The Chief Joseph Hatchery Program

Okanogan River Adult Fish Pilot Weir

2019 Summary of Methods & Results

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BACKGROUND

The Okanogan adult fish pilot weir (herein referred to as the 'weir') was in its eighth year of design modifications and testing in 2019. 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 2019 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

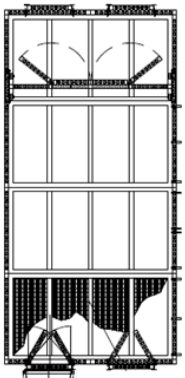
METHODS

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 July 15th at a river flow of 1,540 cfs. and was completed with the underwater video system on July 19th. 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. Gravel 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, 2019. Photo taken in late- August..



Panels 1-5	Panels 6-10	Panels 11-15	Panels 16-20	Panels 21-25	Panels 26-30	Panels 31-35	Panels 36-40	Panels 41-45
1"	1"	1"	1"	1"	1"	1"	1"	1"

Panels 48-53	Panels 54-58	Panels 59-63	Panels 64-69
1"	1" (2) 2" (3)	2" (2) 1" (3)	1"

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 2019.

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. In 2019 the program experienced a higher than normal density of algae in the Okanogan River during weir operations. If the density was too high and too difficult to clear in order to maintain the weir panels within the operating criteria for head differential (<10cm.), pickets within the panels were raised until the algal density decreased.

Five minute tower observations were conducted at least two times a day, in the morning (0600-0800) and early afternoon (1200-1400) 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 under allowable temperature (≤22.5° C) and head differential (<10 cm.) conditions for the season. Trapping operations were suspended for the majority of the season, from July 22-August 25 and August 28-September 8. The last day of trapping was on September 11th. 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.

Nine natural-origin and two hatchery-origin Chinook were collected from the weir trap from August 26-27 and September 9-11, 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 2019 because by the time we were able to trap and collect brood for the program, only 10 adults were needed, which did not justify the program's need to setup the system.

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 to suspend the study until a larger number of fish were captured in the trap (i.e. higher weir efficiency).

RESULTS

The Okanogan River (at Malott) discharge was below normal in 2019 and was below 1,000 cfs. for the majority of the trapping season. Staff were able to safely enter the river and begin installation on July 15th when discharge was 1,540 cfs. (Figure 3). Discharge continued to drop throughout the season and was at 1,000 cfs. by the time the weir was removed for the season.

Migration of sockeye and summer/fall 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 2019, 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 22. Daily mean temperature dropped below 22.5 °C on August 22nd and stayed below this mark until August 30th. Mean temperature dropped below the mark again on September 3rd and stayed below it for the rest of the season.

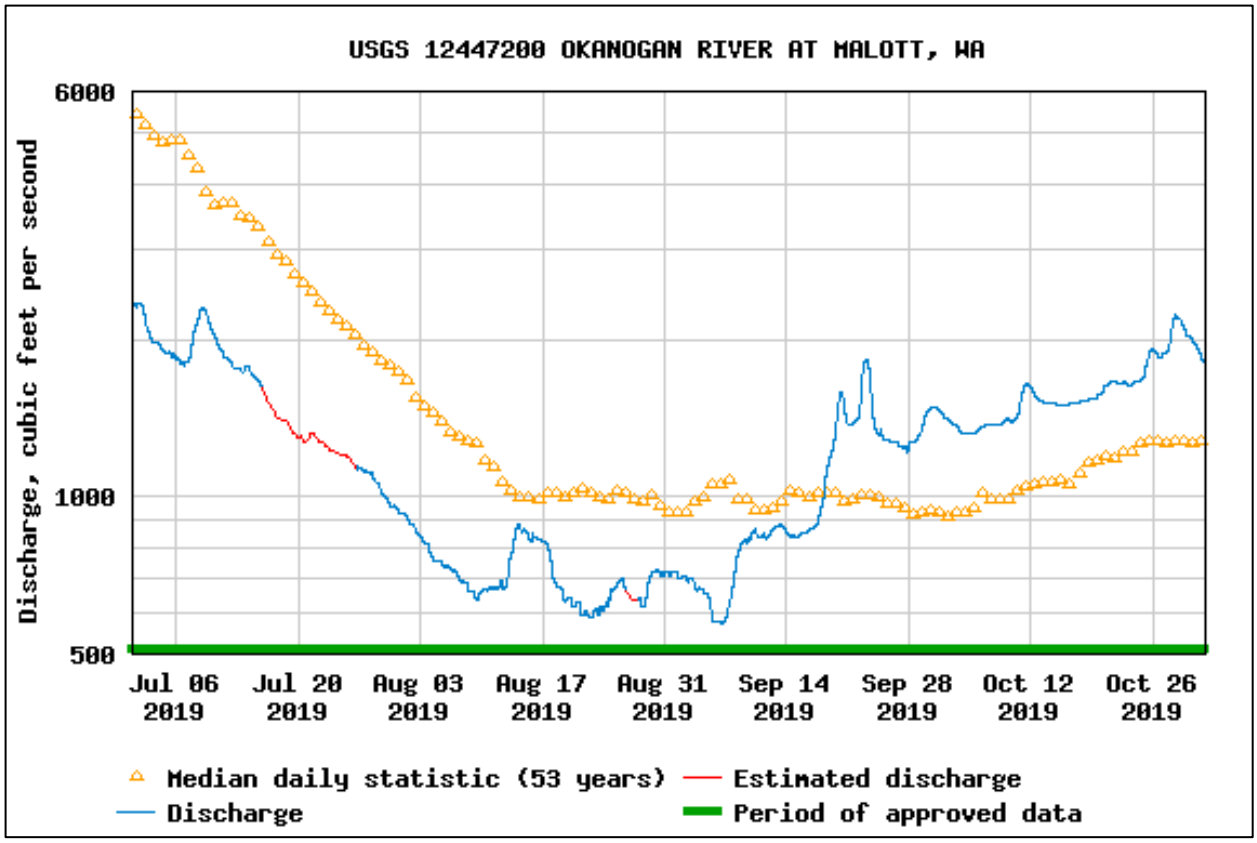


Figure 3. Discharge of the Okanogan River between July 1 and October 31, 2019. This figure was copied directly from the USGS website (http://nwis.waterdata.usgs.gov/wa).

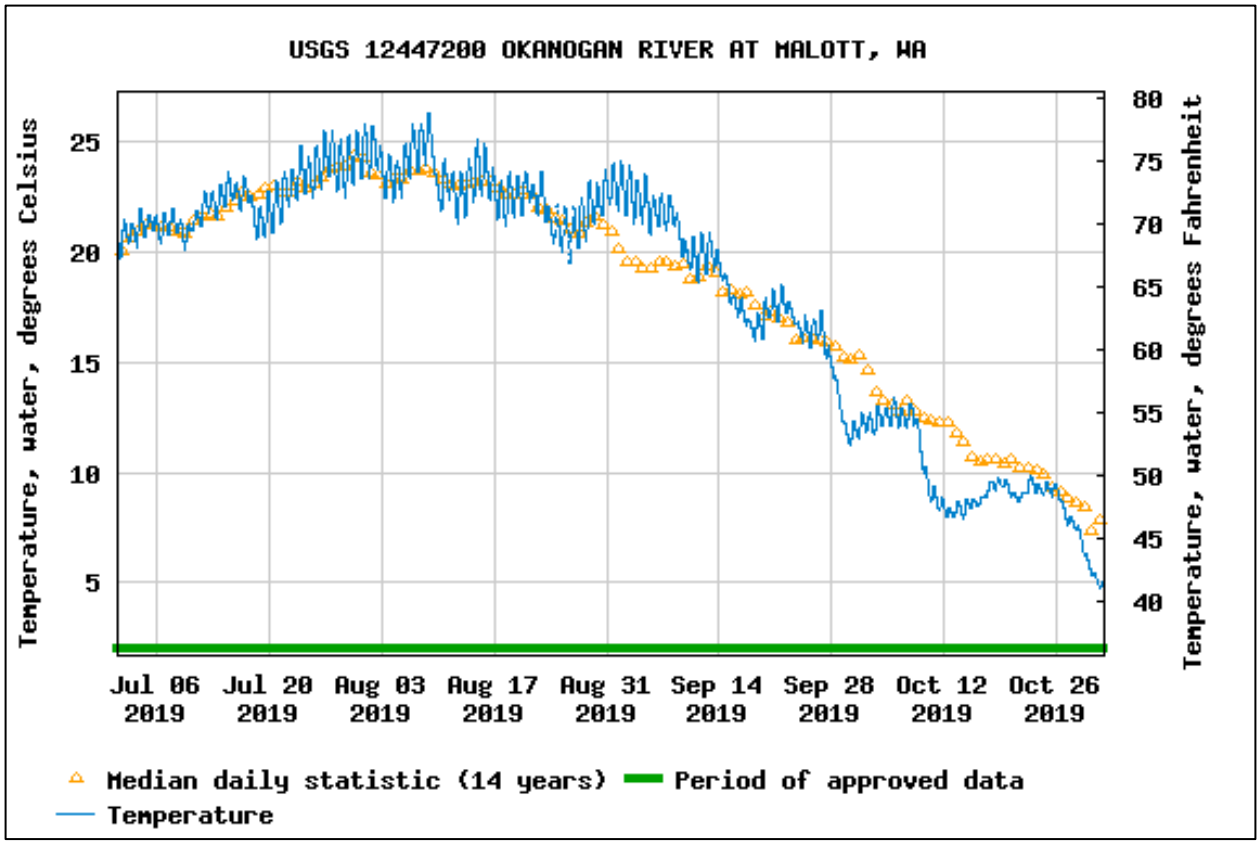


Figure 4. Temperature of the Okanogan River between July 1 and October 31, 2019. This figure was copied directly from the USGS website (http://nwis.waterdata.usgs.gov/wa).

Dissolved Oxygen varied from 6.0 to 9.6 mg. /L, total dissolved solids varied from 130-158 ppm. and turbidity varied from 1.0 and 4.5 NTUs (Table 1). The head differential was measured only when pickets were down and ranged from 2.0-3.0 cm. The maximum water velocity measured was 2.9 ft. /sec. (Table 2).

Table 1. Water quality data at or near the lower Okanogan weir in 2019. Temperature and discharge were taken from the USGS gage at Malott.

Date	Trap Depth (ft.)	Dissolved Oxygen (mg./L)	Total Dissolved Solids (ppm.)	Turbidity (NTU)
7/29	1.7	8.6	130	1.9
7/30	1.7	8.4	130	1.8
7/31	1.7	9.6	135	4.5
8/1	1.7	7.3	133	2.8
8/2	1.7	8.1	138	1.6
8/5	1.5	7.4	142	1.2
8/6	1.5	7.7	145	1.4
8/7	1.5	7.1	149	1.3
8/8	1.4	6.7	151	2.6
8/12	1.6	7.0	149	2.1
8/13	1.7	7.4	151	1.5
8/14	1.7	7.8	152	3.1
8/15	1.7	7.1	149	1.5
8/19	1.4	6.7	149	1.3
8/20	1.5	6.9	155	1.0
8/22	0.8	6.8	155	1.4
8/23	0.8	6.6	155	1.3
8/26	0.8	7.3	144	1.2
8/27	1.5	7.3	155	1.1
8/28	1.4	7.2	154	1.5
8/29	0.7	6.8	151	1.5
8/30	0.7	6.9	155	1.2
9/3	0.8	6.6	157	1.3
9/4	1.4	6.5	157	1.0
9/5	1.4	7.1	157	1.2
9/6	1.4	6.7	158	1.5
9/9	1.6	6.0	148	1.4
9/10	1.7	8.4	149	1.0
9/11	1.5	8.4	146	1.1
Min	0.7	6.0	130	1.0
Max	1.7	9.6	158	4.5

Table 2. 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
7/30	2.1	1.4	1.8	2.2	2.3	3.5	1.6
7/31	1.7	1.5	1.8	2.0	1.8	2.7	2.1
8/01	0.7	1.4	1.5	1.7	1.7	3.3	1.8
8/02	1.7	1.6	2.2	2.2	1.7	3.3	1.6
8/05	1.5	1.4	2.2	2.2	1.9	3.4	1.7
8/06	2.0	1.5	1.7	2.2	1.8	3.1	2.2
8/08	1.8	1.5	2.1	1.9	1.6	3.1	1.8
8/12	1.0	1.3	1.5	1.7	1.4	2.1	1.0
8/13	1.6	1.5	1.8	1.7	1.4	2.0	1.3
8/14	1.8	1.4	1.9	1.9	1.7	3.0	1.7
8/15	1.5	1.5	1.6	1.9	1.9	2.4	1.8
8/19	1.3	1.3	1.6	1.8	1.4	2.6	1.1
8/20	1.6	1.4	1.7	2.0	1.8	2.1	0.6
8/21	0.6	0.6	0.9	1.2	0.9	1.4	0.4
8/22	0.7	0.7	1.1	1.3	1.3	1.3	0.6
8/23	0.6	0.6	1.1	1.5	1.4	1.4	0.5
8/26	0.8	0.6	0.6	1.2	1.1	1.7	0.7
8/27	1.6	1.1	1.5	2.1	1.6	2.6	1.5
8/28	0.8	0.3	0.7	0.8	0.8	2.0	0.5
8/29	0.9	0.9	0.7	1.1	0.6	0.6	0.4
8/30	0.8	0.7	0.5	0.9	1.0	1.3	0.3
9/3	1.6	1.6	2.1	2.1	2.4	2.7	1.6
9/4	1.3	1.3	2.0	1.9	2.2	2.9	1.6
9/5	1.4	1.2	1.9	2.2	2.4	2.8	1.2
9/6	0.9	1.4	1.8	1.8	2.0	2.8	0.9
9/9	1.5	1.5	2.1	2.0	1.7	2.7	0.6
9/10	1.3	1.0	1.8	2.3	2.4	1.6	0.8
9/11	1.5	1.6	2.2	2.6	2.6	3.3	2.0
Min	0.6	0.3	0.5	0.8	0.6	0.6	0.3
Max	2.1	1.6	2.2	2.2	2.4	3.5	2.2

Eight dead fish were removed from the weir between August 1 and September 11. All of the mortalities were Chinook. All mortalities were impinged on the upstream side of weir indicating that they had most likely died upstream and floated down onto the weir.

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 quite a bit lower than previous season, especially during the month of August when the pickets were lifted. Estimates were highest during the last week of the weir season when mean daily river temperatures dropped below 22.5 °C and the majority of fish were trapped. 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 in September (Figure 5). Trapping operations were conducted on August 26-27 and September 9-11 when river temperature was ≤ 22.5 °C. The total fish trapped at the weir in 2019 was 159 with 90% of them being Chinook salmon (Figure 6). Ninety-three percent of the Chinook trapped were released back into the river (Figure 7). No steelhead were trapped in 2019..

Eight natural-origin and two hatchery-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. 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 or before they are mixed with the other brood at the hatchery..

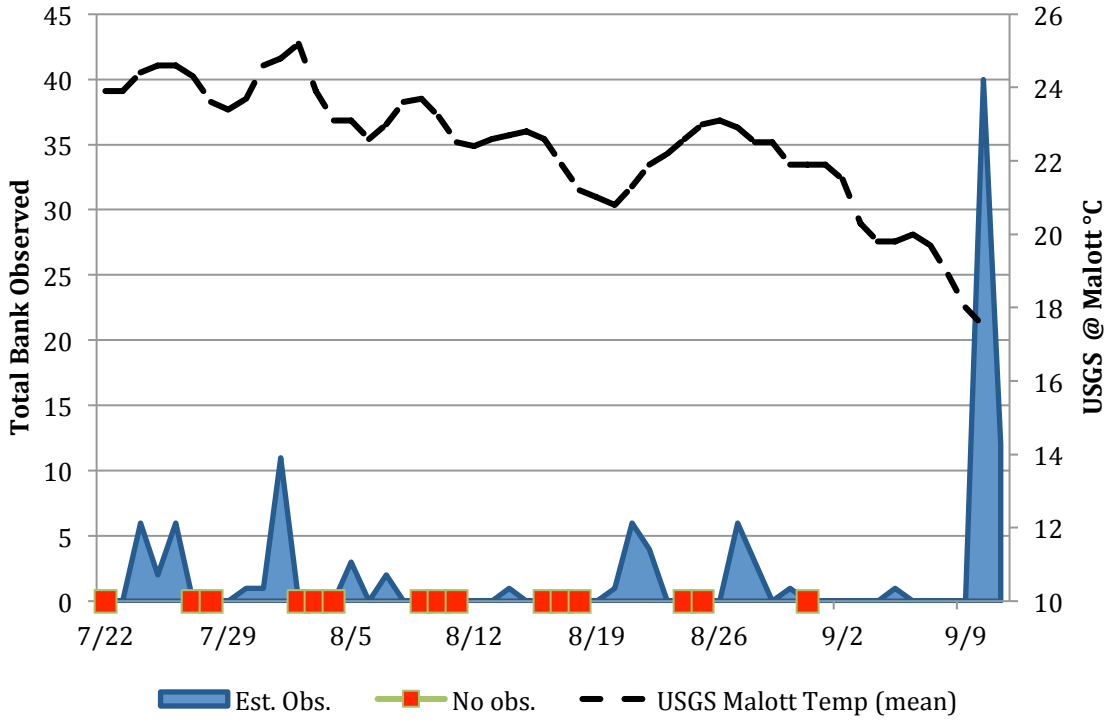


Figure 5. Estimate of Chinook observed from the bank at the lower pool, 0.8 km downstream of the weir.

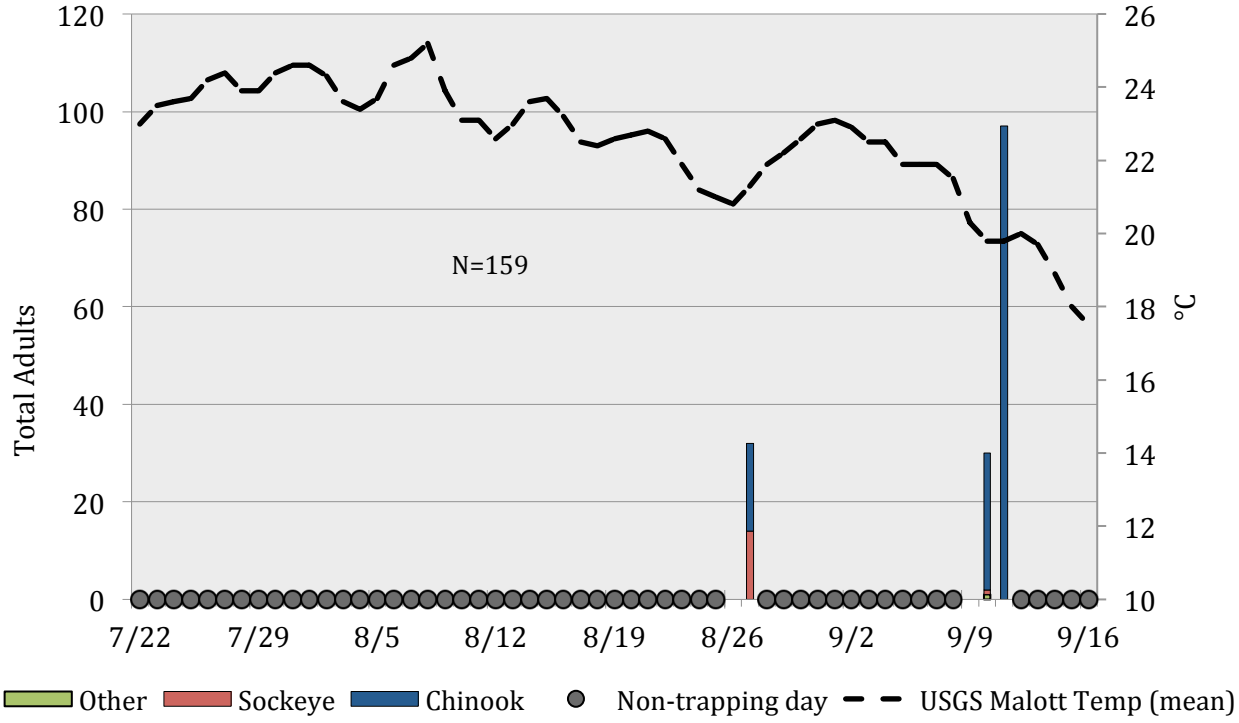


Figure 6. Total number of fish trapped at the Okanogan weir in 2019.

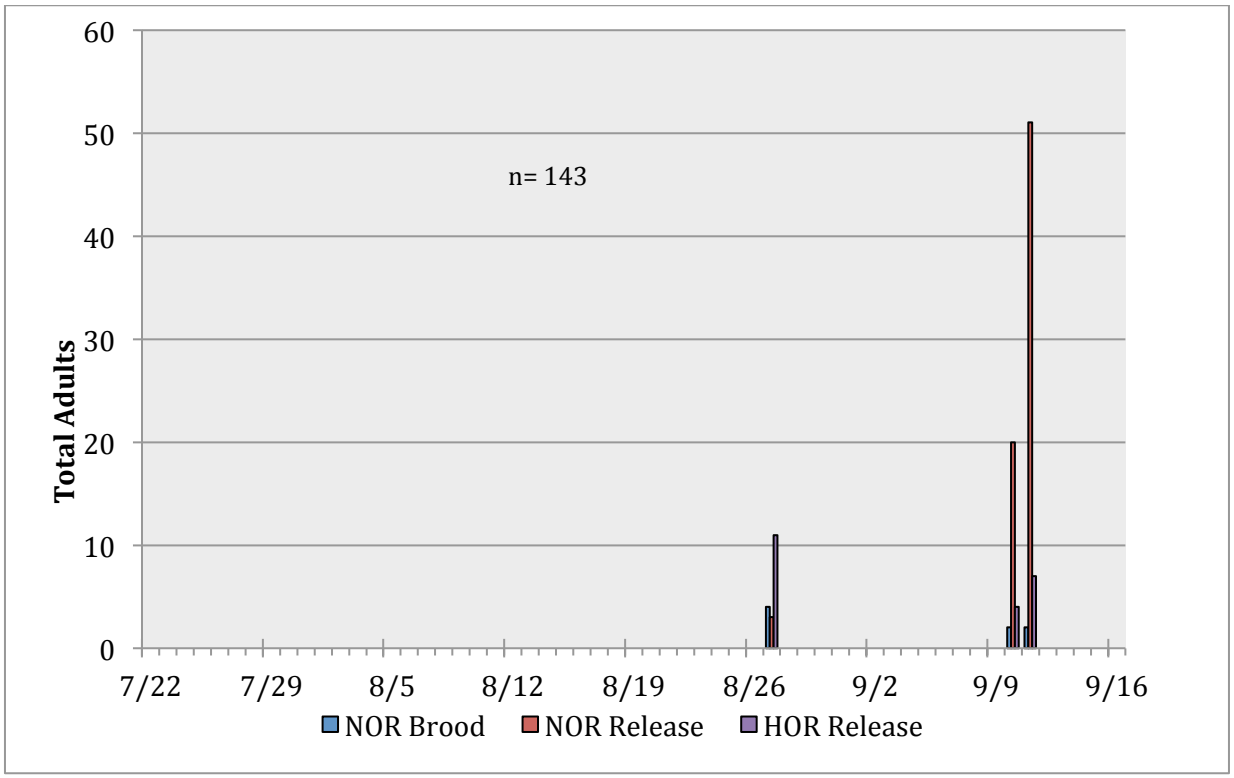


Figure 9. Final destination of Chinook adults captured in the weir trap during trapping operations in 2019.

In 2019, 0.017 (1.7%) of total spawning escapement was detected in the trap (i.e., weir efficiency) (Table 3). The potential weir effectiveness (if we had been removing all of the HOR encountered) was 0.001 (0.1%).

Table 3. The number of hatchery and natural origin Chinook Salmon encountered at the lower Okanogan weir in 2019. 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
2019	82	24	2,619	2.824	0.017	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 2019 were quite a bit lower than those in previous years, allowing installation and operation of the weir in mid- July, which was a month earlier than 2018. Temperatures on the Okanogan River were fairly normal, compared to the 13 year median. They were not a factor for trapping operations once they began on August 26th. Tower observations were relatively low for the majority of the season outside of the last week in July and second week of September, the final week of operation. Bank fish observations were pretty steady throughout July and August and increased after the water temperature stayed below 22.5 °C in early September. In September, fish observations 0.8 km. below the weir, at the lower pool, were similar than observations at the weir. However, this was not the case for August, when bank observations were much higher than the tower observations below the weir. When river

temperature was lower and gage 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. It's reasonable that there were more fish milling in the lower pool than there were milling around the weir in August. In August pickets were up on the weir panels due to a high density of algae in the river. The algae was creating a dense blanket across the weir panels and became too difficult for crew to maintain the weir without creating a head differential across the panels that was within the project's operating criteria. 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 = 143) was more than in 2018 (n= 48). Configuration of the weir was similar to that in 2018 with the trap installed downstream, on the edge of the thalweg, and below the deep pool. The fish entrance chute was added to the trap gate again to test whether it would increase entrainment to the trap box. We evaluated the water conditions as it relates to discharge and stage height and think that we should continue to install the trap at the same location as 2019 to continue testing it with the chute.

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. However, there are other water quality parameters that were not measured (i.e. pH, phosphorous, or nitrogen) that may have provided some insight to the algae issue. The number (8) of dead fish at the weir was the lowest it has ever been , and that can be a result from a lower potential to collect carcass washdowns in 2019. If the weir pickets were down more there likely would have been more prespawn mortalities collected. There were no fish impinged between pickets (head upstream) in 2019. 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 2019. We do not anticipate additional studies in the near future.

There were fifteen sockeye trapped in 2019. It is likely that more sockeye moved through the weir panels when pickets were up. When pickets were down and the trap was operating, there were no observations of jack or small adult Chinook escaping through the 2" weir panels that were intended to allow sockeye passage. We will continue to use 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.

There was no way to know exactly how many fish escaped past the weir before it was installed or how many fish swam through while the pickets were up 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 15% of the fish had migrated past the weir before deployment in July. The thermal barrier did not set up until late July, which was shortly after the weir was fully functional so it's likely that more than 15% of the fish passed the weir before it was installed. The barrier broke down in late –August. Fortunately, this did not affect fish management objectives in 2019 because with a lower adult return, CCT decided to only collect broodstock at the weir and release all others, regardless of origin, back to the river to escape to the spawning grounds. 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/fall Chinook.

The brood stock collection protocol at the weir was to get 15% (n = 84) of the integrated program). By the time the weir trap was operational the protocol changed to collect up to 10 natural-origin and/or hatchery-origin adults. The weir met its brood stock goal, collecting 8 natural-origin and 2 hatchery-origin fish in late August and mid-September, after the post thermal barrier breakdown period.

In 2019 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 a limited trapping season and lower than expected adult summer/fall 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 should 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 or high algal densities in 2019 is important for understanding the range of challenges and resulting weir effectiveness that can be expected through time.