



# **The Chief Joseph Hatchery Program**

## **Okanogan River Adult Fish Pilot Weir**

### ***2017 Summary of Methods & Results***



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## BACKGROUND

The Okanogan adult fish pilot weir (herein referred to as the 'weir') was in its sixth year of design modifications and testing in 2017. Continued operation and improvements to the weir are a central part of CCT's strategy for the successful implementation of the CJHP summer/fall Chinook Salmon (*Oncorhynchus tshawytscha*) programs. Pilot weir test results are essential for updating key assumptions, operations and design of the weir.

Objectives for the pilot weir in 2017 included:

1. Install the weir in early July and operate until late September under allowable flow conditions (<3,000 cfs) and temperature (<22.5 °C);
2. Document environmental effects of the weir through collection of physical and chemical data in the vicinity of the weir;
3. Test weir trapping operations and the Whooshh™ fish transport system including live Chinook capture, handling and release;
4. Direct observations and fish counts for estimating species composition, abundance, health, and timing to inform management decisions and future program operations;
5. Collect NOR broodstock at the weir and transport safely to the CJH;
6. Test the weir configuration, including the location of the trap box, to meet the program's biological and brood-take goals

## METHODS

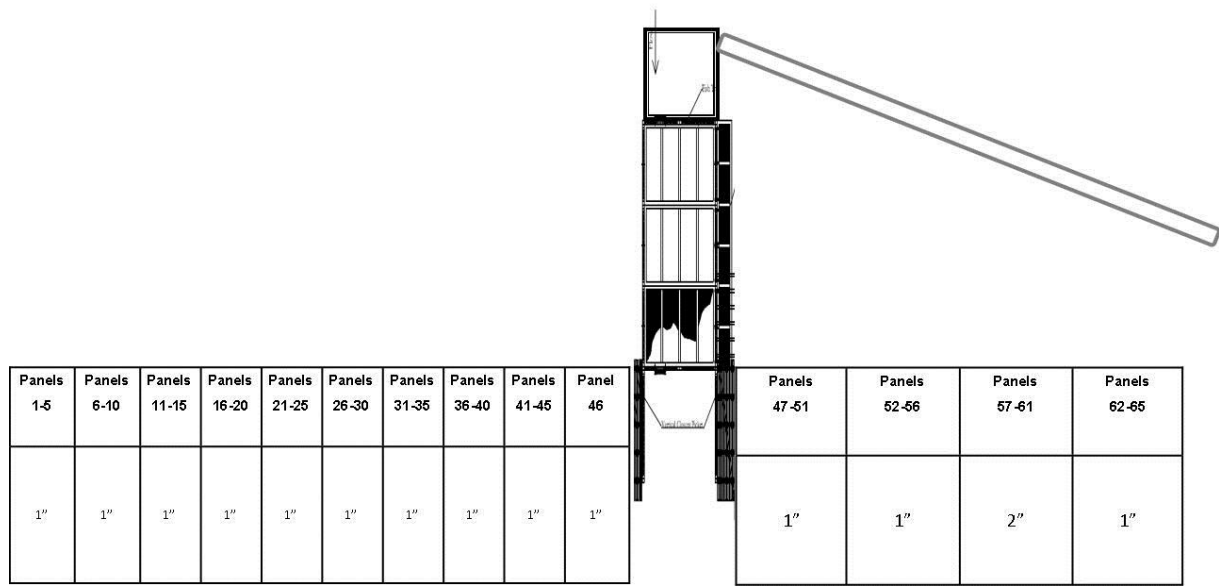
The lower Okanogan fish weir was installed approximately 1.5 km downstream of Malott, WA (48°16'21.54 N; 119°43'31.98 W) in approximately the same location as previous years. Weir installation began on August 14th at a river flow of 2,280 cfs and was complete with the underwater video system on August 18th. An aluminum trap was installed near the center of the channel at the downstream end of the deep pool in the thalweg of the channel. The trap was 3 m wide, 6 m long and 3 m high (Figure 1). The wings of the weir stretched out from either side of the trap towards the river banks, angling downstream in a slight V configuration. The wings consisted of steel tripods with aluminum rails that supported the 3 m long Acrylonitrile butadiene styrene (ABS) pickets. Each panel was zip-tied to the adjacent panel for strength and stability. Sand bags were placed between panels when needed to fill gaps that exceeded the target picket spacing. Picket spacing ranged from 2.5 to 5.1 cm (1 to 2 inch) in 1.2 cm (half-inch) increments (Figure 2). Pickets were manually forced into the river substrate upon deployment and then as needed to prevent fish passage under the weir.

The river-right wing consisted entirely of 2.5 cm picket spacing (Figure 2). A 3 m gap between the last panel and the right shoreline remained to allow for portage of small vessels around the weir. This was a very shallow gravelly area and under most flow

conditions it did not appear to be a viable path for adult salmon passage. However, a set up floating panels that were attached to the substrate extended from the last panel to the river-right shore to limit escapement via this route. The river left wing had variable picket spacing to accommodate non-Chinook fish passage through the pickets. The primary objective of the wider picket spacing was to allow Sockeye (*O. nerka*) to pass through the weir and reduce the number of Sockeye that would enter the trap. River left was selected for this spacing to better accommodate observation/data collection regarding successful passage of smaller fish through the panels. In past years CCT has observed jack and even adult Chinook passing through the 6.4 and 7.6 cm picket spacing panels. These picket spacing panels were replaced with 5.1 cm picket spacing panels during deployment to reduce the escapement of smaller hatchery Chinook. This decision was made after consultation with the Technical Oversight Group (TOG) because the majority of Sockeye had already escaped into Canada before the weir was deployed.



**Figure 1.** Lower Okanogan adult fish pilot weir, 2017. Photo taken in mid- August just after deployment.



**Figure 2.** Conceptual diagram of picket (ABS pipe) spacing within each panel (or set of 5 panels) at the Lower Okanogan adult fish pilot weir in 2017.

On August 22<sup>nd</sup> a negative pressure transport tube, known as a Whooshh™ fish transport system, was installed to assist CCT with broodstock collection at the Okanogan weir. The 49 m tube was connected to an accelerator at the upstream side of the trap and at a mobile trailer fitted with a decelerator, tower, tube reel, blower housing, and accelerator entrance and exit mounts. A diesel generator provided remote power to run the pump that generated power for the pneumatic portions of the system.



Figure 3. Whooshh™ fish transport system installed at the Okanogan weir. Photo taken from the broodstock truck.

Physical and chemical data were collected in the vicinity of the weir including the water depth (ft.) inside the trap, water velocity (ft./sec) upstream, downstream and in the weir trap, dissolved Oxygen (mg/L), total dissolved solids (TDS)(ppm), turbidity (NTU), temperature (°C), discharge (cfs) and head differential (cm). Temperature and discharge were taken from the online data for the USGS gauge at Malott ([http://waterdata.usgs.gov/wa/nwis/uv?site\\_no=12447200](http://waterdata.usgs.gov/wa/nwis/uv?site_no=12447200)). When river temperature exceeded 22.5° C, trapping operations ceased and weir pickets on panels adjacent to the trap on both sides were raised to allow for unrestricted fish passage.

Five minute tower observations were conducted at least three times a day, in the morning (0600-0800), early afternoon (1200-1400) and evening (1700-1900) and an estimate of the number fish observed was recorded. Ten minute bank observations were conducted about 0.8 river km downstream of the weir, around two pools, at least twice a day, in the morning and afternoon. An estimate of the number of fish observed below the weir was recorded. Algae and debris were cleared off of the weir at least once per day generally in the morning (0800-1000). Dead fish on the upstream side of the weir were enumerated, identified to species and the presence and extent of injuries were noted. The tail was cut off of each mortality before they were tossed downstream of the weir so that they would not be double counted during surveys.

Weir efficiency, a measure of the proportion of total spawning escapement encountered by the weir, was calculated by the equation;

$$X = \frac{W_T}{T}$$

where  $X$  was weir efficiency,  $W_T$  was the number of adult summer/fall Chinook encountered in the weir trap including released fish, and  $T$  was the total summer/fall Chinook spawning escapement for the Okanogan River Basin.

Weir effectiveness was a measure of the proportion of the adult hatchery Okanogan summer/fall Chinook run encountered in the weir trap, becoming available for removal from the population as a form of adult fish management. It was calculated by the equation;

$$Y = \frac{W_H}{W_H + HOS}$$

where  $Y$  is weir effectiveness,  $W_H$  is the number of adult hatchery origin fish encountered in the weir trap, and  $HOS$  is the total number of hatchery origin spawners.

Trapping operations were conducted during daylight hours (0700-1500) during the first week, under allowable temperature conditions ( $\leq 22.5^\circ \text{C}$ ) from August 21-25. The trapping operations changed to 24 hours a day, 5 days a week, starting on August 26<sup>th</sup>. The last day of trapping was on September 20<sup>th</sup>. When fish entered the trap during an active trapping session, the downstream gate was closed and fish were identified and either released surplus or collected for brood.

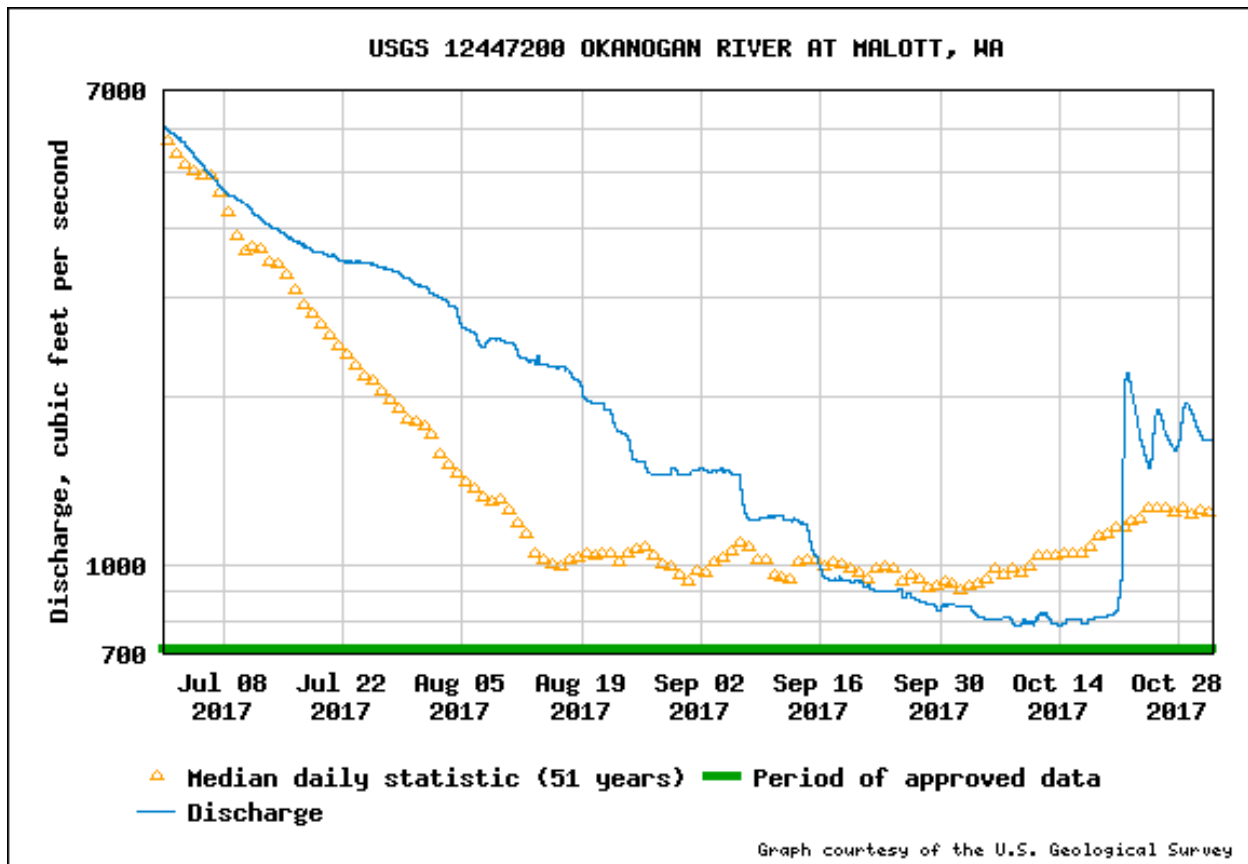
Eighty four natural origin and 9 hatchery origin Chinook were collected from the weir trap from September 5 to September 19, transported to a 2,500 gallon hatchery truck via the Whooshh™ fish transport system. The fish were then transported approximately 32 km to Chief Joseph Hatchery where they were held in the broodstock raceways until spawning in October.

Mark-recapture studies were performed at the weir trap to assess handling mortality at the weir as well as recovery bias of carcasses on the spawning grounds. All natural-origin Chinook that were trapped and destined for release upstream, were anesthetized with electronic anesthetic gloves, measured, and inserted with a floy tag. After the fish were tagged they were released over the crowder and into the upstream side of the trap where they recovered before they exited through the trap gates on their own volition.

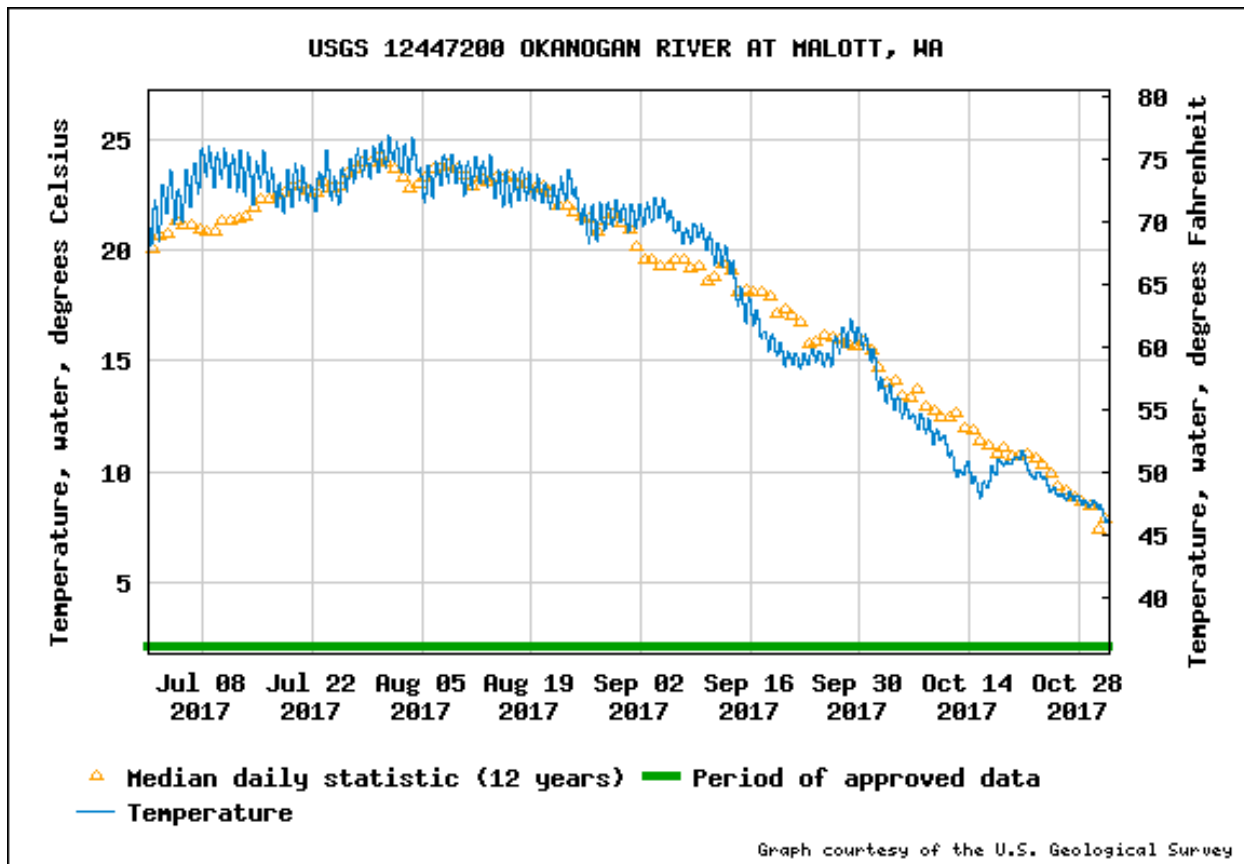
## RESULTS

The Okanogan River (at Malott) discharge was above normal in 2017 and was below 2,000 cfs for the trapping season. Staff were able to safely enter the river and begin installation on August 14th when discharge was 2,280 cfs (Figure 3). Discharge continued to drop throughout the season and was at 860 cfs by the time the weir was removed for the season.

Migration of Sockeye and summer Chinook is generally affected by a thermal barrier that is caused by warm water temperatures ( $\geq \sim 22^{\circ}\text{C}$ ) in the lower Okanogan River. The thermal barrier is dynamic within and between years, but generally it sets up in mid-July and breaks down in late August. In some years, the Okanogan River will temporarily cool off due to a combination of interrelated weather factors including rainstorms, cool weather, cloud cover or wildfire smoke. This 'break' in the thermal barrier can allow a portion of the fish holding in the Columbia River to enter the Okanogan and migrate up to thermal refuge in the Similkameen River or Lake Osoyoos. In 2017, temperatures were similar to, though occasionally higher than the median daily temperatures from the last 10 years (Figure 4). Daily mean temperature was above  $22.5^{\circ}\text{C}$  from July 1 to July 25. Daily mean temperature dropped below  $22.5^{\circ}\text{C}$  on August 25<sup>th</sup> and stayed below this mark for the rest of the season.



**Figure 3.** Discharge of the Okanogan River between July 1 and October 31, 2017. This figure was copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).



**Figure 4.** Temperature of the Okanogan River between July 1 and October 31, 2017. This figure was copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

Dissolved Oxygen varied from 5.2 to 8.2 mg/L, total dissolved solids varied from 134-148 ppm and turbidity varied from 1.2 and 2.5 NTUs (Table 1). The head differential ranged from 0-10 cm across the weir panels (Table 2). The maximum water velocity measured was 3.3 ft./sec. (Table 3).

**Table 1.** Water quality data at or near the lower Okanogan weir in 2017. Temperature and discharge were taken from the USGS gauge at Malott.

Date	Trap Depth (ft.)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (ppm)	Turbidity (NTU)
8/23	2.3	7.5	144	2.0
8/24	2.2	7.9	148	1.5
8/25	2.2	7.8	142	1.8
8/28	2.2	7.7	148	1.8
8/29	2.1	7.4	147	1.8
8/30	2.2	7.0	146	1.5
8/31	2.3	6.3	143	1.9
9/1	2.3	5.8	141	1.7
9/5	2.3	5.6	146	1.5
9/6	2.3	5.5	145	2.2
9/7	2.1	5.9	144	1.6
9/8	2.1	7.1	147	2.5
9/11	2.0	6.5	143	1.6
9/12	2.0	8.1	144	1.5
9/13	2.0	7.3	142	1.5
9/14	2.0	8.2	137	2.5
9/15	2.0	8.1	135	1.3
9/18	2.0	7.9	138	1.7
9/19	1.8	5.2	135	2.2
9/20	1.8	5.6	134	1.7
9/21	1.8	7.3	135	1.2
Min	1.8	5.2	134	1.2
Max	2.3	8.2	148	2.5

**Table 2.** Head differential across the different picket spacings. If differential exceeded 10 cm, pickets were cleaned immediately. Measurements are in cm. Daily mean gage height is included in feet. Gage height is copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

<b>Date</b>	<b>1.0" Picket Spacing (cm)</b>	<b>1.5" Picket Spacing (cm)</b>	<b>2.0" Picket Spacing (cm)</b>	<b>Gage Height (ft.).</b>
8/25	10.2	0.0	5.1	3.7
8/28	10.2	0.0	5.1	3.6
8/29	10.2	0.0	5.1	3.6
8/30	10.2	0.0	5.1	3.6
9/1	10.2	0.0	5.1	3.6
9/5	7.6	0.0	0.0	3.6
9/6	10.2	0.0	0.0	3.5
9/7	7.6	0.0	2.5	3.4
9/8	10.2	0.0	2.5	3.4
9/11	10.2	0.0	2.5	3.4
9/13	5.1	0.0	2.5	3.3
9/15	7.6	0.0	2.5	3.2
9/18	5.1	0.0	2.5	3.1
9/21	7.6	0.0	2.5	3.1
Min	5.1	0.0	0.0	3.1
Max	10.2	0.0	5.1	3.7

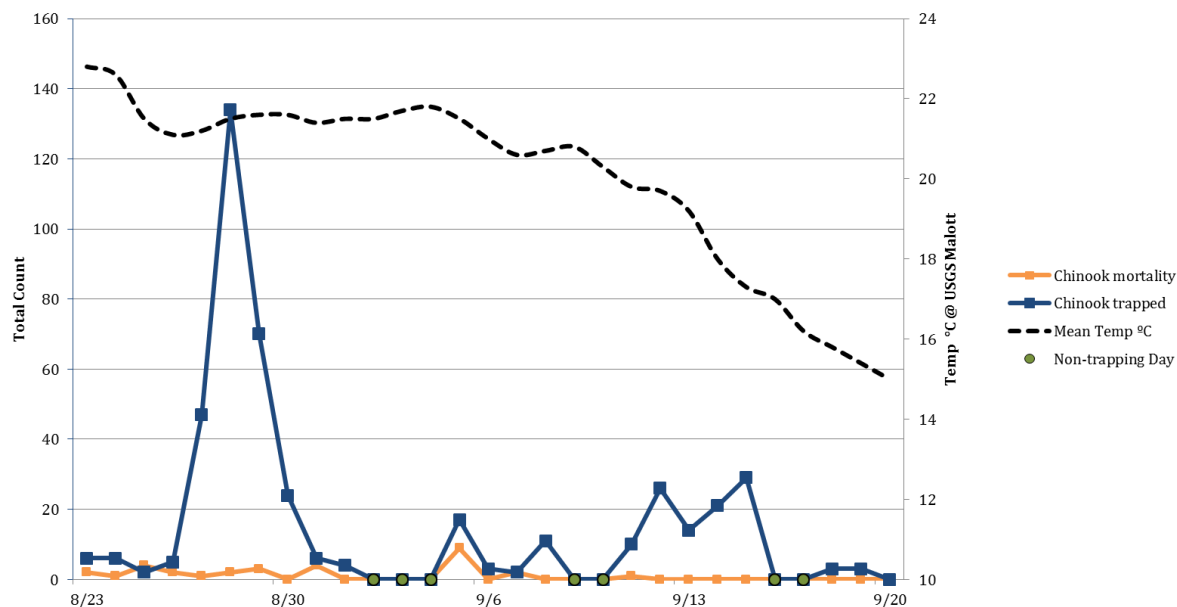
**Table 3.** Water velocity upstream (US) and downstream (DS) of the weir and in the trap. Velocity should not exceed 3.5 ft. /sec. Measurements are in ft. /sec.

Date	River Left US	Center US	River Right US	River Left DS	Center DS	River Right DS	Trap Velocity
8/23	1.9	0.7	1.1	2.5	1.5	2.7	0.2
8/24	2.6	1.4	1.9	2.6	1.8	3.3	1.7
8/25	1.8	1.3	1.7	2.2	2.7	1.5	1.6
8/28	2.5	1.5	1.8	2.4	1.9	2.1	1.7
8/29	2.4	1.3	1.9	1.9	2.7	3.0	2.0
8/30	2.5	1.3	2.1	1.8	2.3	2.8	1.9
8/31	2.5	1.1	2.2	2.3	1.7	2.2	1.2
9/1	2.5	0.3	2.1	2.2	2.0	2.8	1.4
9/5	2.4	1.3	1.6	1.8	1.6	3.3	1.6
9/6	2.4	1.4	1.4	2.4	1.4	3.2	1.8
9/7	2.6	1.3	1.7	2.0	1.7	2.7	1.3
9/8	2.5	1.1	1.9	2.3	1.8	2.5	1.5
9/11	2.3	1.3	2.8	2.2	2.1	2.5	1.7
9/12	2.4	1.1	1.6	2.5	1.5	2.2	1.9
9/13	2.3	1.3	2.2	2.0	1.9	2.8	1.9
9/14	2.5	1.2	1.9	2.1	1.7	2.6	1.8
9/15	2.4	1.2	1.9	1.4	2.3	2.1	1.9
9/18	2.2	1.0	1.5	1.4	1.9	2.0	1.6
9/19	1.9	1.2	1.5	1.7	1.9	2.3	1.9
9/20	1.9	1.6	1.7	1.7	1.5	1.9	1.4
9/21	1.9	1.2	1.9	2.0	2.1	1.8	1.8
Min	1.8	0.3	1.1	1.4	1.4	1.5	0.2
Max	2.6	1.6	2.8	2.6	2.7	3.3	2.0

Ninety one dead fish were removed from the weir between August 23 and September 20 (Table 4). Chinook Salmon were the most commonly encountered species (74%). There were no Steelhead mortalities removed from the weir in 2016. All mortalities were impinged on the upstream side of weir indicating that they had most likely died upstream and floated down onto the weir. The majority of the Chinook carcasses were observed a week before the majority of Chinook were encountered in the trap (Figure 5). There were also no observations of fish caught between pickets in a head upstream direction, which would have indicated that a fish got stuck and died while trying to push through the pickets.

**Table 4.** Date and species of fish mortalities observed at the lower Okanogan fish weir in 2016. All fish mortalities were considered “wash downs” and collected on the upstream panels of the weir.

Date	Carp	Chinook	Mountain Whitefish	Smallmouth Bass	Sockeye	Unknown Sucker
8/23		2				
8/24		1			1	
8/25	3	4			1	
8/26	1	2				
8/27	1	1			1	
8/28	2	2			1	
8/29		3			2	
8/30	1				2	3
8/31		4			2	
9/1				1	4	
9/2						
9/3						
9/4						
9/5		9			2	
9/6	3					
9/7	2	2				
9/8	5					
9/9						
9/10						
9/11		1			2	
9/12					1	
9/13	2					1
9/14	2				1	1
9/15	1					1
9/16						
9/17						
9/18					1	
9/19	1				3	2
9/20						3
<b>Total</b>	<b>24</b>	<b>31</b>	<b>0</b>	<b>1</b>	<b>24</b>	<b>11</b>



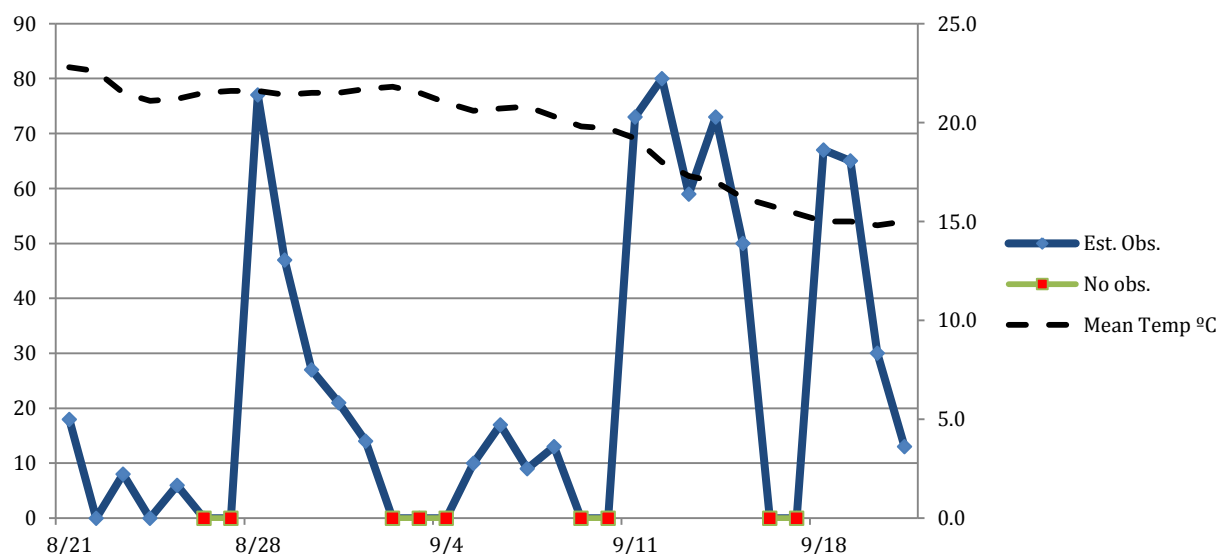
**Figure 5.** Total number of Chinook trapped and total number of Chinook carcasses collected off the weir panels. Chinook mortality was low and did not drastically change after most Chinook were encountered in the trap.

Tower observations showed that most fish were equally distributed across the river, milling in the river right, left and center sections (looking downstream). Estimates were highest during the last week of August when mean daily river temperatures dropped below 22.5 °C. Bank observations showed that the number fish observed holding in the lower pool, 0.8 km below the weir, increased about two days after the thermal barrier breakdown and then decreased until the second week in September. During that time the highest daily estimates of fish were observed throughout the week (Figure 6). Trapping operations were conducted on August 21<sup>st</sup> when river temperature was ≤ 22.5 °C. The total fish trapped at the weir in 2017 was 492 with 91% of them being Chinook Salmon (Figure 7). Seventy percent of the Chinook trapped were released back into the river (Figure 8). Two steelhead were trapped between 9/10-9/20 and released in good condition within 30 minutes of observation. The TOG was notified when steelhead were trapped, including the total number, origin and condition after release. To reduce handling of fish, trap attendants opened the gate of the crowder and the upstream gate of the trap to allow for complete passage. Fish that were passed upstream were classified as having a vigorous condition, swimming away unharmed.

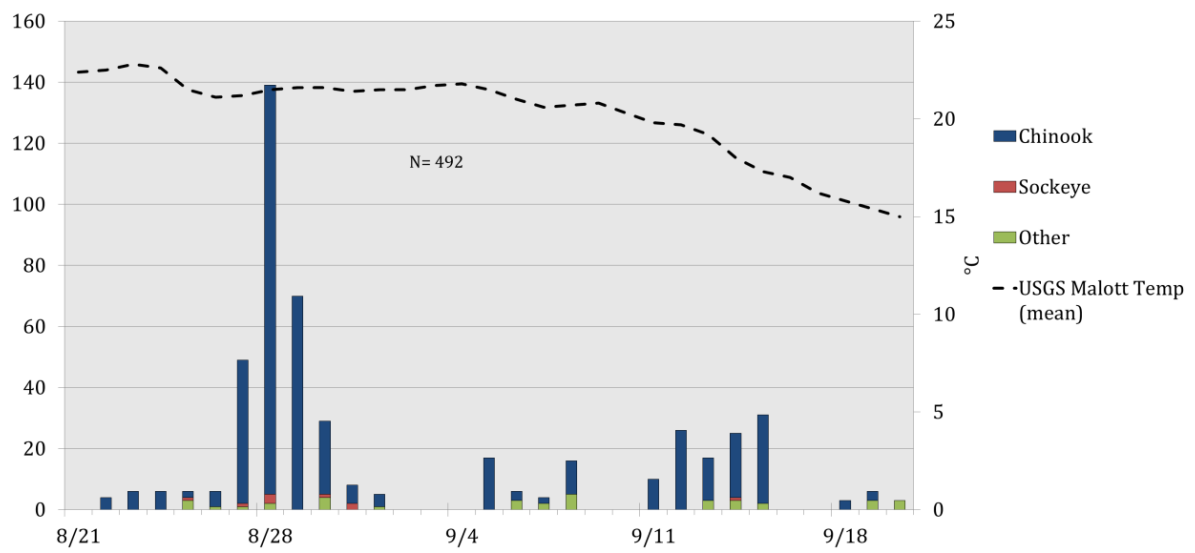
Prior to collecting broodstock we conducted several tests using hatchery origin fish brought to the weir via the hatchery truck. Eight adults and two jacks were manually carried to the weir in a boot (inner-tube) which took approximately 90 seconds each. These fish were sent back to the hatchery truck via the Whooshh™ transport tube in approximately eight seconds. This process was repeated three times over a several hour

period. There were no immediate mortalities, although two fish were dead upon arrival at the hatchery that evening (nearly 10 hours after their initial capture in the hatchery ladder). This test was considered a success and the mortalities were not a concern because the fish had been handled much more extensively than the natural origin brood would be.

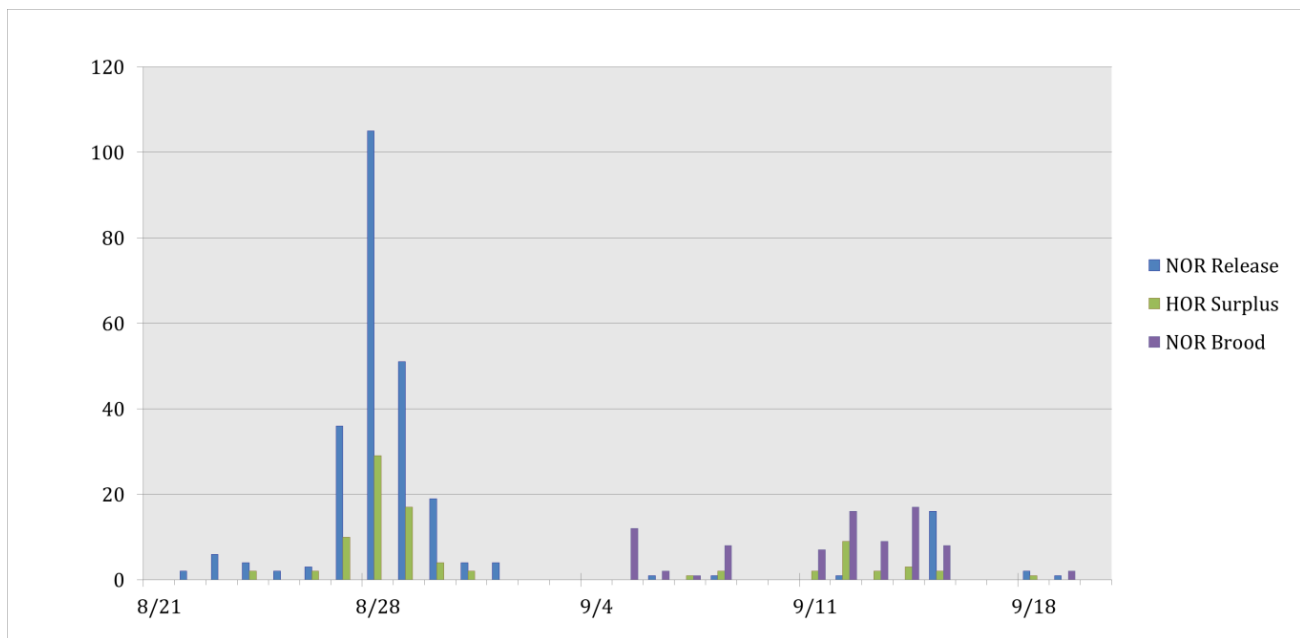
Sixteen natural origin Chinook were transported to the hatchery and held in the broodstock ponds concurrently with the fish taken for broodstock from the purse seine, hatchery ladder, and beach seine. Adult Chinook were transported from the weir trap to the hatchery brood truck via the Whooshh™ fish transport system. No immediate mortalities were observed related to the Whooshh™ transport system or during transport to the hatchery. There were zero mortalities of the Whooshh™ transported fish by September 15<sup>th</sup> (1-6 days). On September 15<sup>th</sup>, 70 natural-origin brood fish collected via a beach seine on the Similkameen River were added to the raceway with the weir collected fish so we could not evaluate longer term pre-spawn mortality separately. The mortality of the combined group was through the entire pre-spawn holding period was 26.7%. The overall pre-spawn mortality of all summer Chinook broodstock was 13.4%; however the majority of these fish were collected earlier and handled differently, making direct comparisons problematic.



**Figure 6.** Estimate of Chinook observed from the bank at the lower pool, 0.8 km downstream of the weir.



**Figure 7.** Total number of fish trapped at the Okanogan weir in 2017.



**Figure 8.** Final destination of Chinook adults captured in the weir trap during trapping operations in 2017.

In 2017, 0.057 (5.7%) of total spawning escapement was detected in the trap (i.e., weir efficiency) (Table 5). The potential weir effectiveness (if we had been removing all of the HOR encountered) was 0.066 (6.6%).

**Table 5.** The number of hatchery and natural origin Chinook Salmon encountered at the lower Okanogan weir in 2017. Weir efficiency and effectiveness were metrics for evaluating the potential for the weir to contribute to the CJHP population management goals in the future.

Survey Year	Chinook Adults Encountered in the Weir Trap		Chinook Spawning Escapement Estimates <sup>c,d</sup>		Weir Metrics	
	Natural Origin (NOR)	Hatchery Origin (HOR)	Natural Origin (NOS)	Hatchery Origin (HOS)	Weir Efficiency <sup>a</sup>	Weir Effectiveness <sup>b</sup>
2013	73	18	5,627	2,567	0.010	0.006
2014	2,006	318	10,402	1,762	0.147	0.138
2015	35	19	10,350	3,398	0.004	0.005
2016	135	34	8,661	1,944	0.014	0.016
2017	346	99	5,283	1,285	0.057	0.066

<sup>a</sup> Estimates for weir efficiency are adjusted for prespawn mortality and include Chinook adults that are harvested, released, and collected for brood.

<sup>b</sup> Estimates for weir effectiveness are adjusted for prespawn mortality and include Chinook adults that are harvested or removed for pHOS management.

<sup>c</sup> Estimates do not include Chinook Zosel Dam counts.

<sup>d</sup> NOS and HOS estimates determined by 'reach-weighted' pHOS calculations

## Discussion

Discharge conditions on the Okanogan River in 2017 were higher than in 2016, delaying installation and operation of the weir until mid-August, which was a week later than 2016. Temperatures on the Okanogan River were fairly normal, compared to the 10 year median. Because temperatures stayed below 22.5 °C once trapping began on August 21st, trapping operations were not suspended because of this reason. Tower and bank fish observations were generally higher after the thermal barrier broke on August 25. During this time, fish observations 0.8 km below the weir, at the lower pool, were similar than observations at the weir. When river temperature was lower and gauge height was less than 4 feet, Chinook were more likely to mill in deeper pools. Continued monitoring of Chinook passage through the weir with respect to temperatures should continue in order to better refine weir operations and future expectations for weir effectiveness. The number of Chinook handled at the weir (n = 447) was more than in 2016 (n= 169). Configuration of the weir was different in 2017 compared to 2016. The trap was installed further downstream on the edge of the thalweg, just below the deep pool. Water velocity was higher downstream of the trap gate in 2017 and this may have attracted more fish to the trap. We expect to keep

the configuration the same in 2018 in regard to location of the trap box.

None of the water quality parameters monitored were at a level that would cause concern regarding an environmental effect of the weir on water quality. The number (91) of dead fish at the weir was higher in 2017 than 2016 but still lower than years prior (2014-2015). Mortality was highest after Labor Day weekend when trapping was suspended, indicating that trap operation and handling were not the immediate cause of mortality. The behavioral observations and lack of fish impinged between pickets (head upstream) were good indicators that this weir configuration and picket spacing were not a major cause of direct mortality. In an attempt to assess immediate indirect mortality, we marked and released 246 adult natural-origin Chinook at the weir trap. Six of them were collected as mortalities at the weir, which is less than 2.5% of all trapped, marked and released fish. None of them were collected as carcasses on the spawning grounds. We do not anticipate additional mark-recapture studies in the future.

There were few observations of Sockeye at the weir during daylight and nighttime hours and only nine were trapped in 2017. Most Sockeye passed the weir before trapping began on August 21. We did observe a few Sockeye (~20) pass through the weir trap during night hours (2000-0400) during the first couple weeks of trapping operations. It is likely that more Sockeye moved through the weir panels at night when observations did not occur. There were no observations of jack or small adult Chinook escaping through the 2" weir panels that were intended to allow Sockeye passage. We recommend using the 2 inch weir panels again next year to increase the efficiency of Chinook trapping without causing too many Sockeye to also use the trap. In 2017, there were no Sockeye observations during daylight hours, but in past years we did have observations of Sockeye passing through the 2.0" picket spacing. We will continue to document passage of Sockeye and Chinook through all picket spacings.

There was no way to know exactly how many fish escaped past the weir before it was installed or how many fish swam through, around or jumped over the wings after it was installed (jumping over the wings has never been observed). The potential weir effectiveness measure of 6.6% was low because, after reviewing PIT detection at the Okanogan Instream Lower array, we suspect that about 30-40% of the fish had migrated past the weir before deployment in August. There was not a thermal barrier breakdown that occurred before the weir was fully functional; so it's unlikely that the majority of fish passed the weir before it was installed. Fortunately, this did not hinder fish management objectives in 2016 because pHOS was already low and only 21% of the Chinook trapped were hatchery origin. In the future, with larger returns of hatchery fish due to CJH releases we anticipate a much higher pHOS at the weir resulting in higher weir effectiveness. Continuing these evaluations in future years will be critical to determining the long-term viability of the weir as a fish management tool for summer Chinook.

The broodstock collection protocol at the weir was to get 15% (n = 84) of the integrated

program from the later arriving fish (in September, post thermal barrier). The weir met its broodstock goal, collecting 84 fish, 100% of the broodstock collection protocol, through the trap post thermal barrier breakdown period. The Whooshh™ transport tube worked well and initial mortality was low, indicating that further use and testing of this system should be continued in the future.

In 2017 CCT F&W staff were able to safely and successfully deploy, operate, and monitor the weir and add to the multi-year evaluation of the weir as a fish management tool for the CJH program. The weir was successful at collecting broodstock for the hatchery's integrated program and the Whooshh fish transport system was a beneficial tool for handling these fish safely for transport to the hatchery. The weir's importance to the Okanogan summer/fall Chinook population will increase in the coming years with larger hatchery returns resulting from the increased production at CJH. Experiencing a broad range of environmental conditions spanning the extremely high summer flows of 2012 to the very low and warm flows in 2015 is important for understanding the range of challenges and resulting weir effectiveness that can be expected through time.