**Little Goose Fish Ladder Potential for Temperature Management Analysis**

**Background**

The Snake River through Hell’s Canyon naturally warms in summer as discharge decreases, solar input increases, and air temperature rises. Juvenile Snake River Fall Chinook out migrate from the Lower Snake River thought the summer. Sockeye salmon, migrate upstream through the reach in July. Snake River steelhead and fall Chinook migrate upstream through the reach beginning in late August. High water temperatures are stressful to all these populations, juvenile fall Chinook were often in poor condition and diseased. Beginning in 1991, cool water releases from Dworshak dam have been used to manage water temperatures in the Lower Columbia River. The NOAA Fisheries Biological Opinion on the Operation and Maintenance of the Federal Columbia River Power System includes a mandate to manage Dworshak to maintain temperatures below 68° F.

The 2015 runoff season started approximately 1 month earlier than normal. As a result of the early runoff and very hot weather, Snake River temperature control releases from Dworshak Dam were initiated approximately 3 weeks earlier than normal. Through careful management, summer release of water from Dworshak is typically sufficient to cool the Lower Granite tailwater to 68 degrees Fahrenheit (F) by varying discharge between 7.5 kcfs and 13 kcfs.

In 2015, due to record high temperatures coupled with very low river flows in the Snake and Columbia Rivers and limited cool water available from Dworshak in July, the Sockeye Salmon run in the Snake River struggled to pass each of the 4 Lower Snake dams. Water temperatures in the Lower Columbia were as high or higher than in the Snake River in 2015, and the majority of the Sockeye run never made it to Ice Harbor Dam.

In the Snake River, a temporary adult ladder water cooling system installed at Lower Granite appeared to aid adult passage. There also appeared to be adult salmon passage issues at Little Goose Dam particularly for sockeye salmon that may have been due to elevated water temperature or temperature differentials ≥ 2° C. Adult passage count differences began to deviate on July 1, 2015 between Lower Monumental and Little Goose Dams however the count differences were confounded by several unquantifiable factors that included mid-Columbia sockeye salmon migrating up the Snake River, unknown reliable fallback rates at Lower Monumental Dam, and manifestation of cumulative effects from previous thermal exposure prior to reaching Little Goose Dam. Twenty nine percent (15 of 51 fish) of the sockeye salmon trapped at Lower Granite Dam were mid-Columbia sockeye salmon based on genetic analysis. The numbers of mid-Columbia sockeye salmon passing Lower Monumental and Little Goose Dams as well as their migration behavior is unknown because no mid-Columbia PIT tagged sockeye were detected in the Snake River. The mid-Columbia sockeye may have passed Lower Monumental Dam and then fell back downstream thus inflating adult counts at Lower Monumental Dam. The number of PIT-tagged Snake River sockeye numbers were relatively small to adequately analyze fall back rates. PIT-tag and count conversion differ for Lower Monumental Dam to Little Goose Dam (42 PIT at LMN and 31PIT at LGO for a conversion of 74%; 888 counts at LMN and 587 at LGO for a conversion of 66%). Finally, the environmental conditions in 2015 resulted in exposure to high water temperatures in the Columbia River for Snake River sockeye salmon. How and where these cumulative effects from previous thermal exposure were expressed is unknown. Therefore, the focus of the analysis in this white paper is on water temperature and does not include additional fish passage analysis due to confounding unquantifiable factors.

**Analysis**

Adult salmon begin to avoid water temperatures in excess of 68° F (20.0° C) and temperatures > 70° F (21.1° C) may be lethal (Dawley 1992). In addition, water temperature differentials between the top and bottom of the fish ladders ≥ 2° C have been shown to cause delays in fish passage (Clabough et al. 2009). We examined the percent of time the average hourly water temperature was ≥ 68° F (20.0° C) and ≥ 72° F (22.2° C) in the Little Goose Dam fish ladder exit, the percent of time the average hourly water temperature differential between the tailrace temperature gage (LGSW) and the ladder exit was ≥ 2° C, and the temperature benefits for adding 25 cfs (12,000 gpm) into the ladder exit pumped from 80 feet depth in the forebay based on TDG forebay temperature gage (LGS\_S1 at 20M and 30M).

Table 1. Percent of the time the average hourly water temperature in the fish ladder exit exceeded 68° F (20.0° C).

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **Average** |
| **April** | 0% |  | 0% | 0% |  |  |  |  |  |  |  |  |  |  |  |  | 0% |
| **May** | 0% | 0% | 0% | 0% |  | 0% |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **June** | 4% | 4% | 0% | 3% | 9% | 0% | 9% | 0% | 0% | 0% | 0% | 0% | 0% | 3% |  | 26% | 4% |
| **July** | 64% | 82% | 57% | 68% | 3% | 81% | 99% | 88% | 11% | 65% | 10% | 0% | 23% | 83% |  | 49% | 52% |
| **August** | 72% | 83% | 41% | 87% |  | 75% | 8% | 83% | 50% | 82% | 66% | 54% |  | 94% | 57% | 47% | 64% |
| **September** | 4% | 22% | 0% | 25% |  | 3% |  | 18% | 1% | 20% | 0% | 5% |  | 71% | 19% | 4% | 15% |
| **October** |  |  | 0% |  |  |  |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **Overall** | 24% | 38% | 14% | 31% | 6% | 32% | 39% | 48% | 16% | 42% | 19% | 15% | 12% | 42% | 38% | 32% | 28% |

Table 2. Percent of the time the average hourly water temperature in the fish ladder exit would exceed 68° F (20.0° C) with addition of 25 cfs into the ladder exit pumped from 80 feet depth in the forebay.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **Average** |
| **April** | 0% |  | 0% | 0% |  |  |  |  |  |  |  |  |  |  |  |  | 0% |
| **May** | 0% | 0% | 0% | 0% |  | 0% |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **June** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |  | 9% | 1% |
| **July** | 0% | 0% | 0% | 0% | 0% | 39% | 92% | 66% | 0% | 26% | 0% | 0% | 0% | 54% |  | 33% | 21% |
| **August** | 0% | 0% | 0% | 0% |  | 22% | 8% | 34% | 15% | 29% | 30% | 15% |  | 33% | 50% | 21% | 18% |
| **September** | 0% | 0% | 0% | 0% |  | 1% |  | 0% | 0% | 4% | 0% | 0% |  | 57% | 8% | 0% | 5% |
| **October** |  |  | 0% |  |  |  |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **Overall** | 0% | 0% | 0% | 0% | 0% | 13% | 34% | 25% | 4% | 15% | 8% | 4% | 0% | 24% | 30% | 16% | 11% |

Table 3. Percent of the time the average hourly water temperature in the fish ladder exit exceeded 72° F (22.2° C).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **Average** |
| **April** | 0% |  | 0% | 0% |  |  |  |  |  |  |  |  |  |  |  |  | 0% |
| **May** | 0% | 0% | 0% | 0% |  | 0% |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **June** | 0% | 0% | 0% | 0% | 0% | 0% | 2% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |  | 5% | 0% |
| **July** | 9% | 21% | 8% | 10% | 0% | 11% | 17% | 32% | 0% | 27% | 0% | 0% | 2% | 5% |  | 14% | 10% |
| **August** | 5% | 28% | 0% | 10% |  | 8% | 0% | 9% | 6% | 4% | 1% | 0% |  | 3% | 3% | 0% | 5% |
| **September** | 0% | 0% | 0% | 8% |  | 0% |  | 0% | 0% | 0% | 0% | 0% |  | 9% | 0% | 0% | 1% |
| **October** |  |  | 0% |  |  |  |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **Overall** | 2% | 10% | 1% | 5% | 0% | 4% | 6% | 10% | 2% | 8% | 0% | 0% | 1% | 3% | 1% | 5% | 4% |

Table 4. Percent of the time the average hourly water temperature in the fish ladder exit would exceed 72° F (22.2° C) with addition of 25 cfs into the ladder exit pumped from 80 feet depth in the forebay.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **Average** |
| **April** | 0% |  | 0% | 0% |  |  |  |  |  |  |  |  |  |  |  |  | 0% |
| **May** | 0% | 0% | 0% | 0% |  | 0% |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **June** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |  | 0% | 0% |
| **July** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |  | 0% | 0% |
| **August** | 0% | 0% | 0% | 0% |  | 0% | 0% | 0% | 0% | 0% | 0% | 0% |  | 0% | 0% | 0% | 0% |
| **September** | 0% | 0% | 0% | 0% |  | 0% |  | 0% | 0% | 0% | 0% | 0% |  | 0% | 0% | 0% | 0% |
| **October** |  |  | 0% |  |  |  |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **Overall** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

Table 5. Percent of the time the Little Goose Dam fish ladder water temperature differential exceeded 2° C.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **Average** |
| April | 0% |  | 1% | 0% |  |  |  |  |  |  |  |  |  |  |  |  | 0% |
| May | 0% | 9% | 2% | 1% |  | 1% |  |  |  |  |  |  |  | 0% |  |  | 2% |
| June | 9% | 15% | 10% | 5% | 19% | 1% | 6% | 0% | 0% | 0% | 0% | 0% | 0% | 8% |  | 7% | 5% |
| July | 14% | 25% | 17% | 13% | 0% | 9% | 13% | 24% | 5% | 28% | 0% | 0% | 15% | 6% |  | 6% | 12% |
| August | 4% | 36% | 4% | 9% |  | 16% | 0% | 6% | 9% | 7% | 0% | 0% |  | 2% | 2% | 0% | 7% |
| September | 6% | 0% | 3% | 9% |  | 0% |  | 4% | 3% | 2% | 0% | 0% |  | 14% | 0% | 0% | 3% |
| October |  |  | 0% |  |  |  |  |  |  |  |  |  |  | 0% |  |  | 0% |
| Overall | 6% | 17% | 5% | 6% | 9% | 5% | 6% | 9% | 4% | 9% | 0% | 0% | 8% | 5% | 1% | 3% | 6% |

Table 6. Percent of the time the Little Goose Dam fish ladder water temperature differential exceeded 2° C with addition of 25 cfs into the ladder exit pumped from 80 feet depth in the forebay.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **Average** |
| **April** | 0% |  | 0% | 0% |  |  |  |  |  |  |  |  |  |  |  |  | 0% |
| **May** | 0% | 0% | 0% | 0% |  | 0% |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **June** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |  | 0% | 0% |
| **July** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |  | 0% | 0% |
| **August** | 0% | 0% | 0% | 0% |  | 0% | 0% | 0% | 0% | 0% | 0% | 0% |  | 0% | 0% | 0% | 0% |
| **September** | 0% | 0% | 0% | 0% |  | 0% |  | 0% | 0% | 0% | 0% | 0% |  | 0% | 0% | 0% | 0% |
| **October** |  |  | 0% |  |  |  |  |  |  |  |  |  |  | 0% |  |  | 0% |
| **Overall** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

**Conclusion**

If 25 cfs of water pumped from 80 feet depth would have been added to the ladder exit in 2015, the number percent of time the average water temperature in the fish ladder exit exceeded 68° F (20.0° C) would have been reduced by 50% (from 32% of the time to 16% of the time). In addition, if 25 cfs of water pumped from 80 feet depth would have been added to the ladder exit in 2015 there would have been no periods of time when the hourly average water temperature at the fish ladder exit exceeded 72° F (22.2° C) nor any hourly averaged water temperature differentials exceeding 2° C. This analysis assumes the flow/temperature augmentation from Dworshak Dam (6.5-13 kcfs cool water releases) to maintain Lower Granite tailrace < 68° F would continue in the future.