The Chief Joseph Hatchery Program

Okanogan River Adult Fish Pilot Weir

2021 Summary of Methods & Results

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BACKGROUND

The Okanogan adult fish pilot weir (herein referred to as the 'weir') was in its tenth year of design modifications and testing in 2021. 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 2021 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 2nd at a river flow of 927 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 riverbanks, 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 spacings included 2.5 cm (1 inch) and 5.1 cm (2 inch) sizes (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.

Figure 1. Lower Okanogan adult fish pilot weir, 2021. Photo taken in early August during deployment.

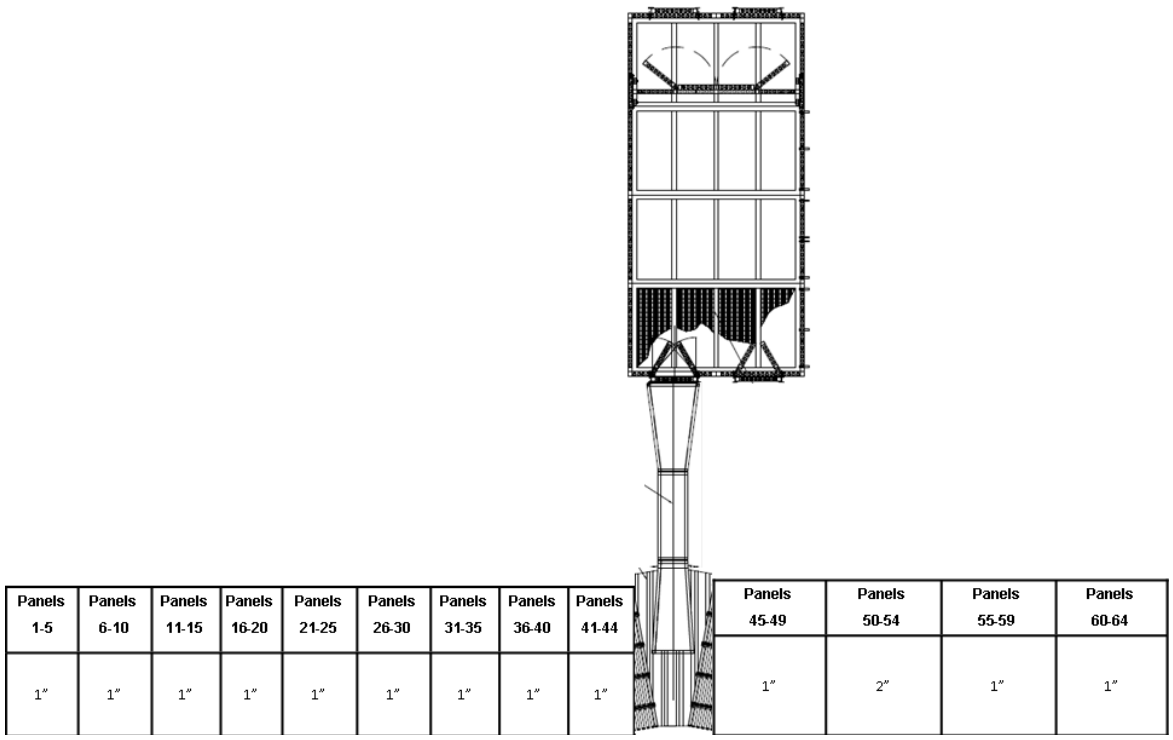

Figure 2. Conceptual diagram of picket (ABS pipe) spacing within each panel (or set of 5 panels) at the Lower Okanogan. A 15 ft. entrance chute was installed at the lower trap gate in 2021.

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 2021 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, and trapping was ceased.

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 during mid-day

(1100-1300) and early evening (1600-1800). 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 adipose-fin present 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 began on August 11 and continued until September 23. When fish entered the trap during an active trapping session, fish were identified and either released or collected for brood.

Ten natural-origin Chinook were collected from the weir trap from September 7 – September 22 and transported to a 600-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 2021 staffing was limited to effectively operate the system during the season.

RESULTS

The Okanogan River (at Malott) discharge was below normal in 2021 which allowed for deployment of the weir to start on August 2nd with the river flow at 927 cfs (Figure 3). Discharge continued to drop throughout the season and was approximately 828 cfs by the time the weir was removed for the season on September 29.

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 it generally 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 and/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 2021, temperatures were similar to the median daily temperatures from the last 15 years (Figure 4). Daily mean temperature was above 22.5 °C from July 1-July 22 and then dropped below it for a couple days before it went back above it from July 25- August 7. The temperature went back below for a couple more days then went back above the threshold for 6 more days from August 11-16. On August 17 the thermal barrier broke down and stayed below the 22.5 °C for the rest of the season.

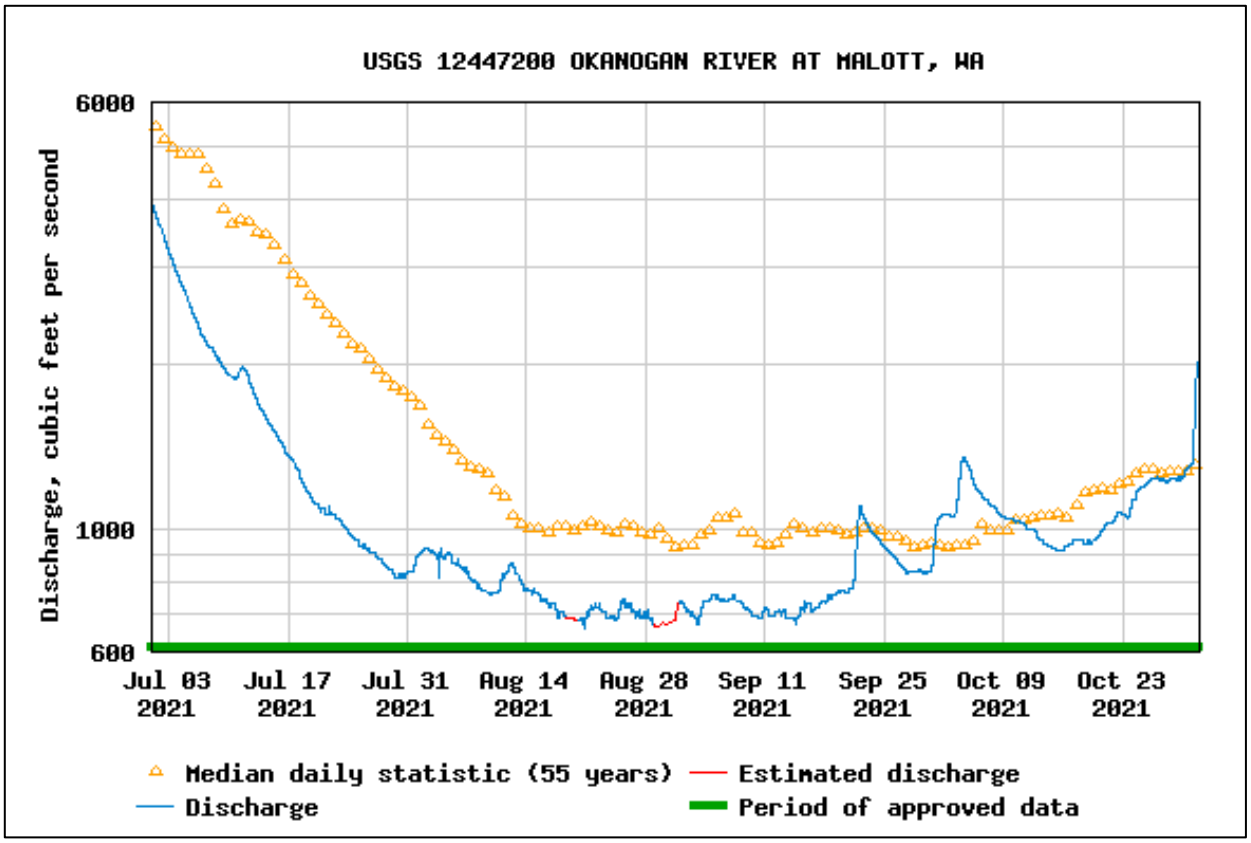

Figure 3. Discharge of the Okanogan River between July 1 and October 31, 2021. This figure was copied directly from the USGS website (http://nwis.waterdata.usgs.gov/wa).

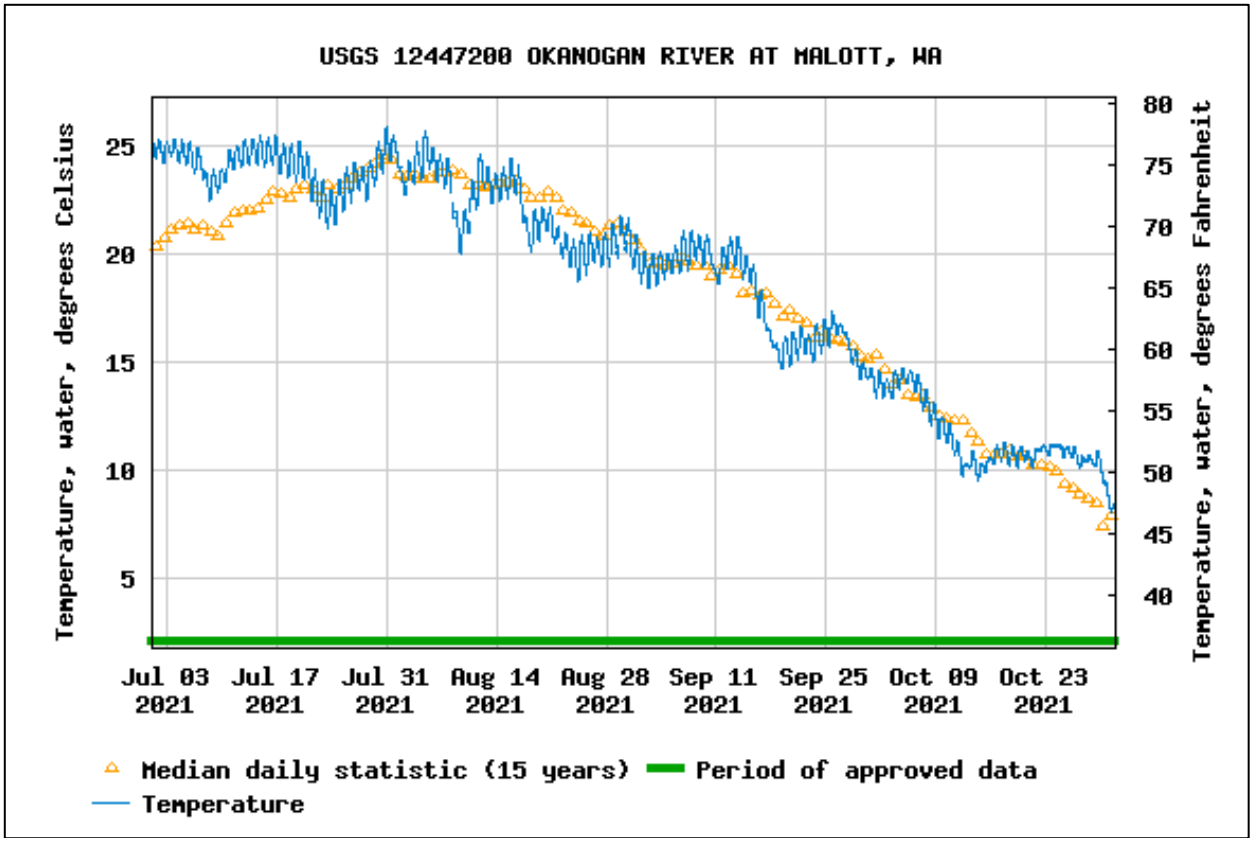

Figure 4. Temperature of the Okanogan River between July 1 and October 31, 2021. This figure was copied directly from the USGS website (http://nwis.waterdata.usgs.gov/wa).

Dissolved Oxygen varied from 6.5 to 9.5 mg. /L, total dissolved solids varied from 122-184 ppm and turbidity varied from 0.6 and 1.6 NTUs (Table 1). The head differential was measured only when pickets were down and ranged from 1.0-21.0 cm. The maximum water velocity measured was 4.4 ft. /sec. (Table 2).

Table 1. Water quality data at or near the lower Okanogan weir in 2021. Temperature and discharge were taken from the USGS gage at Malott. Minimum depth allowed for trap depth is 6 inches and optimal dissolved oxygen levels for adult Chinook should not drop below 6 mg/L.

Date	Trap Depth (ft)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (ppm)	Turbidity (NTU)	Mean Temperature (◦C)	Mean Discharge (cfs)
8/12	1.9	9.10	149	1.2	23.6	850
8/13	2.0	8.10	133	1.0	23.1	795
8/16	1.7	9.29	135	1.3	23.3	735
8/17	1.7	9.50	139	1.2	21.7	714
8/18	1.6	9.14	136	1.2	21.0	698
8/19	1.8	8.95	138	1.6	21.4	686
8/20	2.4	9.00	184	1.6	21.6	681
8/23	2.0	9.10	136	0.9	20.1	688
8/24	1.7	7.53	134	1.0	19.8	688
8/25	1.8	N/A	133	1.0	20.0	725
8/26	1.8	6.45	136	1.6	20.2	704
8/27	1.8	7.90	136	1.2	20.2	690
8/28	1.8	7.60	137	1.0	20.4	683
8/30	1.9	9.00	139	0.6	20.9	673
8/31	1.9	8.60	134	0.7	20.1	702
9/1	1.7	8.50	137	0.8	19.5	726
9/2	1.6	7.80	136	0.7	19.3	698
9/3	2.6	7.34	137	0.9	19.4	716
9/7	1.7	9.30	143	0.7	20.2	747
9/8	1.7	8.72	142	0.7	20.4	725
9/9	1.6	8.90	142	0.8	20.2	702
9/10	1.6	7.30	144	0.9	19.6	701
9/13	1.6	7.42	146	0.7	20.2	699
9/14	1.6	8.99	144	1.2	19.5	689
9/15	1.6	6.75	143	1.1	19.1	722
9/16	1.6	6.95	135	0.7	17.8	722
9/17	1.6	7.24	133	0.8	16.6	734
9/20	1.7	8.00	122	0.6	15.7	775
9/21	1.7	7.54	128	0.7	15.9	881
9/22	2.0	7.50	127	0.9	15.9	1060
9/23	1.9	7.87	122	1.2	15.9	992
Min	1.6	6.5	122.0	0.6	15.7	673
Max	2.6	9.5	184.0	1.6	23.6	1060

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	US Center	River Right US	River Left DS	DS Center	River Right DS	Trap Velocity
8/12	1.9	1.4	2.6	3.1	3.4	2.7	0.2
8/13	0.2	1.5	2.5	2.6	2.9	3.0	0.2
8/16	1.8	1.5	2.1	2.6	3.4	2.3	1.1
8/17	1.9	1.4	1.9	2.5	2.7	2.6	0.1
8/18	1.6	1.5	2.3	2.8	3.2	2.6	0.0
8/19	1.2	1.2	1.9	2.2	2.5	2.2	0.5
8/20	1.2	1.5	1.9	2.2	2.8	2.3	0.5
8/23	1.5	1.4	2.0	2.3	3.5	2.8	1.0
8/24	1.6	1.3	2.1	2.4	2.5	2.5	0.7
8/25	1.6	1.1	2.0	2.4	2.5	2.3	0.4
8/26	1.6	1.1	2.0	2.4	2.6	2.3	0.4
8/27	1.5	0.8	2.3	1.6	2.0	1.3	0.7
8/28	1.5	1.0	1.3	1.2	2.2	1.7	0.7
8/30	1.4	0.9	1.7	1.7	2.0	2.1	0.8
8/31	1.9	0.9	1.7	2.7	2.5	2.2	0.7
9/1	1.6	1.5	2.2	2.7	2.9	2.6	0.7
9/2	1.6	1.3	1.9	2.4	2.8	2.2	1.4
9/3	1.7	1.6	2.1	2.6	2.9	2.5	2.0
9/7	1.6	1.9	2.1	2.7	2.8	2.3	0.1
9/8	1.5	1.3	2.5	3.1	2.8	2.6	1.0
9/9	1.6	1.5	2.3	2.8	2.8	2.9	0.6
9/10	1.8	1.6	2.5	2.8	3.4	2.9	0.9
9/13	1.6	1.7	2.3	2.6	3.0	2.6	0.9
9/14	1.7	1.5	2.3	2.5	2.8	2.7	0.8
9/15	1.9	1.5	2.4	2.8	3.0	2.7	0.6
9/16	1.7	1.6	2.4	2.9	2.8	2.6	0.6
9/17	1.7	1.5	2.4	2.8	2.7	3.0	1.0
9/20	1.8	1.6	2.4	2.6	3.0	3.0	0.6
9/21	1.9	1.6	2.4	2.9	3.1	2.7	0.8
9/22	2.2	1.6	2.5	3.1	4.4	3.1	0.7
9/23	2.2	1.7	2.6	3.0	3.5	3.1	0.7
Min	0.2	0.8	1.3	1.2	2.0	1.3	0.0
Max	2.2	1.9	2.6	3.1	4.4	3.1	2.0

Thirty-two dead fish were removed from the weir between August 13 and September 11. The majority of the mortalities (22) were sockeye and 7 of the mortalities were mountain whitefish. There were no Chinook mortalities removed from the weir in 2021. 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 the fish that were milling below the weir were equally distributed in the left, center, and right (looking downstream) sections of the river Estimates were highest for a couple days in mid-August, about a week after trapping began, 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 after temperatures decreased below 18 °C in mid-September (Figure 5). Trapping was suspended for the first week of the season because of high temperatures but operations began on August 18 and continued till September 23 after river temperatures dropped below 22.5 °C. Similar to 2019, the program experienced a higher-than-normal density of algae in the Okanogan River during weir operations. From August 18-22, trapping only occurred during morning hours so that available staff could keep panels clear of algae. Pickets were pulled up during non-trapping, afternoon, and night-time hours during this five-day period. After August 23rd, the program was able to maintain cleanings on the weir panels through the rest of the season. The total fish trapped at the weir in 2021 was 99 with 57% of them being Chinook salmon (Figure 6). Fifty-seven percent of the Chinook trapped were released back into the river (Figure 7). Ten steelhead were trapped in 2021.

Ten 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. 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. Past efforts have not indicated a problem with survival of brood fish collected at the weir. 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.

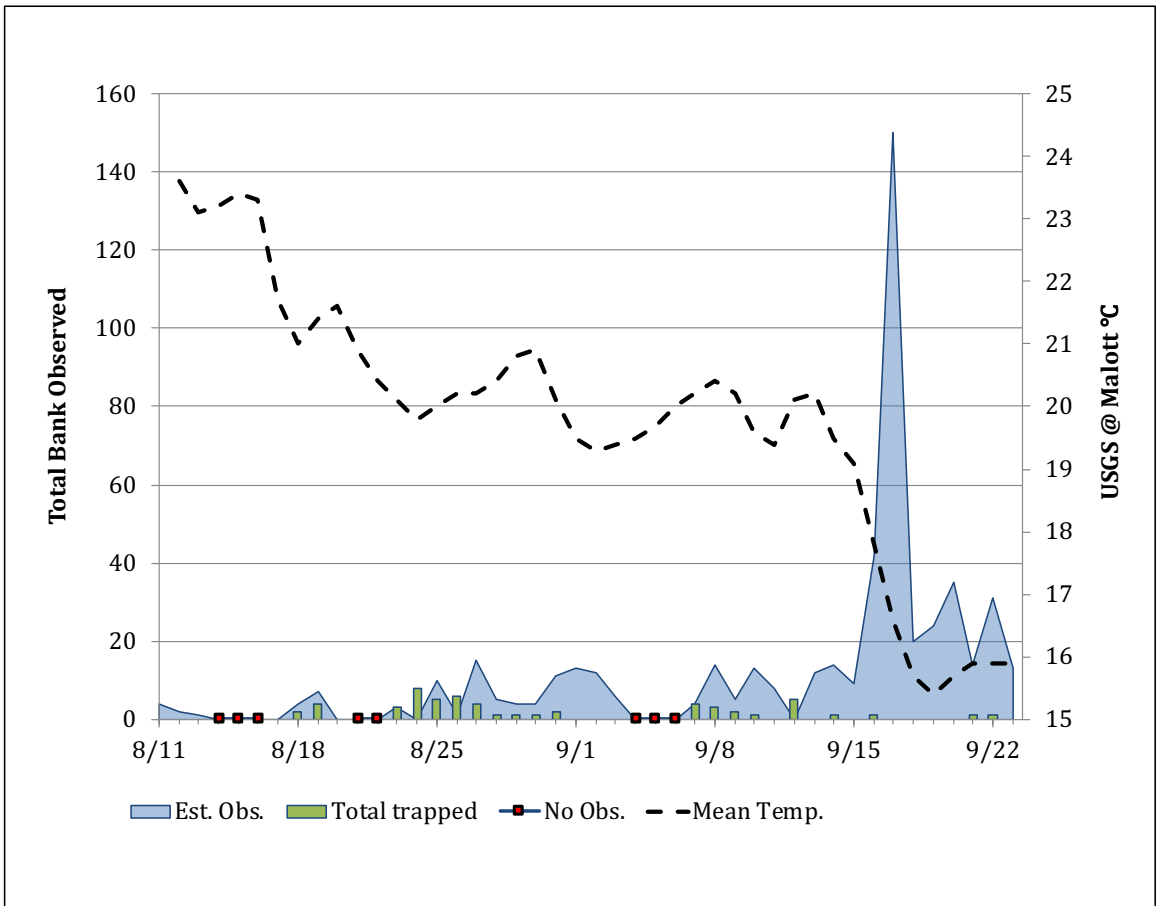

Figure 5. Estimate of Chinook observed from the bank at the lower pool, 0.8 km downstream of the weir.

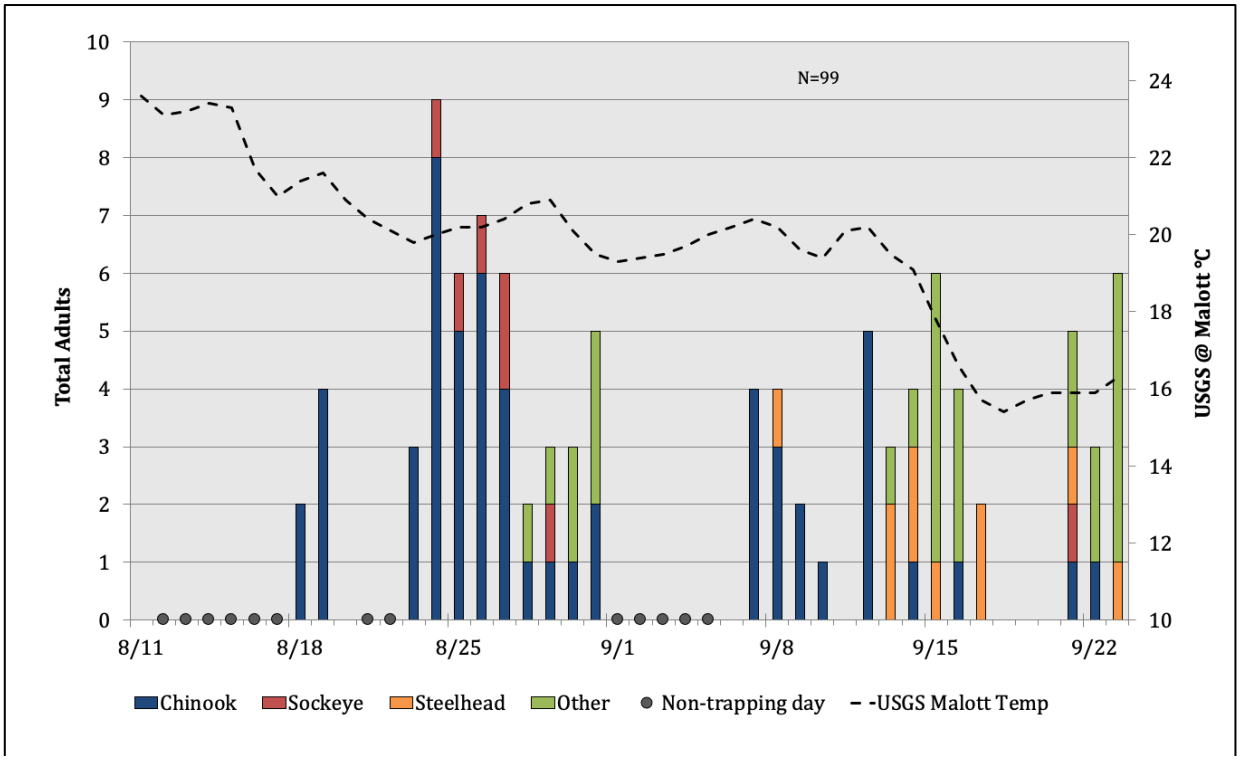

Figure 6. Total number of fish trapped at the Okanogan weir in 2021.

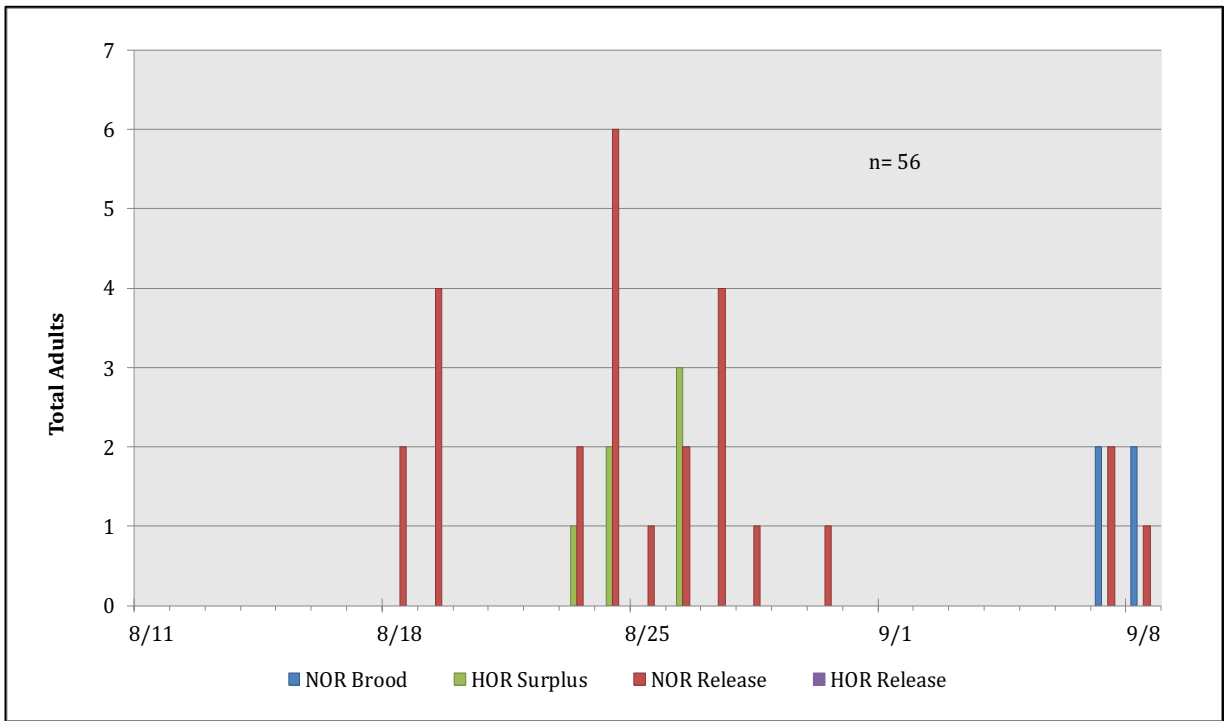

Figure 9. Final destination of Chinook adults captured in the weir trap during trapping operations in 2021.

In 2021, 0.006 (0.6%) of total spawning escapement was detected in the trap (i.e., weir efficiency) (Table 3). The potential weir effectiveness (after removing all of the HOR encountered) was 0.003 (0.3%).

Table 3. The number of hatchery and natural origin Chinook Salmon encountered at the lower Okanogan weir in 2021. 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	Number of Days Trapped	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	23	73	18	5,627	2,567	0.010	0.007
2014	34	2,006	318	10,407	1,756	0.147	0.140
2015	34	36	19	10,439	3,297	0.004	0.005
2016	30	135	34	8,700	1,905	0.014	0.016
2017	24	344	103	5,429	1,139	0.058	0.075
2018	38	32	16	3,266	1,594	0.009	0.009
2019	5	119	24	2,604	2,849	0.023	0.008
2020	27	709	161	7,957	3,062	0.066	0.045
2021	30	37	9	4,525	2,521	0.006	0.003

[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 2021 were quite a bit lower than those in previous years, allowing for the installation of the weir until mid- August, which is similar to 2020. Temperatures on the Okanogan River were fairly normal, compared to the 15-year median. Temperature was not a factor for trapping operations once it began on August 18th. Tower observations were relatively low for the majority of the season outside of a couple days in mid-August. Observations of fish from the bank of the downstream

pool increased after the water temperature stayed below 18 °C in mid-September. For the majority of the season fish observations 0.8 km. below the weir, at the lower pool, were higher than observations at the weir. When river temperature was lower and gage height was less than 4 feet, Chinook were more likely to mill in deeper pools. In previous years tower observations were much higher in September, so it's reasonable that there were more fish milling in the lower pool than there were milling around the weir in September. Over a 5-day period in mid-August, pickets were up on about half of 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. There were a few hours per day when we were able to push pickets down and maintain clean panels with staff, but the majority of time we had to suspend trapping. Continued monitoring of Chinook passage through the weir with respect to temperatures will continue in order to better refine weir operations and future expectations for weir effectiveness.

The number of Chinook handled at the weir (n = 46) was much less than the average (n=466). Configuration of the weir was similar to that in 2020 with the trap installed downstream, on the edge of the thalweg, and below the deep pool. The fish entrance chute was included with 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 2021 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. There were no dead fish and no fish impinged between pickets (head upstream) at the weir in 2021.

There were seven sockeye trapped in 2021. 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, but we did observe some sockeye pass through the panels during the day. 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 0.3% was the lowest to date. Although the barrier broke down in mid-August, this did not affect fish management objectives in 2021. With a lower adult return, CCT was able to collect only a small portion of their full brood stock quota (84) at the weir and remove less than 1% of the hatchery-origin returns. 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.

In 2021 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 program experienced a smaller run than the previous year which limited the program's ability to successfully collect brood stock for the hatchery's integrated program and remove hatchery-origin returns to manage pHOS. The weir's importance to successful management of the Okanogan summer/fall Chinook population should continue 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 and 2021, is important for understanding the range of challenges and resulting weir effectiveness that can be expected through time.