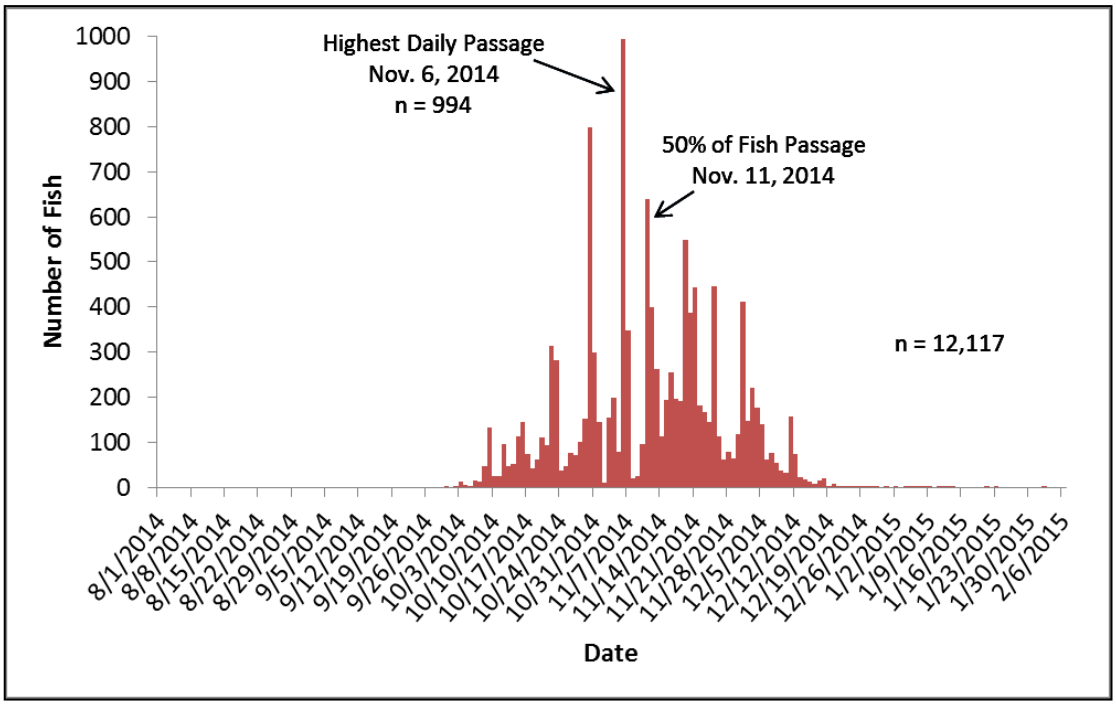


**Figure 1. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD, August 1, 2014 – February 2, 2015.**

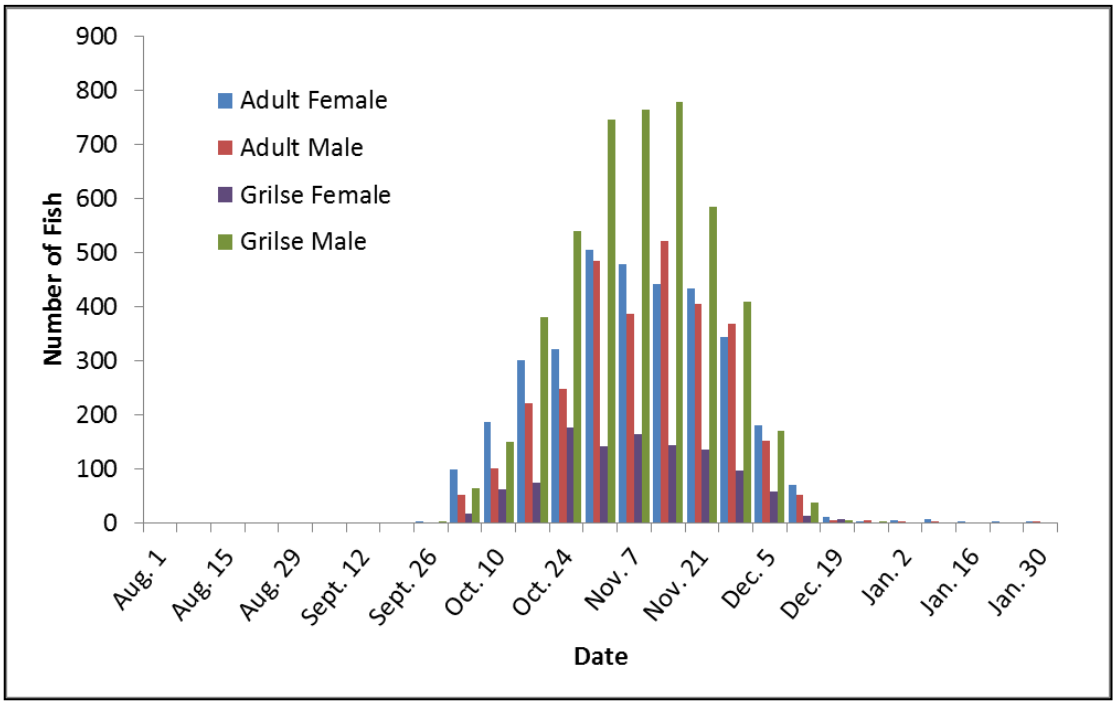


**Figure 2. Weekly sex/age composition of fall-run Chinook salmon passing WIDD, August 1, 2014 – February 2, 2015.**

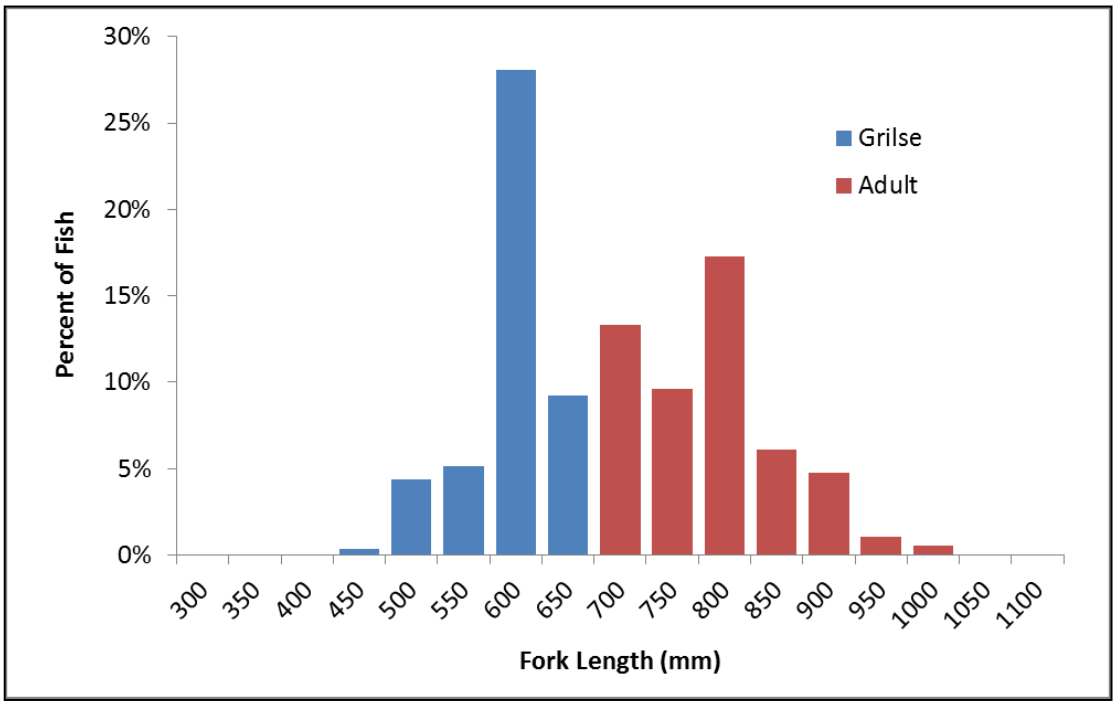


**Figure 3. Length frequency of adult and grilse Chinook salmon (% by size class) passing WIDD, August 1, 2014 – February 2, 2015.**

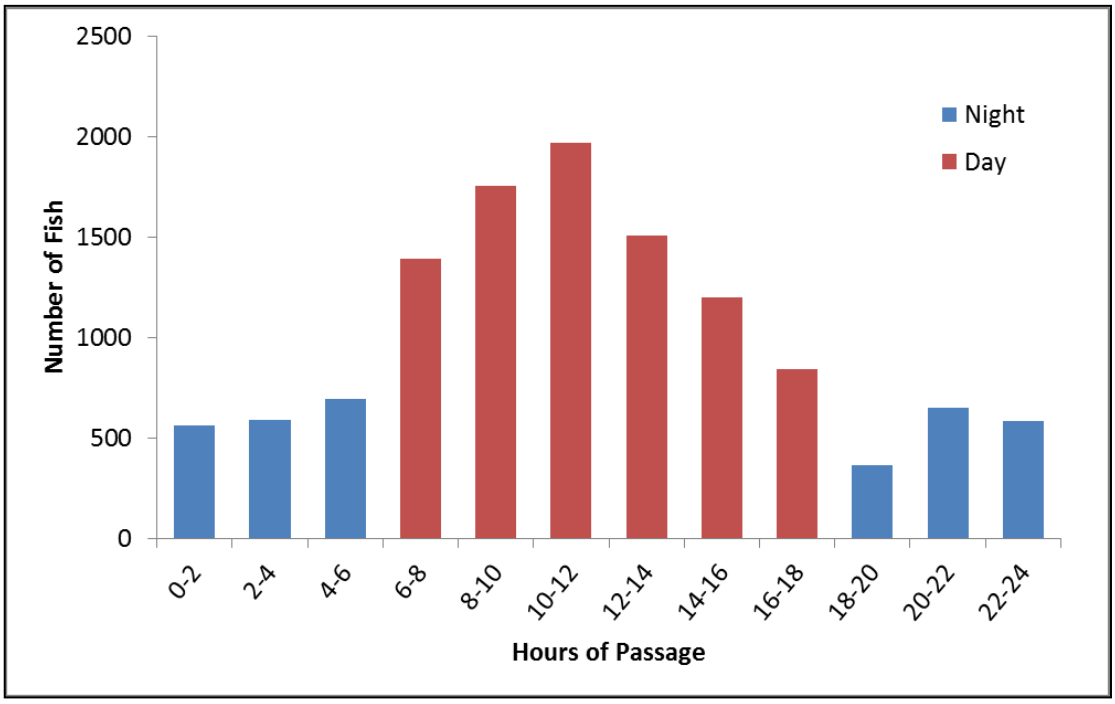


**Figure 4. Chinook salmon passage (2 hour intervals) recorded from video monitoring at WIDD, August 1, 2014 – February 2, 2015.**

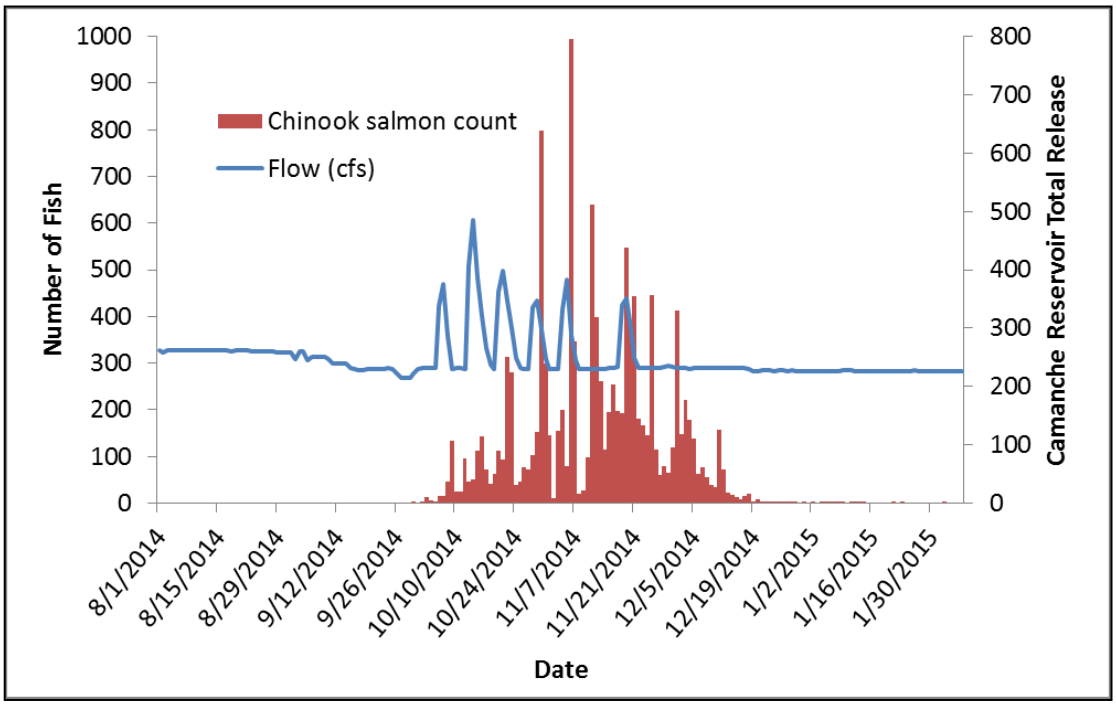


**Figure 5. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to flow below Camanche Reservoir, August 1, 2014 – February 2, 2015. Flow data are preliminary and subject to change.**

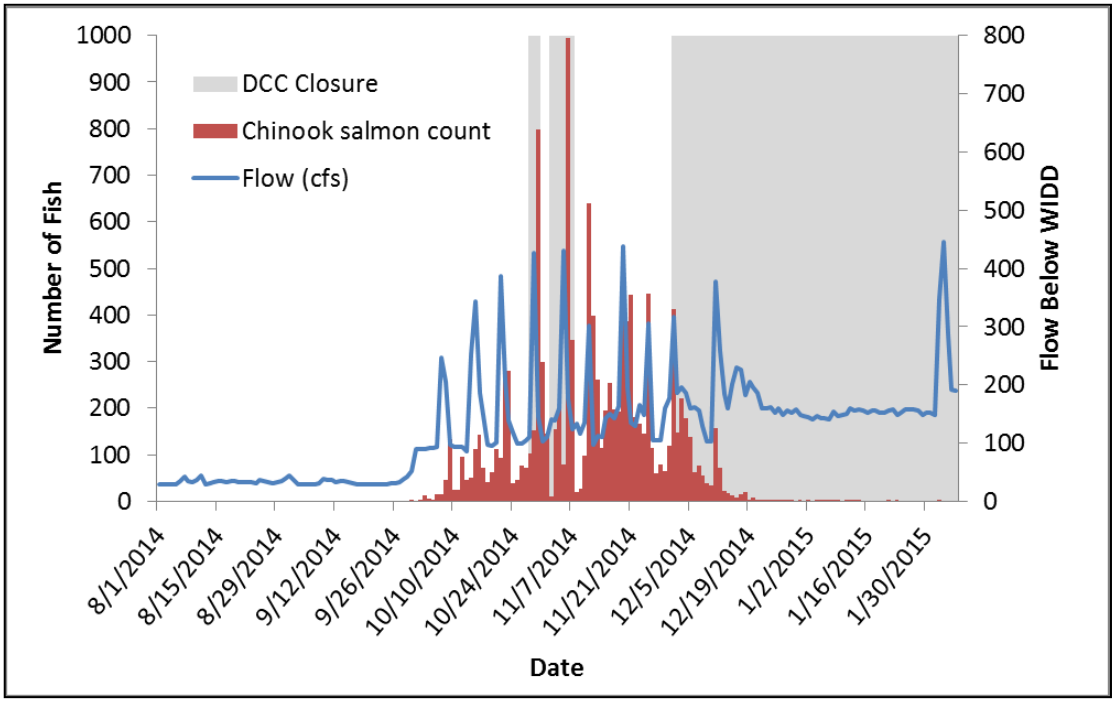


**Figure 6. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to flow below WIDD and DCC closures, August 1, 2014 – February 2, 2015. Flow data are preliminary and subject to change.**

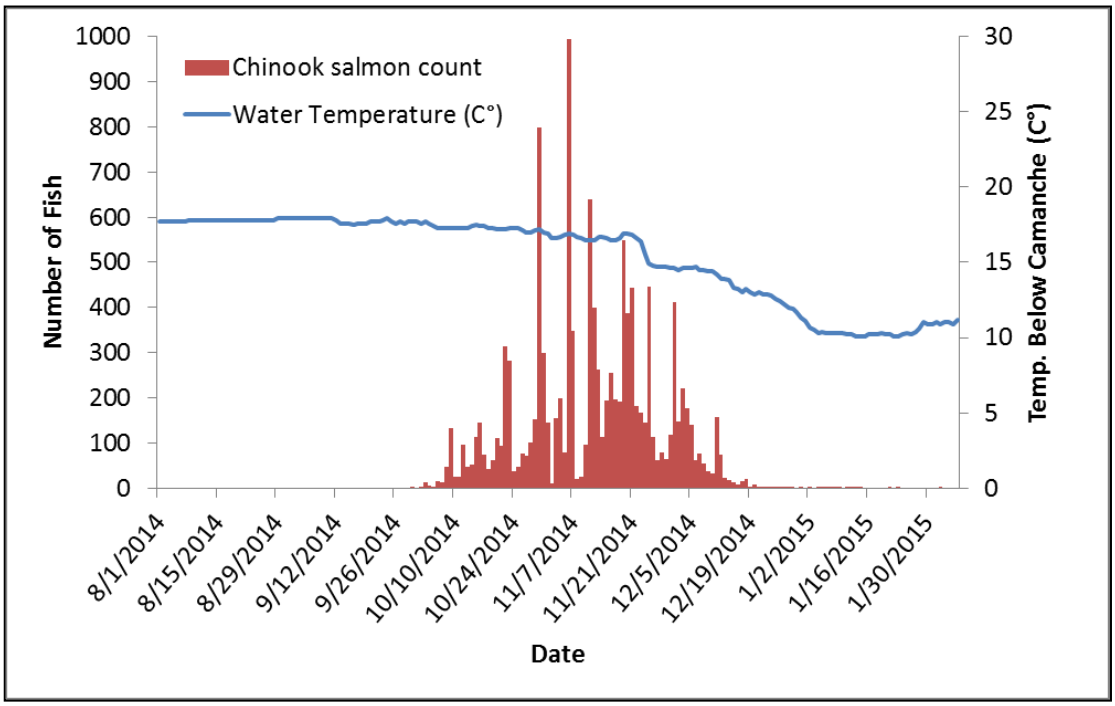


**Figure 7. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to temperature below Camanche Reservoir, August 1, 2014 – February 2, 2015.**

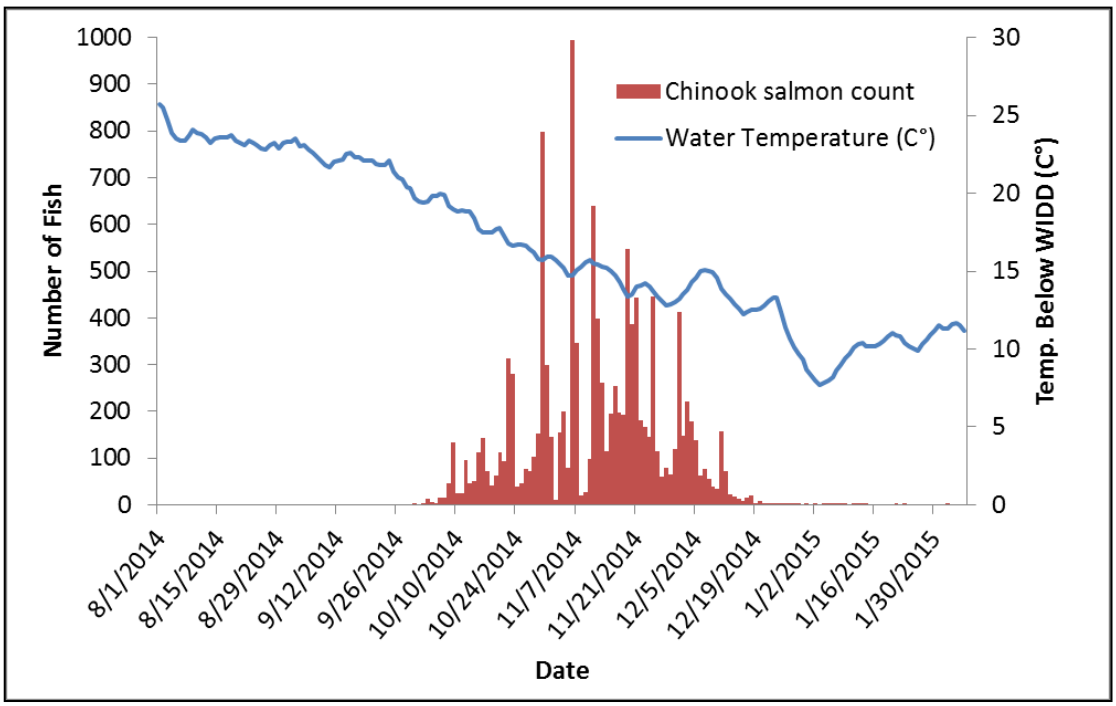


**Figure 8. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to temperature below WIDD, August 1, 2014 – February 2, 2015.**

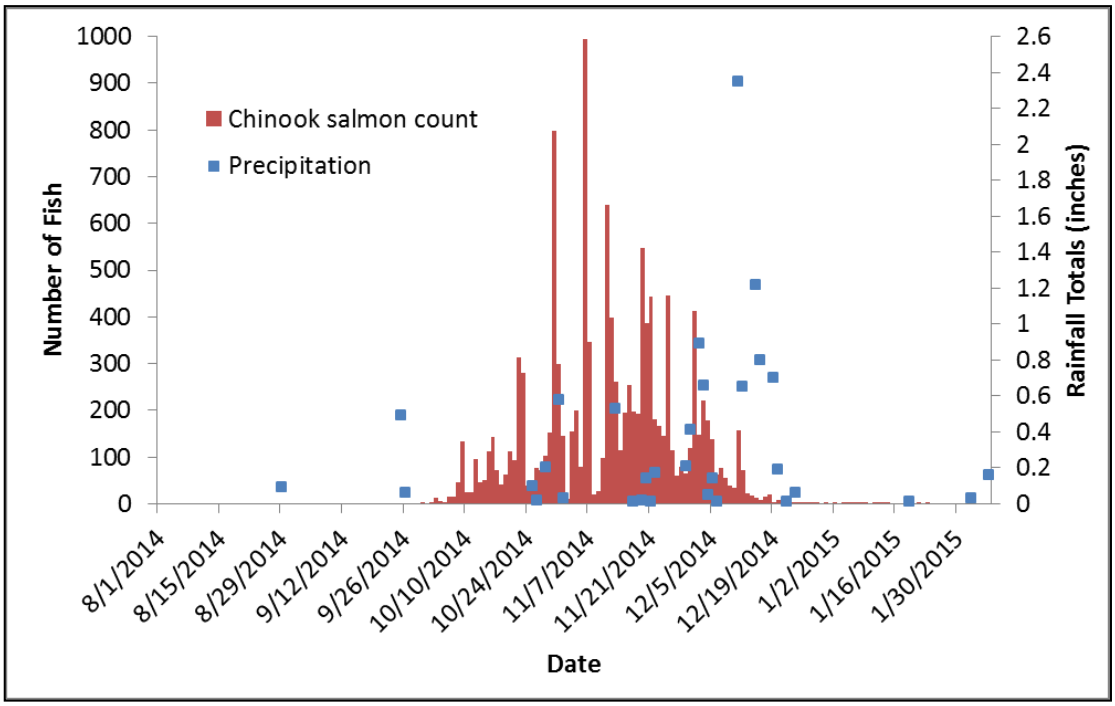


**Figure 9. Daily abundance and timing of fall-run Chinook salmon migrating past WIDD compared to rainfall recorded at Camanche Reservoir, August 1, 2014 – February 2, 2015.**

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