The Chief Joseph Hatchery Program

Okanogan River Adult Fish Pilot Weir

2018 Summary of Methods & Results

Prepared by:	Andrea Pearl (CCT), Casey Baldwin (CCT)

Funding Source:	Bonneville Power Administration (current), Grant County Public Utility District (6/2011 – 4/30/2013)
Agreement No.	430-3128 – Amendment No. 3
BPA Project No.	2003-023-00
Revised:	14 May, 2019

BACKGROUND

The Okanogan adult fish pilot weir (herein referred to as the ‘weir’) was in its seventh year of design modifications and testing in 2018. 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 2018 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 and/or HOR brood stock 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
7. Test fish entrainment through the trap entrance chute and into the trap box

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 6th at a river flow of 1,230 cfs. and was completed with the underwater video system on August 10th. 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). A fifteen foot aluminum accelerator chute was installed at the downstream trap gate. The wings of the weir stretched out from either side of the chute 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 but still allow sockeye to pass through these panels.

Figure 1. Lower Okanogan adult fish pilot weir, 2018. Photo taken in mid- August just after deployment.

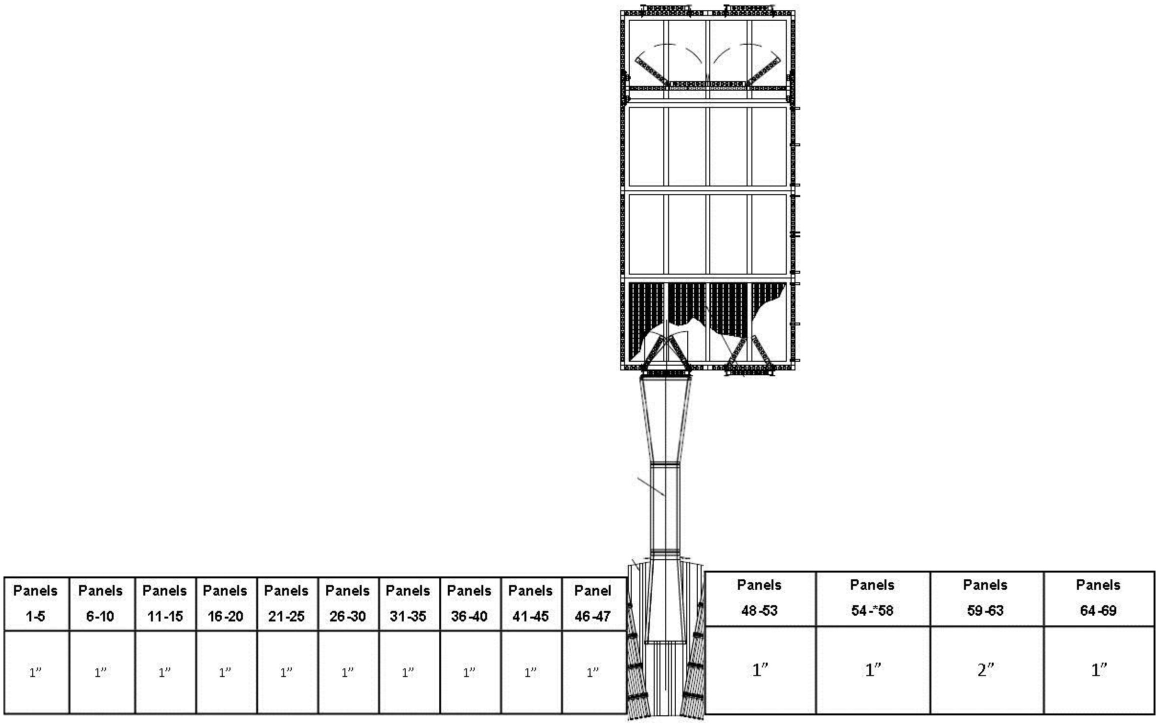

Figure 2. Conceptual diagram of picket (ABS pipe) spacing within each panel (or set of 5 panels) at the Lower Okanogan. A 15 ft. entrance chute was installed at the lower trap gate in 2018.

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). 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 24 hours/day, 7 days/week, under allowable temperature conditions (≤22.5° C) for the season. Trapping operations were suspended from September 1-3. The last day of trapping was on September 21st. When fish entered the trap during an active trapping session, the downstream gate was closed and fish were identified and either released or collected for brood.

Nineteen natural-origin Chinook were collected from the weir trap from August 18 to September 18, transported to a 2,500 gallon hatchery truck via a rubber boot. The fish were then transported approximately 32 km to Chief Joseph Hatchery where they were held in the brood stock raceways until spawning in October. The Whoooshh™ fish transport system was not deployed in 2018 due to insufficient staff needed to operate the system effectively, including breakdown of the system during windy weather conditions

In recent years, 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. Unfortunately there were little to no carcasses recovered on the spawning grounds after the tagging effort, so the program decided not to conduct the study in 2018 until a larger number of fish were captured in the trap (i.e. higher weir efficiency).

RESULTS

The Okanogan River (at Malott) discharge was above normal in 2018 and was below 2,000 cfs. for the trapping season. Staff were able to safely enter the river and begin installation on August 6th when discharge was 1,230 cfs. (Figure 3). Discharge continued to drop throughout the season and was at 1,100 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 (≥~22 °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 2018, temperatures were similar to the median daily temperatures from the last 13 years (Figure 4). Daily mean temperature was above 22.5 °C from July 1 to August 10. Daily mean temperature dropped below 22.5 °C on August 10th and stayed below this mark for the rest of the season.

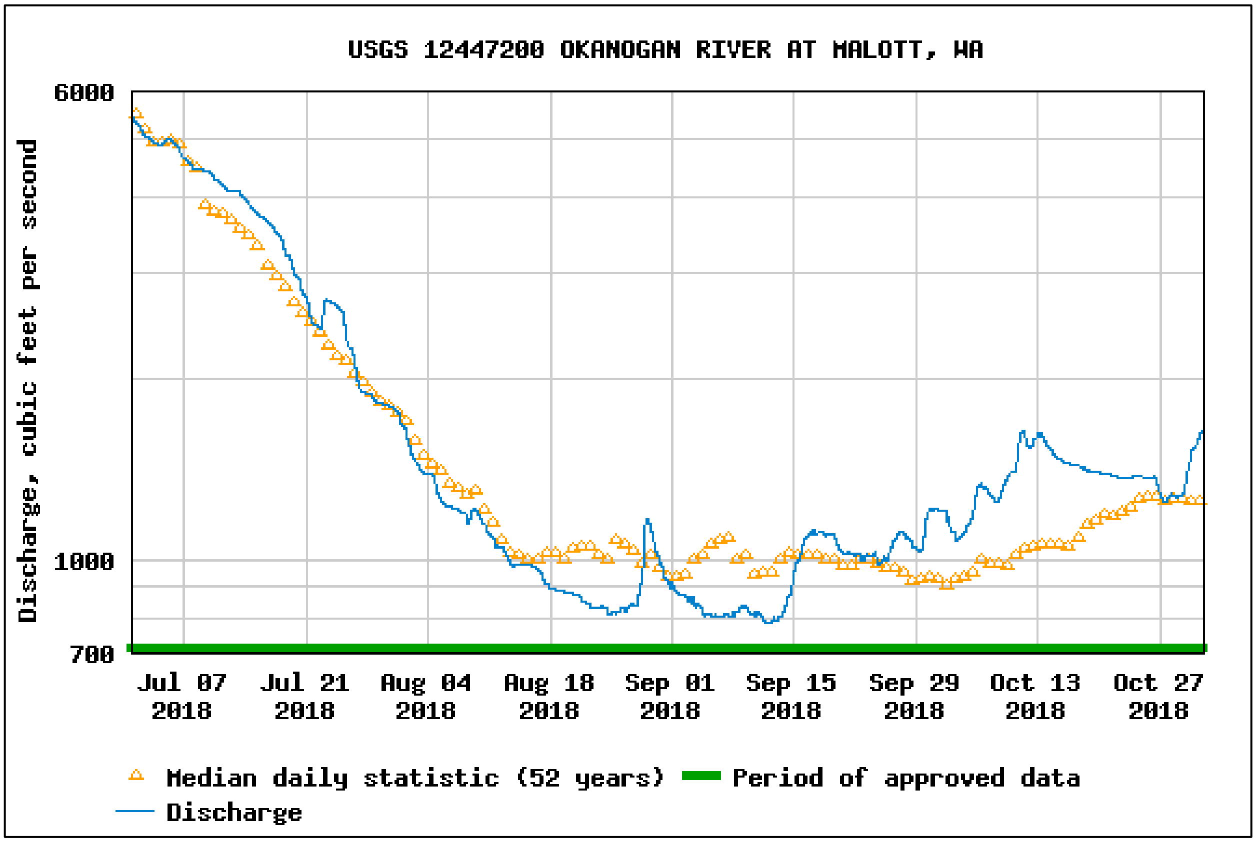

Figure 3. Discharge of the Okanogan River between July 1 and October 31, 2018. This figure was copied directly from the USGS website (http://nwis.waterdata.usgs.gov/wa).

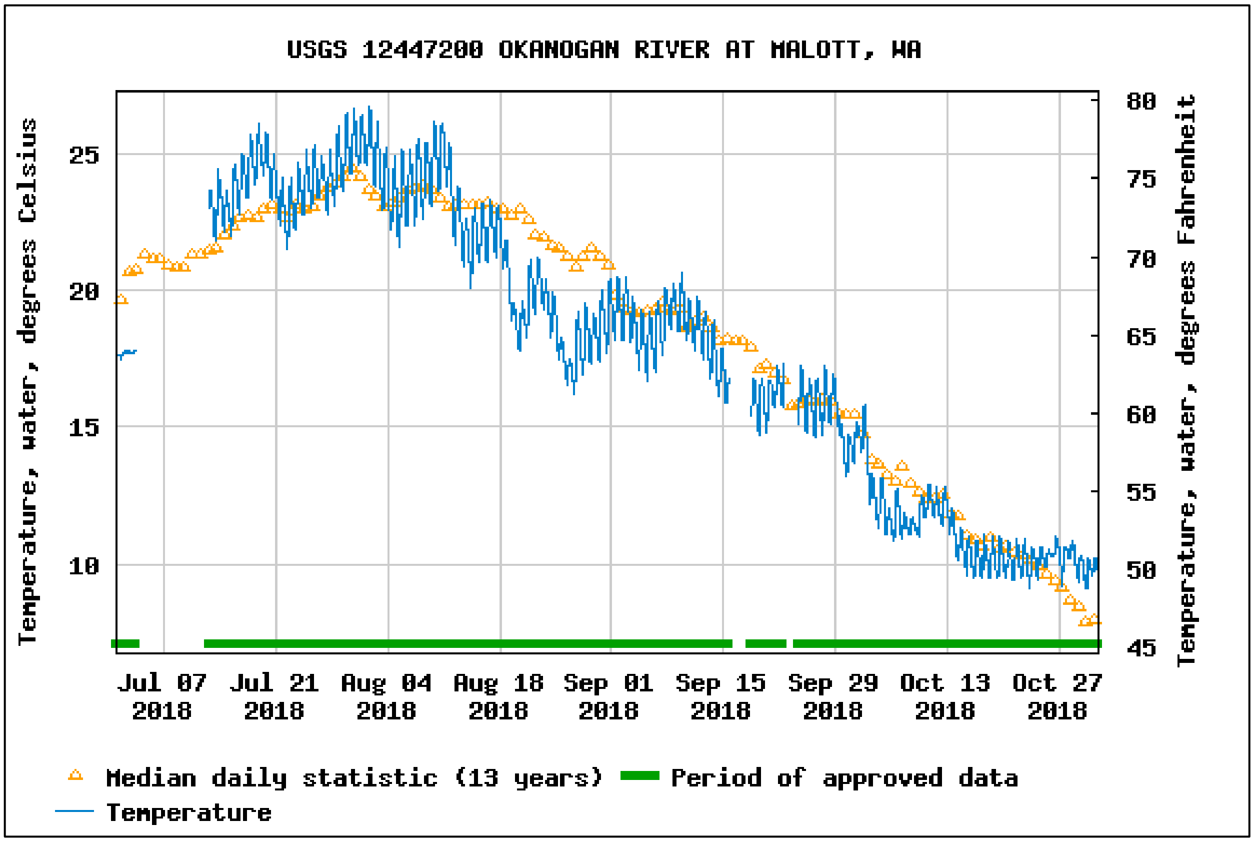

Figure 4. Temperature of the Okanogan River between July 1 and October 31, 2018. This figure was copied directly from the USGS website (http://nwis.waterdata.usgs.gov/wa).

Dissolved Oxygen varied from 4.4 to 8.2 mg. /L, total dissolved solids varied from 121-163 ppm. and turbidity varied from 0.8 and 2.9 NTUs (Table 1). The head differential ranged from 0-2.5 cm. across the weir panels (Table 2). The maximum water velocity measured was 2.9 ft. /sec. (Table 3).

Table 1. Water quality data at or near the lower Okanogan weir in 2018. 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)
8/13	2.9	7.9	155	1.1
8/14	2.9	7.0	153	1.1
8/15	2.9	7.5	157	1.5
8/16	2.9	no data	121	1.2
8/17	2.8	no data	159	1.1
8/20	2.8	no data	150	1.4
8/21	2.7	5.8	152	1.6
8/22	2.8	5.6	163	2.7
8/23	2.8	4.5	158	1.2
8/24	2.7	5.3	160	1.4
8/27	2.8	6.8	149	1.7
8/28	2.8	no data	154	1.4
8/29	3.0	7.5	152	1.4
8/30	3.0	6.2	147	1.2
8/31	2.9	6.4	147	1.4
9/4	2.9	5.4	150	1.5
9/5	2.9	6.5	150	1.3
9/6	2.8	6.0	153	2.0
9/7	2.8	7.5	155	1.9
9/10	2.8	4.4	157	0.9
9/11	2.8	5.1	155	0.8
9/12	2.8	4.7	156	1.1
9/13	2.8	8.2	156	0.9
9/14	2.9	7.8	152	0.9
9/17	3.0	6.5	133	2.2
9/18	3.1	7.9	133	1.0
9/19	3.0	6.3	134	2.0
9/20	3.0	6.2	135	2.6
9/21	3.0	6.8	132	2.9
Min	2.7	4.4	121	0.8
Max	3.1	8.2	163	2.9

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

Date	1.0" Picket Spacing (cm.)	2.0" Picket Spacing (cm.)	Gage Height (ft.)
8/13	1.5	1.0	3.1
8/14	1.5	1.0	3.1
8/16	2.5	2.0	3.1
8/17	1.5	1.0	3.0
8/20	1.0	0.5	3.0
8/21	1.5	1.0	3.0
8/22	1.5	1.0	2.9
8/23	1.0	1.5	2.9
8/24	1.5	1.0	2.9
8/27	1.5	1.0	2.9
8/28	1.5	1.0	3.1
8/29	1.0	1.0	3.2
8/30	1.0	1.0	3.1
8/31	1.5	1.0	3.0
9/4	1.5	1.0	2.9
9/5	1.5	1.0	2.9
9/6	1.5	1.0	2.9
9/7	1.5	1.0	2.9
9/10	1.5	1.0	2.9
9/11	1.5	1.0	2.9
9/12	1.5	1.0	2.9
9/14	1.5	1.0	3.0
9/17	1.5	1.0	3.2
9/19	1.5	1.0	3.2
9/20	1.5	1.0	3.1
9/21	1.5	1.0	3.1
Min	1.0	0.5	2.9
Max	2.5	2.0	3.2

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
8/13	1.7	1.7	1.9	2.0	1.9	2.3	1.6
8/14	2.3	1.6	1.9	2.9	2.5	2.5	0.5
8/16	2.2	1.6	1.9	2.1	1.6	2.4	1.4
8/17	1.7	1.5	1.5	1.8	1.6	2.4	1.6
8/21	1.9	1.6	1.8	1.7	1.8	2.0	1.5
8/23	2.0	1.2	2.0	1.6	1.6	2.5	0.4
8/24	1.9	1.8	1.5	2.2	1.8	2.2	1.3
8/27	1.9	1.6	1.8	2.4	1.9	2.4	0.9
8/28	2.2	1.6	1.9	2.2	2.2	2.1	1.3
8/29	2.4	1.8	1.8	2.2	2.2	2.5	1.3
8/30	2.3	2.2	2.1	2.4	1.8	1.8	0.5
8/31	2.3	1.8	2.0	0.0	2.2	2.5	1.3
9/7	1.4	1.7	1.7	1.8	1.8	2.1	0.4
9/11	1.8	1.9	2.0	1.5	2.0	2.0	0.9
9/12	2.0	1.2	1.2	1.2	1.6	1.5	0.7
9/13	2.2	1.4	1.7	1.8	1.7	2.1	0.6
9/14	1.8	1.2	1.4	1.1	1.5	1.7	0.5
9/17	1.5	1.3	1.7	1.6	1.7	1.9	0.8
9/18	1.4	0.5	1.0	0.9	0.7	1.1	0.5
9/19	1.5	1.3	1.7	1.6	1.4	1.8	0.8
Min	1.4	0.5	1.0	0.0	0.7	1.1	0.4
Max	2.4	2.2	2.1	2.9	2.5	2.5	1.6

One hundred and seventeen dead fish were removed from the weir between August 12 and September 20 (Table 4). Carp were the most commonly encountered species (33%). There were no Steelhead mortalities removed from the weir in 2018. There were very few Chinook carcasses, only 7 (6%), collected throughout the season. There was no drastic increase in mortality after most Chinook were encountered in the trap (Figure 5). All mortalities were impinged on the upstream side of weir indicating that they had most likely died upstream and floated down onto the weir.

Table 4. Date and species of fish mortalities observed at the lower Okanogan fish weir in 2018. All fish mortalities were considered "wash downs" and collected on the upstream panels of the weir.

Date	Carp	Chinook	Mountain Whitefish	Northern Pike Minnow	Smallmouth Bass	Sockeye	Unknown Sucker
8/12	1			1	1	6	
8/14						1	
8/20		1				2	1
8/23				1		1	1
8/25		1					
8/27		1					1
8/28						4	
8/29				1		1	
8/30		1				2	
9/4	1					4	1
9/5		1				1	
9/7						3	
9/10						1	1
9/12		1					
9/14						2	
9/17						1	
9/18					1		
9/19					1	1	
9/20		1	1			1	1
Total	**2**	**7**	**1**	**3**	**3**	**31**	**6**

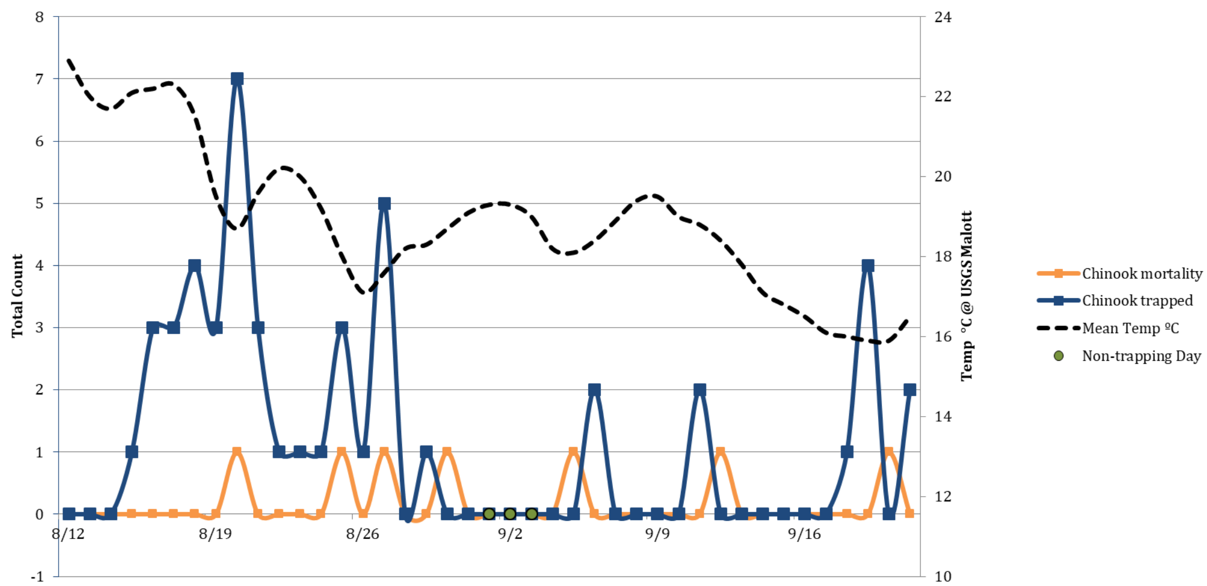

Figure 5. Total number of Chinook trapped and total number of Chinook carcasses collected off the weir panels.

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 first two weeks of trapping in 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 one week after the thermal barrier breakdown and then decreased until the first week in September. During the second week in September, the highest daily estimates of fish were observed throughout the week (Figure 6). Trapping operations were conducted on August 12th when river temperature was ≤ 22.5 °C. The total fish trapped at the weir in 2018 was 205 with 23% of them being Chinook Salmon (Figure 7). Fifty-six percent of the Chinook trapped were released back into the river (Figure 8). Six steelhead were trapped between 9/7-9/21 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.

Nineteen natural origin Chinook were transported to the hatchery and held in the brood stock ponds concurrently with the fish taken for brood stock from the purse seine and hatchery ladder. Adult Chinook were transported from the weir trap to the hatchery brood truck via a rubber boot. We were unable to assess the pre-spawn mortality of the weir brood because they were mixed with the rest of the integrated brood when they were transported to the hatchery. If we need to assess pre-spawn mortality in future years, we will need to mark these fish before they are transported to the hatchery.

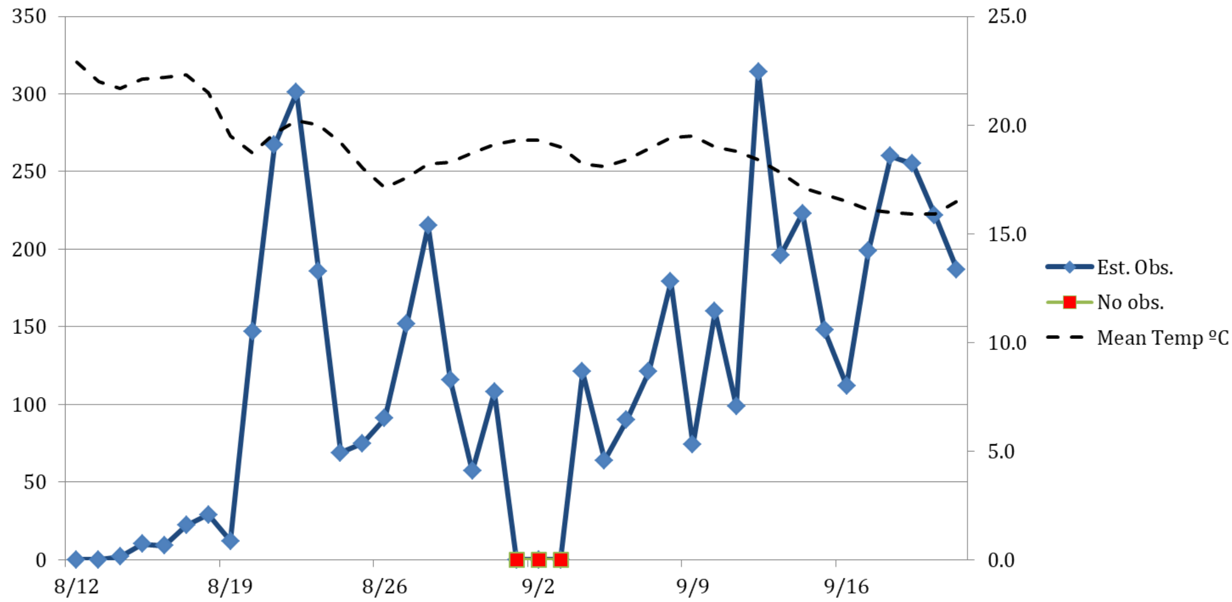

Figure 6. Estimate of Chinook observed from the bank at the lower pool, 0.8 km downstream of the weir.

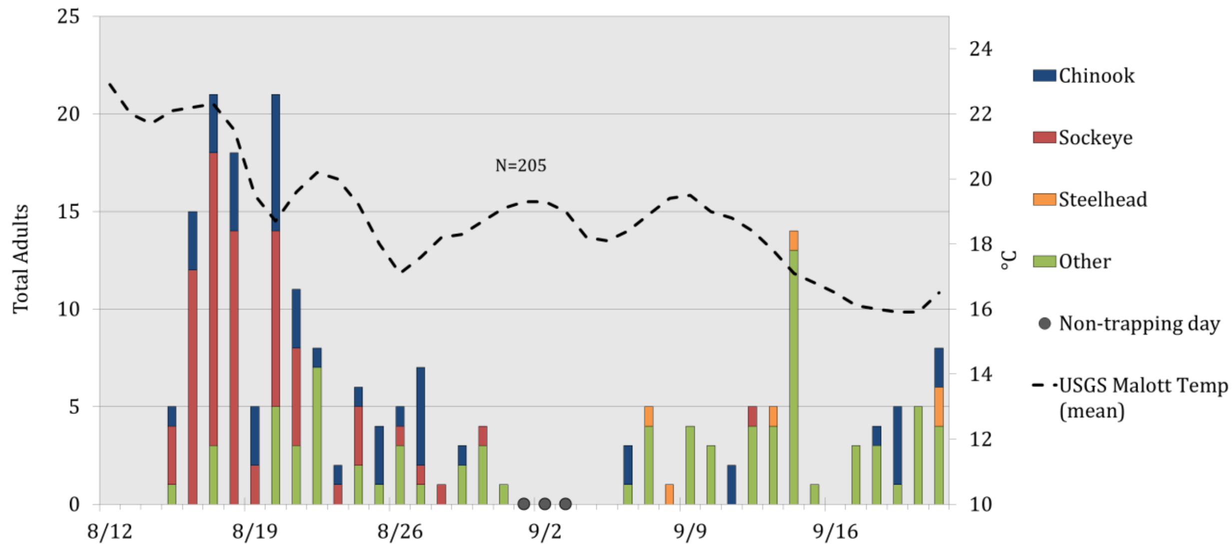

Figure 7. Total number of fish trapped at the Okanogan weir in 2018.

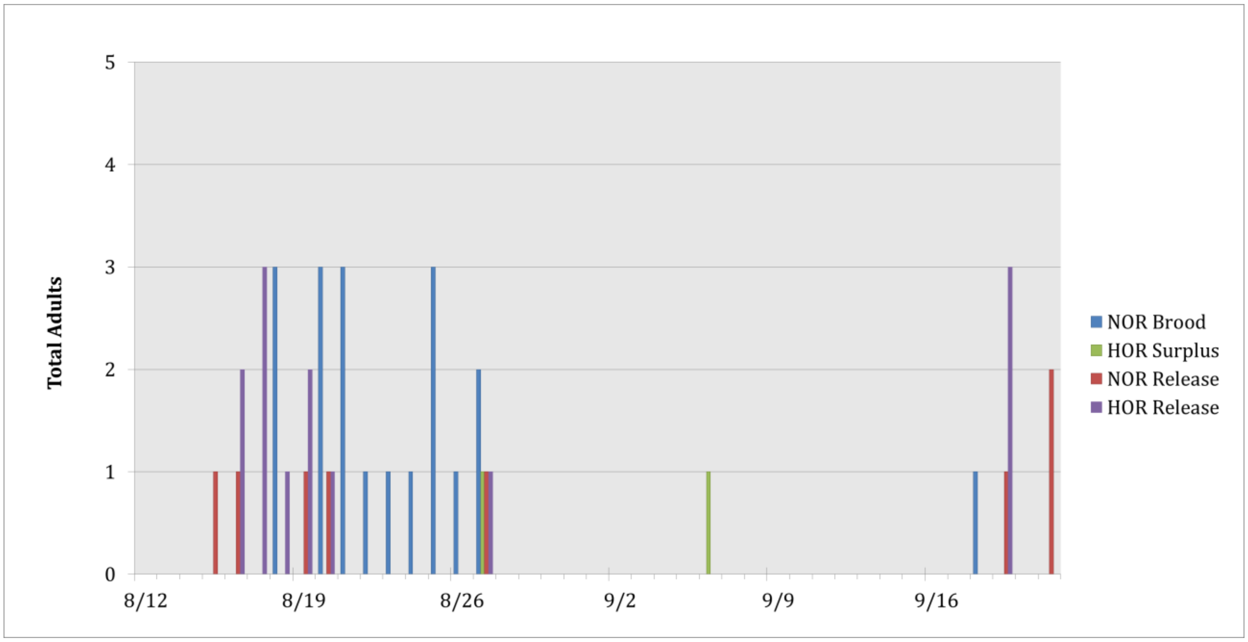

Figure 8. Final destination of Chinook adults captured in the weir trap during trapping operations in 2018.

In 2018, 0.009 (0.9%) 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 0.001 (0.1%).

Table 5. The number of hatchery and natural origin Chinook Salmon encountered at the lower Okanogan weir in 2018. 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[c,d]		Weir Metrics	
	Natural Origin (NOR)	Hatchery Origin (HOR)	Natural Origin (NOS)	Hatchery Origin (HOS)	Weir Efficiency[a]	Weir Effectiveness[b]
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
2018	32	16	3,322	1,538	0.009	0.001

[a] Estimates for weir efficiency are adjusted for prespawn mortality and include Chinook adults that are harvested, released, and collected for brood.

[b] Estimates for weir effectiveness are adjusted for prespawn mortality and include Chinook adults that are harvested or removed for pHOS management.

[c] Estimates do not include Chinook Zosel Dam counts through 2017, the last year of the project

[d] NOS and HOS estimates determined by 'reach-weighted' pHOS calculations

Discussion

Discharge conditions on the Okanogan River in 2018 were a little lower than those in 2017, allowing installation and operation of the weir in early August, which was a week earlier than 2017. Temperatures on the Okanogan River were fairly normal, compared to the 13 year median. Because temperatures stayed below 22.5 °C once trapping began on August 12th, trapping operations were not suspended because of this reason. Tower and bank fish observations were generally higher after the thermal barrier broke on August 12. In August, fish observations 0.8 km. below the weir, at the lower pool, were similar than observations at the weir. This was not the case for September, when bank observations were much higher than the tower observations below the weir. When river temperature was lower and gauge height was less than 4 feet, Chinook were more likely to mill in deeper pools, but in previous years tower observations were much higher in September. 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 = 48) was less than in 2017 (n= 447). Configuration of the weir was different in 2018 compared to 2017. The trap was installed further downstream, about 20 m, on the edge of the thalweg, and below the deep pool. Also a fish entrance chute was added to the trap gate to test whether it would increase entrainment to the trap box. We will evaluate the water conditions as it relates to discharge and stage height to decide if the trap should be moved to an alternate location for higher weir efficiency.

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 (53) of dead fish at the weir was lower in 2018 than 2017 and much lower than years prior (2014-2016). Chinook mortality was consistent throughout the season without a drastic increase after trapping began, 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 adult natural-origin Chinook at the weir trap in 2016 and 2017. Because of the concern for over handling fish in a year with fewer returns and a lack of carcass recoveries on the spawning grounds, we did not conduct a mark-recapture study in 2018. We do not anticipate additional studies in the near future.

There were more observations of Sockeye at the weir during daylight and nighttime hours in 2018 than there were in 2017. Sixty-nine were trapped in 2018. 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 2018, there were very few (<5) 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 sealing aprons after it was installed. The potential weir effectiveness measure of 0.1% was very low because, after reviewing PIT detection at the Okanogan Instream Lower array, we suspect that about 30-35% 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 2018 because pHOS was already low and only 33% 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 brood stock collection protocol at the weir was to get 15% (n = 84) of the integrated program). The weir did not meet its brood stock goal, collecting only 19 fish, 23% of the brood stock collection protocol, through the trap post thermal barrier breakdown period.

In 2018 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. Although the program experienced lower than expected adult summer Chinook returns, the weir was successful at collecting some brood stock for the hatchery's integrated program 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.