



Connecting
Generations
1938-2013



The Chief Joseph Hatchery Program

Okanogan River Adult Fish Pilot Weir

2014 Summary of Results & Methods



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BACKGROUND

The Okanogan adult fish pilot weir (herein referred to as the 'weir') was in its third year of design modifications and testing in 2014. 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 2014 included:

1. Install the weir in early August and operate until late September under allowable flow conditions (<3,000 cfs);
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 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

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). Weir installation began on August 4th at a river flow of 1,360 cfs and was complete on August 11th. An aluminum trap was installed near the center of the channel at the upstream 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. 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 at the base to support the tripod legs and between panels when needed to fill gaps that exceeded the target picket spacing. Picket spacing ranged from 2.5 to 7.6 cm (1 to 3 inch) in 1.2 cm (half-inch) increments (Figure 2). Pickets were manually forced into the river substrate daily to prevent fish passage under the weir.



Figure 1. Lower Okanogan adult fish pilot weir, 2014.

The river-right wing consisted entirely of 2.5 cm picket spacing. 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 block net was set up 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.

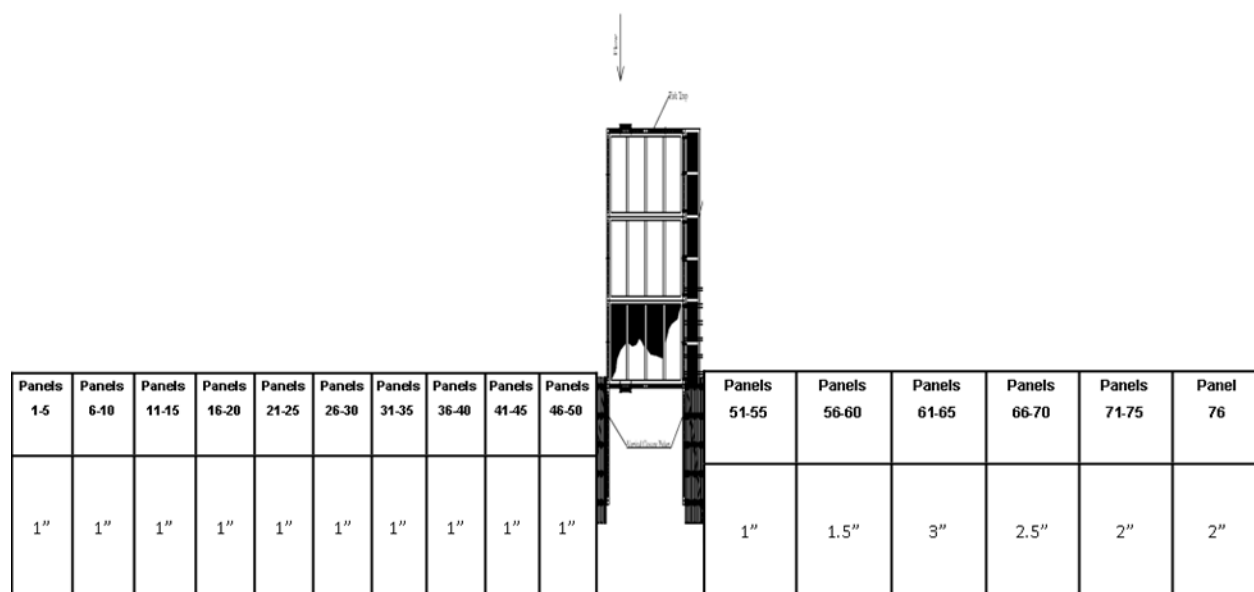


Figure 2. Picket (ABS pipe) spacing within each panel (or set of 5 panels) at the Lower Okanogan adult fish pilot weir in 2014.

Physical and chemical data were collected in the vicinity of the weir including the water depth (ft) inside the trap, water velocity (ft./sec) above and below the weir, 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 passage by Chinook.

Algae and debris were cleared off of the weir at least once per day, generally in the morning. 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 snorkel 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 summer/fall Chinook encountered in the weir trap, 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 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 hatchery origin fish encountered in the weir trap, and HOS is the total number of hatchery origin spawners.

Trapping operations were conducted 24 hours under allowable temperature conditions ($\leq 22.5^\circ \text{C}$). From August 15 to September 25 when fish entered the trap during an active trapping session, the downstream gate was closed and fish were identified and either released, surplussed or collected for brood. Seventy six natural origin Chinook were collected from the weir trap from September 2 to September 25, transported to shore via a fish boot (rubber tire inner tube) and immediately taken to a 2500 gallon hatchery truck. The fish were then transported approximately 32 km to Chief Joseph Hatchery where they were held in the broodstock raceways until the first week of spawning in the first week of October.

RESULTS

The Okanogan River (at Malott) discharge was around the norm in 2014 and dropped to 2,000 cfs on July 28, 2014. Staff were able to safely enter the river and begin installation on August 4 when discharge was 1,350 cfs (Figure 3). Discharge continued to drop rapidly throughout the installation period until August 9 when it increased approximately 700 cfs over a two week period, presumably due to water management releases from Lake Okanogan designed to improve pre-spawn holding conditions for Sockeye in Lake Osoyoos. Discharge levels stayed below 1,200 cfs for the rest of the season.

Migration of Sockeye and summer Chinook is generally affected by a thermal barrier that is caused by warm water temperatures ($\geq 22^\circ \text{C}$) 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 2014, temperatures were similar to, though often slightly higher than the median daily temperatures from the last 9 years (Figure 4). Temperature surpassed 22.5°C on July 15 when flow was 3,260 cfs. Temperatures stayed above 22.5°C until July 19 but then increased above 22.5°C again on July 30. Temperatures stayed above 22.5°C for a three week period. A steady decrease in

temperatures from a high of 24.0°C to a low 21.3 °C occurred from August 20 to 25. On August 29 temperatures stayed below 22.5 °C for the rest of the season.

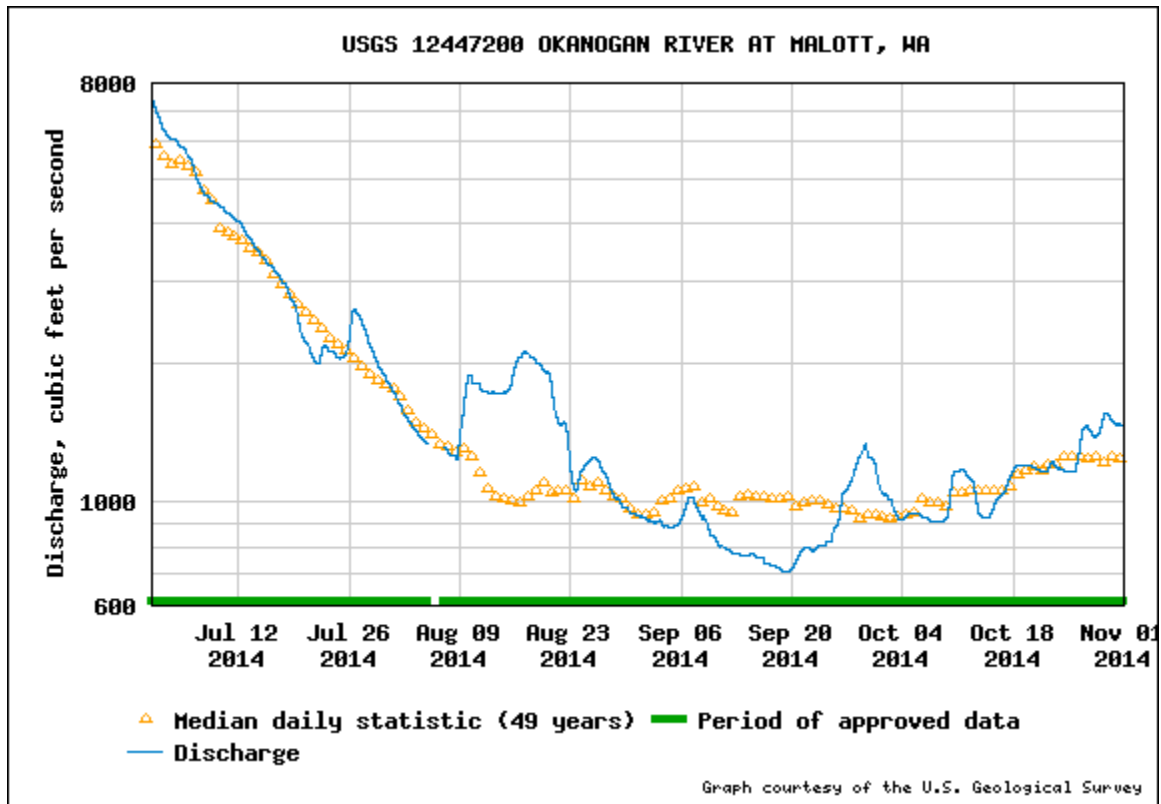


Figure 3. Discharge of the Okanogan River between July 1 and October 31, 2014. This figure was copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

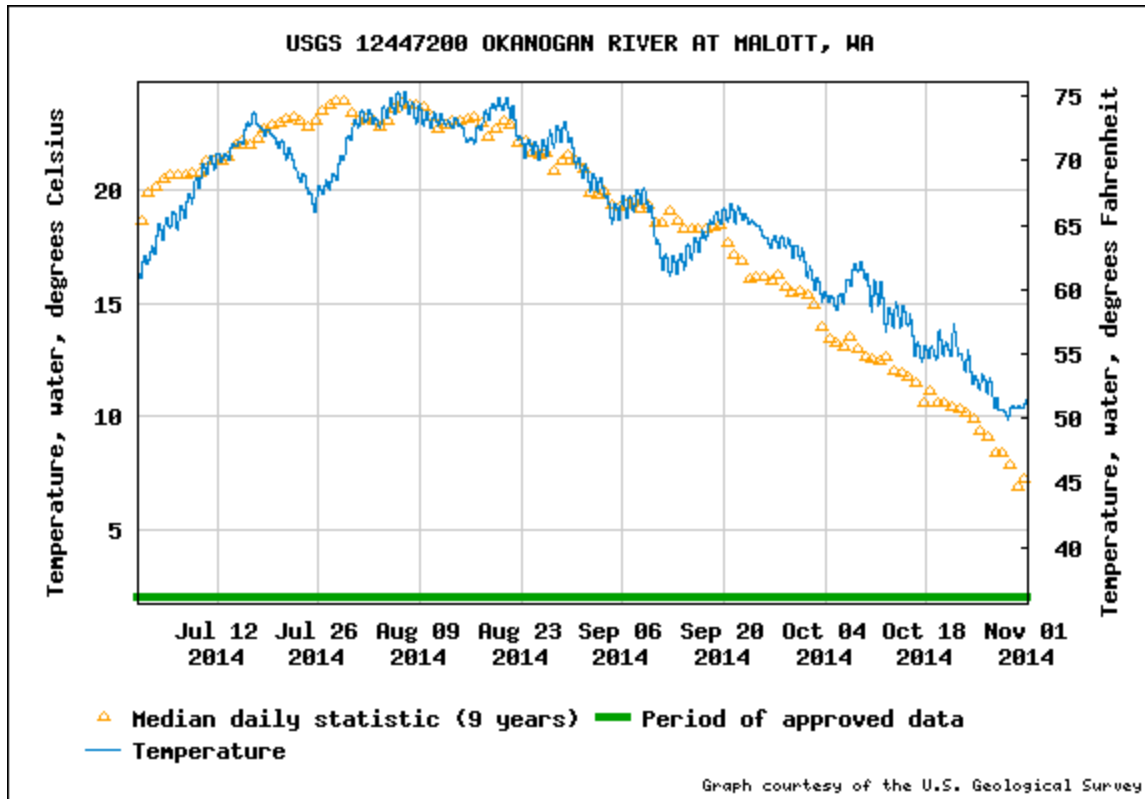


Figure 4. Temperature of the Okanogan River between July 1 and October 31, 2014. This figure was copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

Dissolved Oxygen varied from 6.3 to 11.6 mg/L, total dissolved solids varied from 120-136 ppm and turbidity varied from 0.6 and 3.6 NTUs (Table 1). The head differential ranged from 0-12 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 2014. 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)	Mean Temperature (°C)	Mean Discharge (cfs)
8/20	2.6	6.9	121	3.6	23.7	1,780
8/21	2.5	6.3	121	3.5	23.5	1,500
8/22	2.3	6.4	122	2.7	22.5	1,390
8/25	2.0	8.6	125	1.7	21.7	1,240
8/26	2.0	9.4	122	2.6	22.0	1,220
8/27	2.0	8.4	123	1.6	22.3	1,130
8/28	1.9	9.9	120	1.1	22.6	1,030
8/29	1.9	8.2	123	1.6	22.4	988
8/30	1.9	8.9	123	1.6	21.4	956
9/01	1.9	8.7	127	0.8	20.4	922
9/02	1.8	9.2	127	0.9	20.3	905
9/03	1.8	9.4	128	1	19.9	901
9/04	1.8	11.6	128	1.1	19.0	884
9/05	1.8	10.6	127	0.8	19.2	898
9/06	2.0	10.2	125	0.7	19.3	973
9/07	2.0	10	126	1.3	19.5	1,010
9/08	2.0	9.2	126	0.9	19.7	940
9/09	2.0	9.2	121	0.9	19.4	874
9/10	2.0	10.1	124	0.9	18.1	822
9/11	1.6	10.4	123	0.9	17.0	799
9/12	1.7	10.7	126	0.6	16.7	781
9/15	1.7	10.1	126	1.2	17.4	763
9/16	1.7	9.4	134	1	17.7	748
9/17	1.7	9.2	133	0.9	18.1	734
9/18	1.7	8.7	136	1.1	18.7	718
9/19	1.7	9.3	135	1.1	18.8	710
9/22	1.7	8.6	135	0.9	18.9	794
9/23	1.7	9	136	1.1	18.7	808
9/24	1.7	9.1	135	1.1	18.4	816
9/25	1.8	9.5	135	1	18.0	882

Table 2. Head differential across the different picket spacings. If differential exceeded 10 cm, pickets were cleaned immediately. Measurements are in cm.

Date	1.0"	1.5"	2.0"	2.5"	3.0"
8/11	2.5	0.0	2.5	0.0	0.0
8/12	4.0	4.0	4.0	0.0	2.5
8/13	0.0	0.0	1.0	0.0	0.0
8/14	2.5	2.5	0.0	0.0	0.0
8/15	0.0	0.0	0.0	0.0	0.0
8/18	4.0	2.5	1.0	0.0	0.0
8/19	2.5	1.0	1.0	0.0	0.0
8/20	0.0	0.0	0.0	0.0	0.0
8/21	10.0	0.0	0.0	0.0	0.0
8/22	11.0	5.0	4.0	2.0	2.0
8/25	12.0	7.0	5.0	6.0	2.0
8/27	11.0	7.0	2.0	1.0	7.0
8/29	1.0	1.0	1.0	1.0	1.0
8/30	6.0	3.0	0.0	2.0	3.0
9/2	2.0	3.0	2.0	1.0	1.0
9/3	3.0	2.0	2.0	1.0	1.0
9/4	6.0	4.0	2.0	1.0	4.0
9/5	9.0	5.0	0.0	2.0	3.0
9/6	4.0	6.0	1.0	4.0	4.0
9/7	5.0	4.0	1.0	2.0	4.0
9/8	2.0	2.0	0.0	0.0	1.0
9/9	3.0	2.0	2.0	1.0	1.0
9/10	4.0	5.0	1.0	3.0	5.0
9/11	4.0	2.0	1.0	0.0	3.0
9/12	2.0	1.0	1.0	0.0	0.0
9/17	2.0	2.0	0.0	1.0	2.0
9/22	3.0	4.0	0.0	0.0	2.0
9/23	4.0	3.0	0.0	3.0	2.0
9/24	3.0	2.0	0.0	2.0	2.0

Table 3. Water velocity upstream (US) and downstream (DS) of the weir and in the trap. Trap depth is also included. 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	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8/13	1.6	1.7	2.0	1.5	1.6	1.8	0.9
8/14	1.6	1.8	2.2	2.5	1.5	1.4	0.7
8/15	1.3	1.2	2.0	1.7	1.2	1.7	0.4
8/18	2.3	1.7	2.2	2.7	1.6	1.6	1.3
8/19	2.4	1.7	2.3	2.2	1.2	1.5	0.9
8/20	2.0	1.7	2.0	2.9	1.0	2.0	1.1
8/21	2.2	1.5	2.0	2.5	1.1	2.0	1.0
8/22	1.8	1.5	2.0	2.2	0.7	2.1	0.7
8/25	1.7	1.3	2.0	2.3	0.8	2.0	0.7
8/26	2.1	1.4	2.0	2.5	0.8	1.6	0.5
8/27	2.0	1.3	2.0	2.5	1.0	1.4	0.6
8/28	1.6	1.1	1.7	2.1	0.9	3.7	0.5
8/29	1.6	1.3	1.6	2.5	1.5	1.7	0.6
8/30	1.5	1.4	1.6	2.5	1.7	1.8	0.7
9/1	1.2	1.2	1.7	1.4	2.1	1.6	0.9
9/2	1.5	1.3	1.8	2.0	1.8	1.6	0.8
9/3	1.3	1.3	1.6	2.2	1.7	1.8	1.1
9/4	1.5	1.4	1.5	2.2	1.5	1.7	1.0
9/5	1.6	1.4	1.6	2.8	1.5	1.9	0.8
9/6	1.7	1.0	1.7	1.9	1.6	1.4	0.6
9/7	1.7	1.6	1.8	1.9	1.6	1.9	0.9
9/8	1.5	1.3	1.4	1.4	1.6	1.8	0.8
9/9	1.9	1.5	1.5	1.5	1.1	1.7	1.0
9/10	1.5	1.4	1.7	1.8	1.0	1.6	1.0
9/11	1.6	1.3	1.4	1.5	1.1	1.4	1.1
9/12	1.5	1.3	1.6	2.5	2.2	1.5	1.1
9/15	1.6	1.3	1.6	2.0	0.9	1.4	0.6
9/16	1.6	1.4	1.6	2.2	0.8	1.3	0.9
9/17	1.5	1.3	1.7	1.3	1.6	1.4	0.8
9/18	1.7	1.1	1.5	1.2	1.2	1.6	1.2
9/19	1.7	1.4	1.6	1.3	1.6	1.6	1.0
9/22	1.7	1.1	1.8	1.5	1.4	1.2	0.9
9/23	1.7	1.3	1.7	1.8	1.7	1.9	0.7
9/24	1.8	1.3	1.7	1.4	1.8	1.7	0.8
9/25	1.7	1.1	1.7	2.1	1.9	1.9	0.5
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	2.4	1.8	2.3	2.9	2.2	2.1	1.3

Two hundred and two dead fish were removed from the weir between August 6 and September 25 (Table 4). Sockeye and Chinook Salmon were the most commonly encountered species. All fish were impinged on the upstream side of weir indicating that they had most likely died upstream and floated down onto the weir. There was not an increase in the number of Chinook carcasses after the first Chinook was encountered in the trap (Figure 5). The higher mortality observed on August 16-17 was not due to Chinook being handled in the trap. 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 2014.

Date	Black Bullhead	Bridgelip Sucker	Carp	Chinook	Mountain Whitefish	Northern Pikeminnow	Sockeye	Unknown Sucker
8/6							1	
8/7							2	
8/8				1				
8/10				1				
8/12							1	
8/14				1				
8/15							1	
8/16				9			3	
8/17				7	1		5	6
8/18		1		1	1		6	
8/19		1		2	8	1	8	
8/20		2		2	3		7	
8/21				1	6		4	
8/22			1	2	4		1	1
8/23				1	2			2
8/24				2			5	1
8/25		1		1			2	
8/26				1			3	
8/27		3					2	
8/28				5			3	
8/29		1					2	
8/30		1			1		2	
8/31				2	1		1	
9/1				1			1	
9/2			1	2				1
9/3				3				
9/4				2			1	
9/6				2				
9/7				4				
9/8					1		2	
9/9	1		1				2	
9/10		1		2				
9/11							1	
9/15		1					2	
9/16					1			
9/17				1			2	
9/18		1					1	
9/19		1				1		
9/22	1	1		3	2		2	
9/23		1		1			1	
9/25								1
Total	2	16	3	60	31	2	74	12

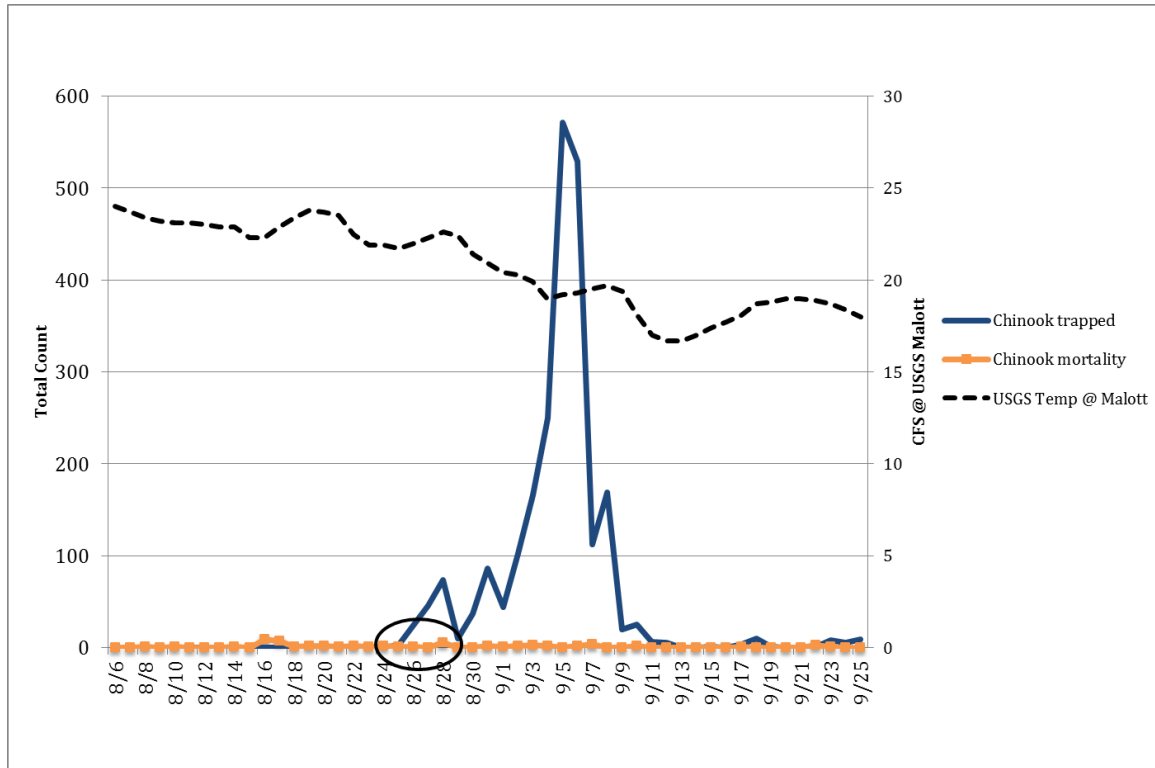


Figure 5. Total number of Chinook trapped and total number of Chinook carcasses collect off the weir panels. There was no drastic increase in Chinook carcasses at the weir after Chinook were encountered in the trap. This is indicated by the circle.

Trapping operations were conducted from August 15 to September 25 when river temperature was ≤ 22.5 °C . The total fish trapped at the weir in 2014 was 2477 with 94% of them being Chinook Salmon (Figure 6). Most of the Chinook trapped were released back into the river (Figure 7). Seventy-six hatchery Chinook were transported to the hatchery and held in the broodstock ponds concurrently with the fish taken for broodstock from the purse seine. None of the weir collected fish died at the hatchery as of the first spawn in early October.

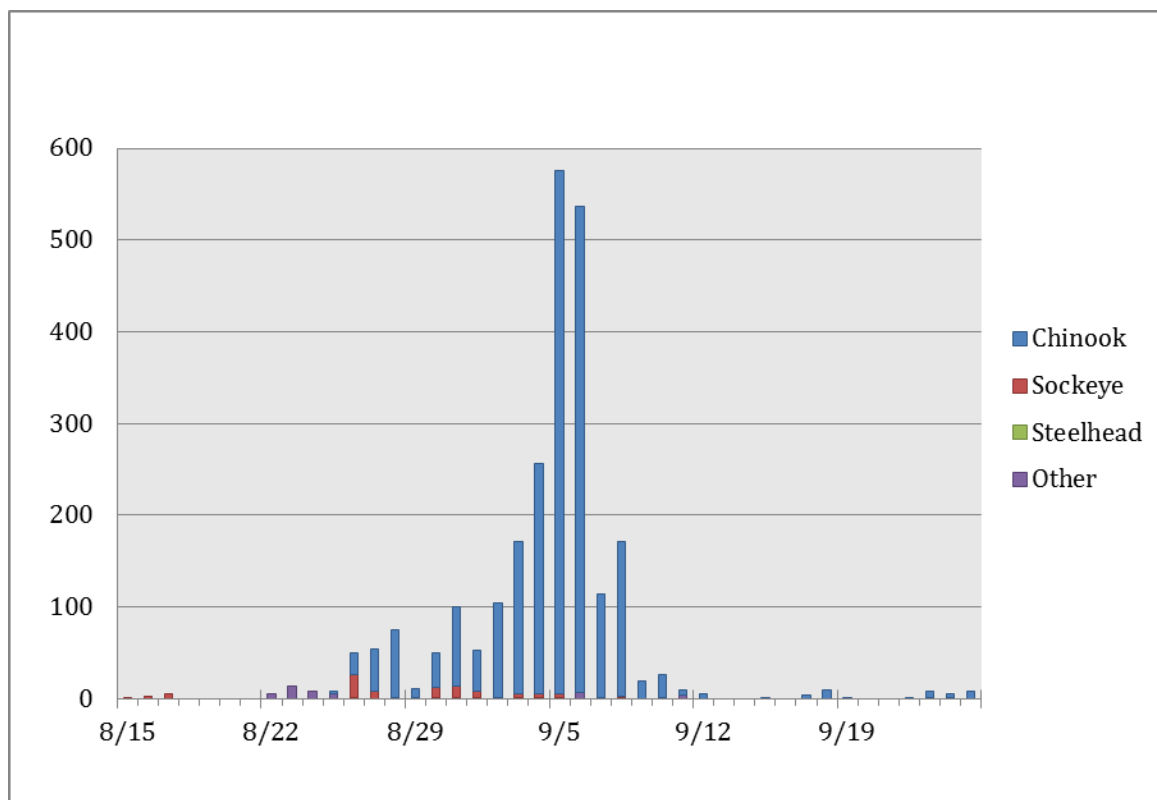


Figure 6. Total number of fish trapped at the Okanogan weir in 2014.

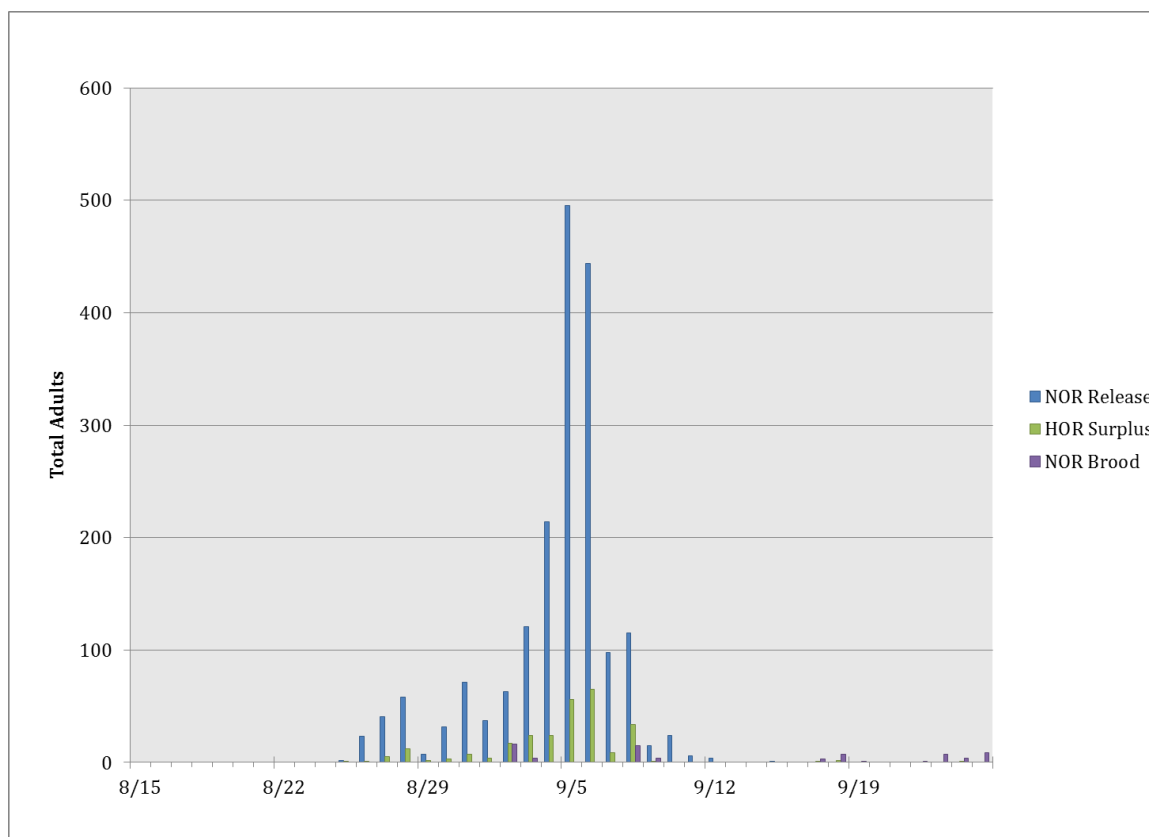


Figure 7. Final destination of Chinook adults captured in the weir trap during trapping operations in 2014.

In 2014, 0.17 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 0.16.

Table 5. The number of hatchery and natural origin Chinook Salmon encountered at the lower Okanogan weir in 2014. 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 summer/fall Chinook carcasses					
	Chinook Encountered in the Weir Trap		Chinook Spawning Escapement Estimates		Weir Metrics	
	Natural Origin	Hatchery Origin	Natural Origin	Hatchery Origin	Weir Efficiency	Weir Effectiveness
2014	2,006	318	11,669 ^a	1,682 ^a	0.17	0.16

^a Results for Chinook spawning escapement estimates include the number of summer/fall Chinook that escaped into Canada at Zosel Dam.

Discussion

Temperature and discharge conditions on the Okanogan River in 2014 were fairly typical, allowing for installation and operation of the weir in August and capture and observation of many Chinook and Sockeye. There was an abrupt break in the thermal barrier during the month of July but flows were too high (>3,000 cfs) for installation. IN August, the thermal barrier did not appear to break down as abruptly. Temperature slowly dropped below 22.5 °C in late August and the mode of fish passage occurred about a week after the mean daily temperature dropped below 22.0 °C. With two years of data, further speculation regarding the relationship between temperature at Malott and the post thermal barrier passage of mid-late arriving summer Chinook is not merited. However, 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.

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, rain events in 2013 caused discharge and ambient turbidity to increase to a level that prohibited effective observations, video, and trap operations. We will continue to monitor weather conditions throughout the season and their effect on trapping operations.

Although the number (202) of dead fish at the weir seems high, the reality was that dead 'wash ups' were not a good indicator of weir effects. A fish kill upstream that had nothing to do with the weir could cause many fish to wash up on the upstream side of the weir. Conversely, any adverse effects of the weir would not have been detected if fish carcasses were stranded on shore or taken by scavengers before washing up on the weir. However, behavioral observations and the 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. No data were collected to assess indirect mortality.

Weir trapping and fish handling commenced when temperatures were sufficient. Natural-origin Chinook were successfully trapped and released into the river. Hatchery-origin broodstock were successfully implemented and there was 100% survival to spawning. Similar to 2013, many Sockeye were observed swimming through the 2.5 to 3.0 inch picket spacing that were intended for that purpose. Unfortunately there was no way to quantify the number of Sockeye that swam through the weir panels versus those that entered the trap. Many jack and small adult Chinook also escaped through the 2.5 and 3.0 weir panels that were intended to allow Sockeye passage. We recommend removing the 3.0 inch weir panels to increase the efficiency of Chinook trapping without causing too many Sockeye to also use the trap.

There was no way to know 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. However, we were able to relate observations at the weir to estimates of total spawners and evaluate efficiency and effectiveness of the weir. The potential weir effectiveness measure of 16% shows high potential for using the weir as an important tool for PHOS management. Although only 14% of the Chinook trapped were hatchery origin, 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.

Broodstock collected at the weir was successful with no prespawn mortality. The high survival rate provided confidence that the weir can be used for broodstock collection in the future. We recommend a continued risk-averse approach to broodstock collection at the weir in 2015, particularly if natural origin broodstock are collected. The effects on survival and egg viability due to prolonged prespawn holding in the Columbia River and late migration into the relatively warm Okanogan have not been evaluated.