

THE CHIEF JOSEPH HATCHERY PROGRAM 2016 ANNUAL REPORT

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This report includes both hatchery production/operations and the corresponding monitoring activities completed through April of 2017. It is structured to meet the RM&E technical report formatting requirements for BPA, and therefore the hatchery production portion is included in Appendix A.

Reports, program descriptions, annual review materials and background information, news and contact information can be found on our website at: <https://www.cct-fnw.com/reports/>.

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EXECUTIVE SUMMARY

The Colville Confederated Tribes (CCT) Chief Joseph Hatchery (CJH) is the fourth hatchery obligated under the Grand Coulee Dam/Dry Falls project, originating in the 1940s. Leavenworth, Entiat, and Winthrop National Fish Hatcheries were built and operated as mitigation for salmon blockage at Grand Coulee Dam, but the fourth hatchery was not built, and the obligation was nearly forgotten. After the Colville Tribes successfully collaborated with the United States to resurrect the project, planning of the hatchery began in 2001 and construction was completed in 2013. The monitoring program began in 2012 and adult Chinook Salmon were brought on station for the first time in June 2013. Bonneville Power Administration (BPA) is the primary funding source for CJH, and the Mid-Columbia PUDs (Douglas, Grant and Chelan County) have entered into cost-share agreements with the tribes and BPA in order to meet some of their mitigation obligations.

The CJH production level was set at 100% in 2016 during the fourth year of operation for the Spring and Summer/Fall Chinook programs. Leavenworth National Fish Hatchery (LNFH) provided 639 Spring Chinook broodstock in May 2016. The Leavenworth Spring Chinook program broodstock survival was 99.4% for females, 98.8% for males with a combined survival of 99.1%. The total green egg take for the Leavenworth Spring Chinook program was 1,060,200 (97% of full program). Green egg to eyed egg survival was 51.1%. This survival was much lower than the standard (90%). Survival from incubation to ponding for the Leavenworth groups was 94.5% which was on par with the standard (95%). With the lower than anticipated hatchery survival of eggs and juveniles the segregated spring Chinook program was 53% of full program. The 10(j) spring Chinook reintroduction program received its full component of 206,138 eyed eggs from the Winthrop NFH in October.

In July and August the CCT used a purse seine vessel to collect 1,124 summer/fall Chinook for broodstock for both the integrated and segregated programs (including Similkameen). Additionally, 14 summer/fall Chinook were collected at the Okanogan adult weir in September. Because we had fallen short of our target goal of late-arriving brood from the weir, hatchery staff beach seined the Kline site on the Similkameen River and collected the remaining 72 brood fish. The summer/fall collected enough brood to meet full production levels. The cumulative pre spawn holding survival, for all Summer/Fall brood collected, was 95.9% for hatchery-origin broodstock (HOB) and 93.4% for natural-origin broodstock (NOB). Both hatchery-origin and natural-origin brood met the survival standard (90%) except Jacks, which are not included in the stated cumulative survival. Total green egg take for the season was 2,675,000 (98% of full program). Egg survival from green egg to eyed egg averaged 75.1% for NOB and 81.3% for HOB, both under the survival standard (90%) for this life stage. Cumulative egg survival from green egg to eyed egg was 85.8% for NOB and HOB, which is

under the survival standard (90%) for this life stage. Ponding survival for the integrated subyearling program was 96.7% and for the segregated subyearling program it was 98.4%, both exceeding the survival standard (95%) for this life stage. The cumulative ponding survival for the integrated and segregated programs was 96% for the subyearlings, which was over the survival standard (95%) and 97% for the yearlings, which also exceeded the survival standard. After in-hatchery mortalities from pre-spawn holding through ponding there were 1,245,695 fish on hand at the end of April for the yearling releases in 2018 (96% of full program) and 403,753 fish on hand for the sub-yearling releases in May 2017 (58% of full program).

2016 was the third year for Summer/Fall Chinook sub-yearling hatchery releases from the CJH programs and the second year for yearlings released from Similkameen and Omak acclimation ponds that had been reared at the CJH central facility. In April, 232,353 integrated yearling summer/fall Chinook were released from the Omak acclimation pond (58% of full program) and 256,294 were released by Washington Department of Fish & Wildlife (WDFW) from the Similkameen Pond (64% of full program). Subsequently, sub-yearlings from brood year (BY) 2015 were transferred to Omak Pond for short term acclimation and 175,771 were released in May (59% of full program). Additionally, 401,215 yearling and 218,383 sub-yearling segregated Chinook were released directly from Chief Joseph Hatchery (80% and 55% of full program, respectively). For Spring Chinook, 201,821 smolts (101% of full program) were released in the spring of 2017 and mark the third year of implementation of the non-essential experimental population under section 10(j) of the Endangered Species Act. Additionally, 555,636 segregated Spring Chinook smolts were released directly from Chief Joseph Hatchery (79% of full program).

After release, yearling hatchery spring Chinook survival was 57-80% to Rocky Reach Juvenile bypass and 50-60% to McNary Dam and was similar to 2015 and to other nearby programs in the Methow. Summer Chinook sub-yearling survival was 35-44% to Rocky Reach Dam and 14% to McNary Dam. The vast majority (82-95%) of PIT tagged hatchery smolts released from Omak Pond and Riverside Pond migrated to the lower Okanogan River within one week of release. This assessment suggests that the program was successful at releasing actively migrating smolts. Two yearling Summer Chinook migrants with a PIT tag from Omak Pond in 2016 returned to the Okanogan as mini-jacks in September after migrating to below Bonneville Dam.

The CJH monitoring project collected field data to determine Chinook population status, trend, and hatchery effectiveness centered on six major activities; 1) rotary screw traps (juvenile outmigration, natural-origin smolt PIT tagging) 2) beach seine (natural-origin smolt PIT tagging, smolt to adult return) 3) lower Okanogan adult fish pilot weir (adult escapement, proportion of hatchery-origin spawners [pHOS], broodstock) 4) spawning ground surveys (redd and carcass surveys)(viable salmonid population [VSP] parameters) 5) eDNA collection (VSP parameter—distribution/spatial structure) and 6) coded wire tag lab (extraction and reading).

Rotary screw trap operations began on April 4 and continued through June 24, capturing 12,660 natural-origin Chinook and 661 hatchery-origin Chinook. After conducting 4 mark-recapture events, the efficiency of the trapping configuration was calculated to be approximately 0.10%. This translated to an overall juvenile natural-origin Chinook outmigration estimate of 10,566,870 with 95% confidence intervals of 2,118,348 to 19,015,391. 70 steelhead (*O. mykiss*) were also captured in the rotary screw trap including 27 natural-origin (adipose fin present and no CWT) and 43 hatchery-origin (adipose fin clipped and/or CWT present). Other species commonly caught in the rotary screw traps included sockeye (*O. nerka*) (11), yellow perch (*P. flavescens*) (121), bluegill (*L. macrochirus*) (82) and mountain whitefish (*Prosopium williamsoni*)(452).

15,802 juvenile Chinook salmonids were collected with the beach seine, and 13,650 (86%) were PIT tagged and released. Pre- and post-tag mortality was 2% and 4% respectively. In 2016, wild summer Chinook tagged at the mouth of the Okanogan had a minimum apparent survival to Rocky Reach Juvenile Bypass (RRJ) of 0.10. Apparent survival to McNary (MCN), John Day (JDA) and Bonneville (BON) Dams was 0.6%, 0.2% and 0.1% respectively

The lower Okanogan Adult Fish Weir was deployed on August 8th when discharge was 1,530 cfs. The thermal barrier was present in the lower Okanogan after installation until August 22th when the mean Okanogan River temperature began dropping below 22.5 °C. The mean temperature generally varied between 21.4 °C and 22.5 °C until August 25th. On August 26 the thermal barrier began to break down, allowing Chinook to migrate up the Okanogan. After reviewing the number of adult Chinook pit tagged at Bonneville and their detections at the Wells Adult Ladder and the Lower Okanogan Pit Array, we suspect that about 45% of fish passage occurred before the weir trap was operational on August 22. After trapping began, the majority of Chinook (75%) were trapped between August 31 and September 6. 169 adult Chinook were trapped in 2016. Sixteen natural-origin Chinook were transported to the hatchery and held as broodstock for the integrated program. Adult brood were transported from the weir trap to the hatchery brood truck with the Whooshh™ fish transport system. There were no immediate mortalities of these fish within the first week after transport to the hatchery. All other natural-origin fish were released upstream of the weir unharmed. All of the hatchery-origin fish encountered in the weir trap were removed for proportion of hatchery-origin spawner (pHOS) management. Only 1.4% of the Chinook spawning escapement was detected in the trap. All Chinook and sockeye mortality encountered at the weir were categorized as impinged on the upstream side, indicating that they most likely died upstream and floated down onto the weir. The majority of the Chinook carcasses were encountered a week before the majority of Chinook were encountered in the trap, which suggests that the weir was not causing the mortality. The head differential, river velocity, and trap capacity were within the NOAA standard operating criteria. Water quality information, including dissolved oxygen, turbidity, and total dissolved solids were collected to assess potential impacts to increased fish mortality. Weir trapping operations ceased on September 22.

Spawning ground surveys estimated 5,276 summer/fall Chinook redds and 2,755 carcasses were recovered (2,171 natural-origin and 584 hatchery-origin). Adult summer/fall Chinook spawning escapement in 2016 was estimated to be 10,605, with 8,661 natural-origin spawners. The values for pHOS (0.18) and proportion of natural influence (PNI) (0.87) in 2016 met the program objectives (<0.30 and >0.67, respectively). The five-year average for pHOS (0.27) and PNI (0.82) met the long-term goal (<0.30 pHOS; >0.67 PNI). Selective harvest activities by CCT and WDFW contributed to the reduced pHOS and increased PNI in 2016, along with removals of more than 6,000 surplus hatchery fish at the CJH ladder and trap.

Spatial distribution of spring-Chinook in the Okanogan basin has been monitored using analysis of environmental DNA (eDNA) beginning in 2012. This data is used to assess status and trends in spatial structure and to track the progress of the reintroduction which began in 2015. Results revealed that the Okanogan basin likely saw a limited distribution of spring Chinook, even prior to the reintroduction effort. Following the initial reintroduction, several tributaries have produced consistent annual detections of Chinook eDNA, including Shingle Creek, Vaseux Creek, Salmon Creek and Omak Creek.

PIT tags were also used to evaluate Spring Chinook presence and distribution in the Okanogan. Of the 64 returning fish with a PIT tag to the Okanogan, 12 (19%) had a final detection in the Methow, and 12 were detected in a U.S. tributary and four (6%) were detected in Canada with the remaining 36 (56%) only being detected at a mainstem site (OKL and Zosel Dam). Forty-five (70%) PIT tags detected in the Okanogan had been tagged as an adult at Wells Dam, thirteen (20%) were from the 2015 release at Riverside Pond, four (6%) were from juvenile releases in the Methow and two (3%) were natural-origin that had been tagged as a juvenile in the Methow and Entiat rivers.

The CJH coded wire tag lab was in its first year of operation in 2016. Coded wire tags were extracted and read from Chinook snout recoveries from broodstock, ladder surplus, purse seine harvest, and creel and spawning ground surveys in 2013-2016. Prior to 2013 WDFW had always processed CWT from the Okanogan program. However, after 2013, WDFW decided they could not process the increasing number of snouts generated by the expanding CCT programs without a separate contract. In 2016, CJH M&E program was able to set up a CWT lab at the hatchery and process all the snouts, thereby catching up on three years of backlogged CWT data. From this point forward CCT will be able to efficiently process and upload (to RMIS) all of the CJH program and Okanogan monitoring CWT data each year. From 2013-2016 the majority of the summer Chinook adult returns to the CJH ladder were from Wells (26%), Chelan (29%) and Dryden (14%). The Similkameen represented an average of 9% over the four year period. The high proportion of fish from downstream Upper Columbia River programs is not surprising because adult returns from the CJH segregated program will not return until 2017. Spring Chinook were encountered during the summer Chinook ladder operations (generally early July to October). The majority were from the Leavenworth Hatchery 44% and Chiwawa Pond (34%).

The majority (95%) of hatchery-origin spawners recovered on the spawning grounds in 2016 were from Similkameen (92%) and Okanogan (3%). This was very similar to the average (95%) of recent years (2006-2016). Fish acclimated at the Similkameen Pond site spawned primarily in the lower Similkameen River (55%, reach S1) with substantial numbers of fish also spawning in habitat within the upper Okanogan reaches, O5 and O6 (45%). Less than 1% of the spawning escapements in the non-target basins of Wenatchee, Methow, Chelan or Entiat consisted of hatchery-origin Okanogan summer/fall Chinook in 2016. The most recent brood year that could be fully assessed (through age 5) for stray rate of Okanogan/Similkameen fish to spawning areas outside the Okanogan was 2011. The 2011 brood year had a stray of 1.1%, which was similar to the long term and recent five year average.

An Annual Program Review (APR) was held in March 2017 to share hatchery production and monitoring data, review the salmon forecast for the upcoming year, and develop action plans for the hatchery, selective harvest, and monitoring projects. Based on a strong pre-season forecast of 63,100 Upper Columbia summer/fall Chinook, the plan for 2017 is to operate the hatchery at full program levels of 2 million summer/fall Chinook and 900,000 spring Chinook. To maximize PNI, broodstock for the integrated program would be 100% natural-origin broodstock (NOB) and CCT would plan to harvest their full allocation with the selective harvest program removing as many adult hatchery Chinook as possible with the purse seine, the weir, and at the hatchery ladder.

INTRODUCTION

Salmon (*Oncorhynchus* spp.) and steelhead (*O. mykiss*) faced many anthropogenic challenges ever since European settlement of the Pacific Northwest. Harvest, hydropower development, and habitat alteration/disconnection have all had a role in reducing productivity or eliminating entire stocks of salmon and steelhead (MacDonald 1894; UCSRB 2007). These losses and reductions in salmon had a profound impact on Native American tribes, including the Confederated Tribes of the Colville Reservation. Hatcheries have been used as a replacement or to supplement the wild production of salmon and steelhead throughout the Pacific Northwest. However, hatcheries and hatchery practices can pose a risk to wild populations (Busack and Currens 1995; Ford 2002; McClure et al. 2008). As more studies lead to a better understanding of hatchery effects and effectiveness, hatchery reform principles were developed (Mobrand et al. 2005; Paquet et al. 2011). The CJHP is one of the first of its kind to be structured using many of the recommendations emanating from Congress's Hatchery Reform Project, the Hatchery Science Review Group (HSRG) and multiple independent science reviews. Principally, the success of the program is not based on the ability to meet the same fixed smolt output or the same escapement goal each year. Instead, the program is managed for variable smolt production and natural escapement. Success is based on meeting targets for abundance and composition of natural escapement and hatchery broodstock (HSRG 2009). Chief Joseph Hatchery Program

(CJHP) managers and scientists are accountable for accomplishments and/or failures, and therefore, have well-defined response alternatives that guide annual program decisions. For these reasons, the program is operated in a manner where hundreds of variables are monitored, and activities are routinely and transparently evaluated. Functionally, this means that directed research, monitoring, and evaluation (RM&E) are used to determine status and trends and population dynamics, and are conducted to assess the program's progress in meeting specified biological targets, measure hatchery performance, and in reviewing the key assumptions used to define future actions for the entire CJHP.

The actions being implemented by the Colville Tribes, in coordination with regional management partners, represent an extraordinary effort to recover Okanogan and Columbia River natural-origin Chinook Salmon populations. In particular, the Tribes have embraced hatchery program elements that seek to find a balance between artificial and natural production and address the goals of increased harvest and conservation.

Two hatchery genetic management plans (HGMPs) were initially developed for the CJH during the Northwest Power and Conservation Council (NPCC) three-step planning process – one for summer/fall Chinook (CCT 2008a) and one for spring Chinook (CCT 2008b). Each of the two plans included an integrated and a segregated component. Integrated hatchery fish have a high proportion of natural origin parents, are released into the Okanogan River system and a proportion of these fish are expected to spawn in the natural environment. Segregated fish have primarily hatchery parents, are to be released from CJH directly into the Columbia River and adult returns are targeted exclusively for harvest.

In 2010 the CCT requested that the National Marine Fisheries Service (NMFS) designate a non-essential experimental population of spring Chinook in the Okanogan utilizing section 10(j) of the Endangered Species Act (ESA). In order to obtain a permit to transfer ESA listed fish from the Methow River to the Okanogan River, a new HGMP was developed (CCT 2013). Biological Opinions (BiOps) and permits have been issued by NMFS for the 2008 HGMPs, and CCT acquired a BiOp and permit for the 2013 spring Chinook in 2014. The program will be guided by all three HGMPs.

At full program the facility will rear up to 2 million summer/fall Chinook and 900,000 spring Chinook. Up to 1.1 million summer/fall Chinook will be released in the Okanogan and Similkameen Rivers as an integrated program and 900,000 will be released from CJH as a segregated program. Up to 700,000 segregated spring Chinook will be released from CJH and up to 200,000 Met Comp spring Chinook from the Winthrop National Fish Hatchery (WNFH) will be used to reintroduce spring Chinook to the Okanogan under section 10(j) of the ESA. In 2015, the summer/fall and spring Chinook program's production level was set at full production capacity.

The CJHP will increase harvest opportunity for all anglers throughout the Columbia River and Pacific Ocean. Additionally, the Colville Tribes and other salmon co-managers have worked

with the mid-Columbia Public Utility Districts to meet some of their hydro-system mitigation through hatchery production (CPUD 2002a; CPUD 2002b; DPUD 2002).

In order to make full use of the best science available the program operates on the following general principles¹:

1. Monitor, evaluate and adaptively manage hatchery and science programs
2. Manage hatchery broodstock to achieve proper genetic integration with, or segregation from natural populations
3. Promote local adaptation of natural and hatchery populations
4. Minimize adverse ecological interactions between hatchery- and natural-origin fish
5. Minimize effects of hatchery facilities on the ecosystem
6. Maximize survival of hatchery fish in integrated and segregated programs
7. Develop clear, specific, quantifiable harvest and conservation goals for natural and hatchery populations within an “All-H” (Hatcheries, Habitat, Harvest and Hydro) context
8. Institutionalize and apply a common analysis, planning, and implementation framework
9. Use the framework to sequence and or prioritize actions
10. Hire, train, and support staff in a manner consistent with successful implementation of the program
11. Conduct annual reviews to include peers, stakeholders, and regional managers, and
12. Develop and maintain database and information systems and a highly functional informational web-presence.

The CJHP annual RM&E activities were focused on five primary field activities to provide data for answering key management questions. These activities included:

1. Rotary screw traps (juvenile outmigration, natural-origin smolt PIT tagging)
2. Beach seine (natural-origin smolt PIT tagging)
3. Lower Okanogan adult fish pilot weir (adult escapement, pHOS, broodstock)
4. Spawning ground surveys (redd and carcass surveys)(VSP parameters)
5. eDNA collection (VSP parameter—distribution/spatial structure)

Additional data compilation activities occurred and were necessary in conjunction with our field efforts to answer the key management questions. These included:

1. Harvest (ocean, lower Columbia, terminal sport, and CCT)
2. Query RMIS for coded wire tag (CWT) recoveries to evaluate strays and stock composition

¹ Adapted from the Hatchery Reform Project, the Hatchery Science Review Group reports and independent science review.

3. Query PTAGIS for PIT tag returns at mainstem dams and tributaries
4. EDT model estimates for abundance and productivity (from OBMEP)

In-hatchery monitoring/data collection was focused in five areas (see Appendix A):

1. Broodstock collection and bio-sampling
2. Life stage survival
3. Disease monitoring
4. Tagging, marking, and release
5. Ladder surplus / PHOS reduction

Study Area

The primary study area of the CJHP lies within the Okanogan River Subbasin and Columbia River near Chief Joseph Dam in north central Washington State (Figure 1). The Okanogan River measures approximately 185 km long and drains 2,316,019 ha, making it the third-largest subbasin to the Columbia River. Its headwaters are in Okanogan Lake in British Columbia, from which it flows south through a series of four lakes before crossing into Washington State at Lake Osoyoos. Seventy-six percent of the area lies in Canada. Approximately 14 km south of the border, the Okanogan is joined by its largest tributary, the Similkameen River. The Similkameen River watershed is 510 km long and drains roughly 756,096 ha. The Similkameen contributes approximately 75% of the flow to the Okanogan River. The majority of the Similkameen is located in Canada. However, part of its length within Washington State composes an important study area for CJHP. From Enloe Dam (Similkameen rkm. 14) to its confluence with the Okanogan, the Similkameen River contains important Chinook pre-spawn holding and spawning grounds. Downstream of the Similkameen confluence, the Okanogan River continues to flow south for 119 km until its confluence with the Columbia River at Columbia River km 853, between Chief Joseph and Wells dams, near the town of Brewster, Washington.

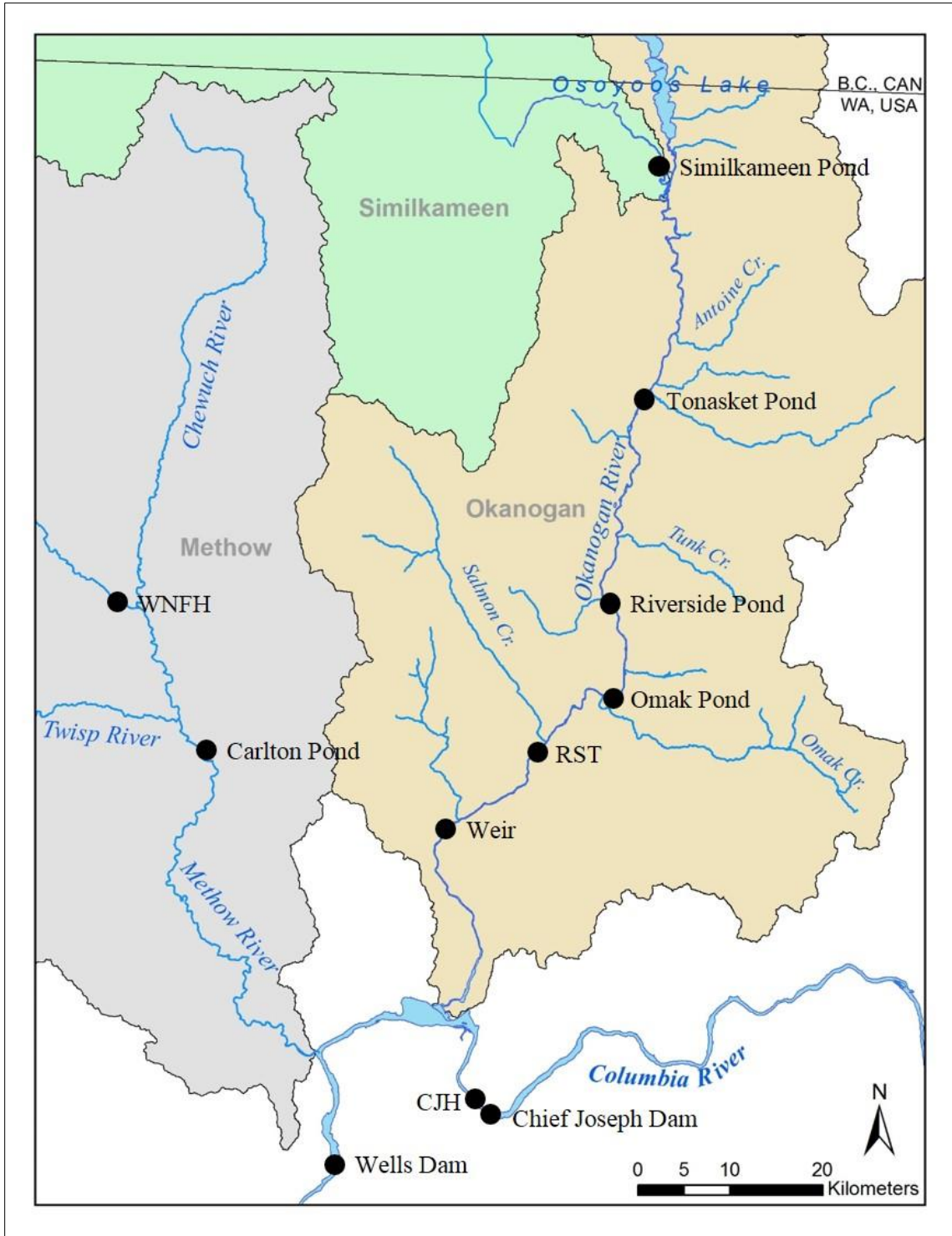


Figure 1. Map of the U.S. portion of the Okanogan River Basin, the Chief Joseph Hatchery (CJH), Winthrop National Fish Hatchery (WNFH), Okanogan adult weir (Weir), Rotary screw trap (RST), and Chinook Salmon acclimation sites. Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Similar to many western rivers, the hydrology of the Okanogan River watershed is characterized by high spring runoff and low flows occurring from late summer through winter. Peak flows coincide with spring rains and melting snowpack (Figure 2). Low flows coincide with minimal summer precipitation, compounded by the reduction of mountain snowpack. Irrigation diversions in the lower valley also contribute to low summer flows. As an example, at the town of Malott, Washington (rkm. 27), Okanogan River discharge can fluctuate annually from less than 1,000 cfs to over 30,000 cfs (USGS 2005).

The Okanogan Subbasin experiences a semi-arid climate, with hot, dry summers and cold winters. Water temperature can exceed 25° C in the summer, and the Okanogan River surface usually freezes during the winter months. Precipitation in the watershed ranges from more than 102 cm in the western mountain region to approximately 20 cm at the confluence of the Okanogan and Columbia Rivers (NOAA 1994). About 50% to 75% of annual precipitation falls as snow during the winter months.

For most of its length, the Okanogan River is a broad, shallow, low gradient channel with relatively homogenous habitat. There are few pools and limited large woody debris. Fine sediment levels and substrate embeddedness are high and large woody debris is rare (Miller et al. 2013). Towns, roads, agricultural fields and residential areas are adjacent to the river through most of the U.S. reaches.

Near its mouth, the Okanogan River is affected by the Wells Dam on the Columbia River, which creates a lentic influence to the lowermost 27 km of the Okanogan River. Water level fluctuates frequently because of operational changes (power generation, storage) at Wells Dam.

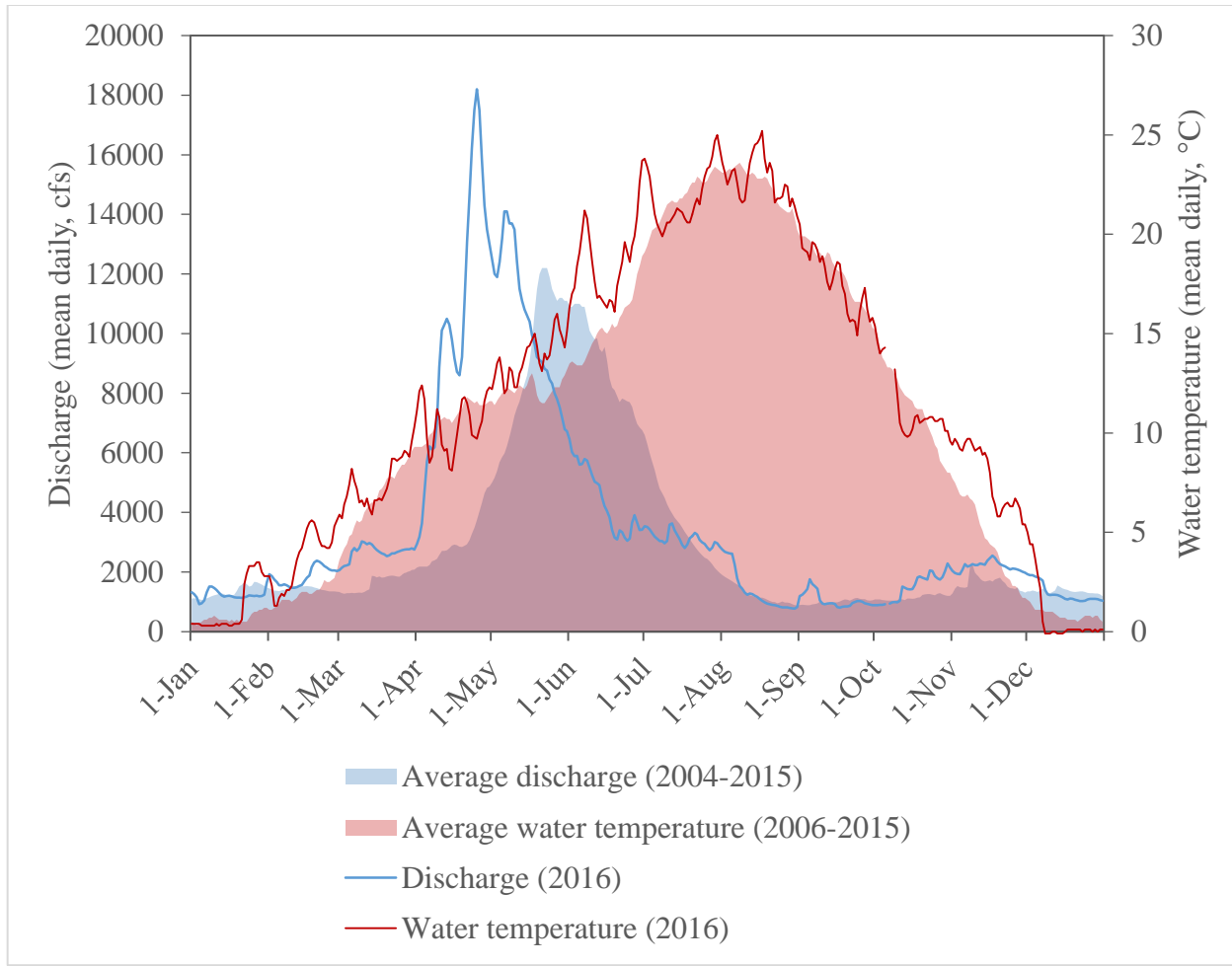


Figure 2. Okanogon River mean daily discharge (blue lines) and water temperature (red lines) at Malott, WA (USGS Stream Gage 12447200).

METHODS

Tag and Mark Plan

HATCHERY SUMMER/FALL CHINOOK. —All summer/fall hatchery-origin Chinook were marked with an adipose fin clip to ensure differentiation from natural-origin fish in the field and in fisheries. Additionally, all summer/fall Chinook raised for the integrated program have been/will be tagged with a CWT (with distinct codes differentiated by release location), which is inserted into the snout of fish while in residence at the hatchery. A batch of 200,000 summer/fall Chinook in the segregated program will receive a CWT, so the presence or absence of a CWT in adipose-clipped fish is a partial diagnostic as to which program an ad-clipped, hatchery-origin fish belongs (Table 1). This will allow for selective efforts in broodstock collection, purse seining, and hatchery trapping activities to be program specific by determining

the presence or absence of a CWT in the field. It was decided that losing some resolution on field differentiation of the segregated and integrated populations was a good tradeoff in order to get the harvest information back from the batch of 200,000 CWT in the segregated program.

Under this strategy, a returning adult from the CJH with an adipose fin clip and CWT would be considered part of the integrated program and either collected for broodstock in the segregated program, allowed to escape to the spawning grounds (if pHOS is within acceptable levels), or removed from the population (for harvest or pHOS management). If a fish has an adipose fin clip but no CWT, then it is assumed from the segregated program (or a stray from another hatchery program) and removed for harvest or pHOS management. In this way, CWTs assist with in-season management of hatchery-origin stocks in the field. The 200,000 segregated fish with a CWT represent about 15% of the combined segregated (900,000) and integrated (1.1 million) hatchery fish with a CWT. If smolt to adult survival and adult holding/migration behaviors are identical, this would mean that 15% of the subsequent generation of segregated fish would have a segregated parent and would not be consistent with the 'stepping stone' approach. However, segregated fish should spend less time holding at the mouth of the Okanogan and therefore have a lower probability of being collected as broodstock in the purse seine. CWT monitoring from broodstock collections during the first several years of returns will provide insight to this tradeoff.

Coded wire tags are recovered from salmon carcasses during Chief Joseph Hatchery ladder surplus, CCT creel surveys, CCT purse seine, Okanogan weir trapping, and spawning ground surveys in the Okanogan Basin. All recovered CWTs are sent to the Chief Joseph Hatchery coded wire tag lab for extraction, reading, and data upload to the Regional Mark Processing Center operated by the Pacific States Marine Fisheries Commission (PSMFC)². These data are used to develop estimates of total recruitment, rate of return to point of release (homing), contribution to fisheries, survival rates, mark rate, and other parameters, helping inform future management and production decisions within the CJHP.

² website: http://www.psmfc.org/Regional_Mark_Processing_Center_RMPC

Table 1. General mark and tag plan for Chief Joseph Hatchery summer/fall Chinook.

Mark Group	Target max smolt released	Life-stage released	% CWT	Adipose Fin-Clip	PIT tag
Okanogan Integrated	1,100,000				
Similkameen	400,000	Yearling	100%	100%	
Omak Pond	400,000	Yearling	100%	100%	5,000
	300,000	Sub-yearling	100%	100%	5,000
Chief Joseph Segregated	500,000	Yearling	20%	100%	5,000
	400,000	Sub-yearling	25%	100%	5,000
Natural-Origin	RST and Confluence Seine	N/A	0%	0%	≤ 25,000

¹The original plan was to use Riverside Pond for approximately 1/3 of the summer Chinook yearling production, however, to date it has been only been used to acclimate the 10(j) spring Chinook because Tonasket Pond has not been rehabilitated for acclimation of spring Chinook.

In addition to the adipose fin-clip and CWT, a subset of hatchery-origin fish will be PIT-tagged to further assist with fish monitoring efforts in subsequent years. Table 1 represents the general plan at full production.

HATCHERY SPRING CHINOOK. —The general tag and mark plan for spring Chinook can be seen in Table 2.

Table 2. General marking and tagging plan for Okanogan spring Chinook as part of the Chief Joseph Hatchery Program.

Mark Group	Smolt released	Life-stage released	% CWT (#)	Adipose Fin-Clip	PIT tag
Chief Joseph Segregated	700,000	Yearling	29% (200,000)	100%	5,000
Reintroduction (§10(j) fish from Winthrop)					
Tonasket or Riverside Pond	200,000	Yearling	100%		5,000
Natural-Origin	RST	Yearling	0%	0%	≤ 5,000

NATURAL-ORIGIN FISH TAGGING. —The RM&E plan called for up to 25,000 PIT tags in juvenile natural-origin summer/fall Chinook parr/smolts. PIT tagging of natural-origin

summer/fall Chinook occurred at the rotary screw trap and the juvenile beach seine in 2016. Please see those sections for details.

Genetic Sampling/Archiving

The CJHP collects and archives genetic samples for future analysis of allele frequency and genotyping of naturally spawned and hatchery Chinook populations. Genetic samples (fin clips) from outmigrant juvenile Chinook were collected during rotary screw trap operations. Samples were preserved in 200-proof molecular grade ethanol and are currently archived at USGS Snake River Field Station, Boise, ID. No genetic analyses are currently being conducted. Annual tissue collection targets are at least 200 samples for: (1) natural-origin sub-yearling Chinook handled at the rotary screw trap/beach seine; (2) natural-origin yearling (>130 mm) Chinook handled at the rotary screw trap/beach seine and (3) natural- and hatchery-origin (100 each) Chinook encountered during carcass surveys on the spawning grounds.

The CJHP has also supported requests from Columbia River Inter-tribal Fish Commission (CRITFC) to provide genetic samples (caudal punches) from CJH summer- and spring-Chinook broodstock to aid in the development of a Columbia River Parentage Based Tagging (PBT) program. Samples were preserved on pre-labeled Whatman (GE Healthcare, Pittsburg, PA, USA) cellulose chromatography paper and shipped to CRITFC Lab in Hagerman, ID, USA. Genetic samples will continue to be collected from all hatchery broodstock at CJH.

Rotary Screw Traps

One 2.4 m and one 1.5 m rotary screw trap (RSTs) were deployed from the Highway 20 bridge near the City of Okanogan (rkm. 40) (Figure 3). The RSTs were operated from April 4 to June 24, 2016. Trapping typically occurred continuously from Monday through Friday, and for 12 hours, from 2000-0800 Saturday and Sunday. Trapping operations were suspended on April 23-26, April 30, May 28-29, June 4-5, June 11-12, and June 17-19 due to high river discharge and debris load or staffing constraints. To continue trapping operations in varying river conditions, traps were operated in one of three trapping configurations: 2.4 m only, 1.5 m only, and both traps operational.



Figure 3. 2.4-m (left) and 1.5-m (right) traps fishing in the Okanogan River. The boat is used by technicians to access the 2.4-m trap. Photo by CCT.

During operation, the trap locations were adjusted in the river to achieve between 5-10 revolutions per minute. The traps were checked every two hours unless a substantial increase in flow (≥ 500 cfs in a 24-hour period) or debris load occurred, in which case they were checked and cleaned more frequently. All fish were enumerated, identified to species, and life stage, origin (adipose fin present or absent), and disposition (whether the fish was alive or dead), and a subsample of natural-origin Chinook was measured. The fork lengths of the first 10 unmarked Chinook of each 100 encountered in the live well were measured to the nearest mm and released during each trap check. Steelhead smolts were not measured in order to minimize handling and stress of ESA-listed species. Unmarked (adipose fin present) Chinook captured in the RST that were ≥ 65 mm total length received a 12 mm full duplex PIT tag. A tissue sample (fin clip) was collected from (1) all fish that received a PIT tag and (2) any yearling unmarked Chinook for future genetic analyses.

EFFICIENCY ESTIMATES. — An estimate of the daily number of juvenile out migrants passing the trap location requires an estimate of the proportion of fish caught by the traps. This was accomplished using mark-recapture methodologies developed by Rayton and Wagner (2006), maintaining continuity with the techniques employed at this RST operation in previous years. This mark-recapture procedure (hereafter referred to as an efficiency trial) was

conducted using both natural-origin sub yearling Chinook and hatchery-origin yearling Chinook. Only fish with a fork length of at least 45 mm were used in efficiency trials.

After collection from both the 2.4 m and 1.5 m rotary screw traps, fish were marked in 5 gal buckets with Bismarck Brown dye at a concentration of 0.06 g/gal, held for 10-15 minutes with aeration and transported in buckets via a truck for release. Fish were released at night (typically between 0000 and 0330) approximately 1.6 river km upstream by the Oak Street Bridge. Fish were distributed evenly on both sides of the river to allow for equal distribution across the channel. The probability of capture was assumed to be the same for hatchery-origin fish as it was for natural-origin fish.

Because of variable flow and debris conditions, at any given moment, one of several trapping configurations could have been employed, in which either one, both, or neither of the 2.4 and 1.5 m screw traps could be operating. In order to derive an ultimate out migrant estimate, efficiency estimates for all of these configurations were calculated.

Trap efficiency was calculated by the equation

$$E_{ti} = \sum R_{ti} / \sum M_i$$

where E_{ti} is the trap efficiency for trapping configuration t in sampling period i , $\sum R_{ti}$ is the sum of marked fish that are recaptured in trap configuration t during sampling period i , and $\sum M_i$ is the sum of marked fish released during the sampling period i .

Trap efficiencies were recorded for each individual trap as it operated, and for both traps operating in unison. Trap efficiencies for each individual trap were further refined by including results for each individual trap while both traps were in operation. For example, if 100 marked fish were released, and 1 was recaptured in each trap, each individual trap displays an efficiency of 1%, and the efficiency of both traps operating simultaneously is 2%. This relies on the assumption that the efficiency of each trap is unaffected by whether the other is operating or not.

RST ANALYSIS. — Hourly catch was expanded to an hourly outmigration estimate based on measured trap efficiency by using the Lincoln-Peterson mark-recapture model with a Chapman modifier, which can improve estimates when recapture rates are low (Seber 1982). This model relies on the following assumptions:

- 1.) All marked fish passed the screw trap or were recaptured during time period i
- 2.) The probability of capturing a marked or unmarked fish is equal
- 3.) All marked fish recaptured were correctly identified as a marked fish
- 4.) Marks were not lost or overlooked between time of release and recapture

Total juvenile Chinook emigration was calculated for each trap configuration using a pooled Peterson estimator with a Chapman modification, such that

$$\hat{N} = \left[\frac{(M_p + 1)(C_p + 1)}{(R_p + 1)} \right] - 1$$

Where \hat{N} is total emigration estimate, M_p is the total number of marked individuals during the trapping season, C_p is the total number of fish caught during the trapping season, and R_p is the total number of recaptured fish during the trapping season.

An approximately unbiased estimate of the variance of the population, $\hat{V}[\hat{N}]$, is calculated by the equation

$$\hat{V}[\hat{N}] = \frac{(M_p + 1)(C_p + 1)(M_p - R_p)(M_p - R_p)}{(R_p + 1)^2(R_p + 2)}$$

The precision of the population estimates was assessed by including 95% confidence intervals calculated by the equation

$$\hat{N} \pm 1.96 \sqrt{\hat{V}[\hat{N}]}$$

Estimates and confidence intervals were calculated for all trapping configurations and then summed to generate an overall estimate for the trapping season. During periods when neither trap was operating, an estimate was calculated based on the average catch of an equal time period immediately prior and following the inoperable period. For example, no traps were operable on April 30, so catch for that day was estimated to be the average of total catch on April 29 and May 1.

Trapping efficiency and outmigration estimation was also examined using a smolt abundance estimator provided by WDFW and developed for its efforts in the Wenatchee River that incorporates stream flow and weights efficiency trials according to the number of released fish (Murdoch et al. 2012; Ryding 2000).

Juvenile Beach Seine/PIT tag effort

Portions of the following text describing the methods were taken directly from a draft DPUD report (DPUD 2014).

Beach seining took place from May 12 to June 23 in the area near the confluence of the Okanogan and Columbia Rivers. Efforts focused on beaches along the North bank of the Columbia River, downstream of the mouth of the Okanogan (48° 6'12. 46"N, 119°44'35. 48"W) (Figure 4). In 2016, Gebber's Landing and Washburn Island were the only areas used for

collection. This location provided reasonable catch rates, limited bycatch, and provided suitable substrates (limited debris loads/underwater snags) for efficient sampling. Juvenile Chinook from this location were likely primarily fish originating from the Okanogan River; however, it is possible that offspring from mainstem Columbia River spawning could also be included, especially at the Washburn Island site.



Figure 4. Seining locations downstream (Gebber’s Landing) and upstream (Washburn Island) of the confluence.

A single beach seine (30.49 m × 3.05 m with a 28.32 m³ 'bag'; Christensen Net Works, Everson, WA) was used to capture fish. Netting was Delta woven 6.4 mm mesh with “fish-green” treatment. Weights (3-5 kg) were attached to each end of the seine to help keep it open during retrieval.

To capture fish, one end of the seine was tied off to shore, while the other was towed out by boat until the seine was stretched perpendicular to shore. The boat would then pull the seine upstream and return to shore, causing the seine to form a semi-circle intersected by the shore line (Figure 5). The seine bridle was handed from the boat to a shore crew that would retrieve the seine. Juvenile Chinook were transferred to a 10-gallon tub filled with river water and transferred to a nearby floating net pen. Handling/holding time in the tub was generally <15 minutes. Floating net pens were approximately 5 m³ and consisted of a PVC pipe frame covered with black 19.1-mm and 3.2-mm mesh. The mesh allowed for adequate water exchange, retained juvenile Chinook and prevented the entrance of predators. Noticeable bycatch, most commonly three-spine stickleback (*Gasterosteus aculeatus*) were released from the seine without enumeration. Any bycatch inadvertently transferred to the floating net pen were later sorted and released during tagging (untagged). On May 12, 19, and 25, fish captured in the beach seine were immediately tagged on the river shore and released after recovery from anesthesia.



Figure 5. Juvenile beach seine being retrieved by CCT staff near the confluence of the Okanogan and Columbia Rivers.

Juvenile Chinook were held 24 hours prior to tagging to assess capture/handling effects. Chinook ≥ 65 mm were tagged with a full duplex 12 mm PIT tag, and Chinook between 65 and 50mm were tagged with a full duplex 9mm PIT tag. After tagging, fish were returned to a floating net pen for 24 hours post-tagging to assess tag loss and tag application/handling mortality rates. Fish were then released to the Columbia River (Wells Pool) several hundred meters downstream of their capture location.

TAGGING PROCEDURES. —Tagging was conducted by CCT staff with support from USGS using a mobile tagging station (Biomark, Co., Boise, ID, USA). The tagging station consisted of an approximately 1 m² aluminum work surface with a trough for holding fish during the tagging process as well as all the necessary electronics (computer, scale, tag reader, and antenna) needed for tagging. Water was pumped directly from the river using a ¼ horsepower pump and radiator system to keep water temperatures ambient with river temperatures. When tagging water temperatures were >17 °C, ice was added to the anesthetic solution to decrease the temperature. A solution of 4.0 g Tricaine methanesulfonate (MS-222) per 1 L of water was used to anesthetize fish prior to tagging. The applied concentration of MS-222 would sedate fish to the desired level of stage-2 anesthesia in approximately 3 to 4 minutes. All fish were tagged within 10 minutes of the initial exposure. Recovery time was approximately 1 to 2 minutes.

Each tagging location had two net pens: one containing the fish to be tagged, and an empty pen for holding fish post-tagging. Fish to be tagged were collected from the respective net pens using a dip net and placed into an 18.9 L bucket of water. Up to 40 fish at a time were then transferred from the bucket using a smaller dip net and placed into the trough containing the anesthetic solution.

Fish were tagged with 12.5 mm 134.2 kHz ISO PIT tags using pre-loaded, 12-gauge hypodermic needles (BIO12.BPLT) fitted onto injection devices (MK-25). 12.5 mm PIT tags were used to maximize detection at downstream locations, particularly the Rocky Reach Juvenile Bypass and the Bonneville Dam Corner Collector. Detection efficiencies at both of the former sites would dramatically suffer when using the smaller PIT tags available. The tagging crew consisted of one fish sorter, one tagger and one data collector. The data collector interrogated the tag in each tagged fish, recorded its fork length with an electronic wand on a digitizer board, and noted any anomalies. Tagged fish were transferred to the recovery/holding pen via a PVC pipe with flowing water.

Data collected during tagging were stored using PITTAG3 (P3) software (Pacific States Marine Fisheries Commission). After completion of the tagging events, tag files were consolidated, uploaded to PTAGIS (www.ptagis.org), and shared with Douglas PUD.

FISH RELEASES. —Tagged fish were released the morning after they had been tagged. Prior to release, the net pen was opened and all observed mortalities and moribund fish were removed. Once the mortalities were removed the net pen was tilted to allow the fish to voluntarily exit. PIT tags were recovered from dead/moribund fish, the associated tag codes

were marked as “Mortalities” in the tag files and the tag codes were deleted. Expelled tags were recovered from the mesh floor via a powerful magnet.

Lower Okanogan Adult Fish Pilot Weir

The Okanogan adult fish pilot weir (herein referred to as the ‘weir’) was in its fifth year of design modifications and testing in 2016. 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 2016 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 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;

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 8th at a river flow of 1,530 cfs and was complete with the underwater video system on August 17th. 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 6). The wings of the weir stretched out from either side of the trap towards the river banks, angling downstream in a slight V configuration. The wings consisted of steel tripods with aluminum rails that supported the 3 m long Acrylonitrile butadiene styrene (ABS) pickets. Each panel was zip-tied to the adjacent panel for strength and stability. Sand bags were placed between panels when needed to fill gaps that exceeded the target picket spacing. Picket spacing ranged from 2.5 to 6.4 cm (1 to 2.5 inch) in 1.2 cm (half-inch) increments (Figure 7). 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 7). 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. In past years CCT has observed jack and even adult Chinook passing through the 7.6 cm picket spacing panels. The 7.6 cm picket spacing panels were replaced with 6.4 cm picket spacing panels during deployment to reduce the escapement of smaller hatchery Chinook. This decision was made after consultation with the Technical Oversight Group (TOG) because the majority of Sockeye had already escaped into Canada before the weir was deployed.



Figure 6. Lower Okanogan adult fish pilot weir, 2016. Photo taken in early August during deployment.

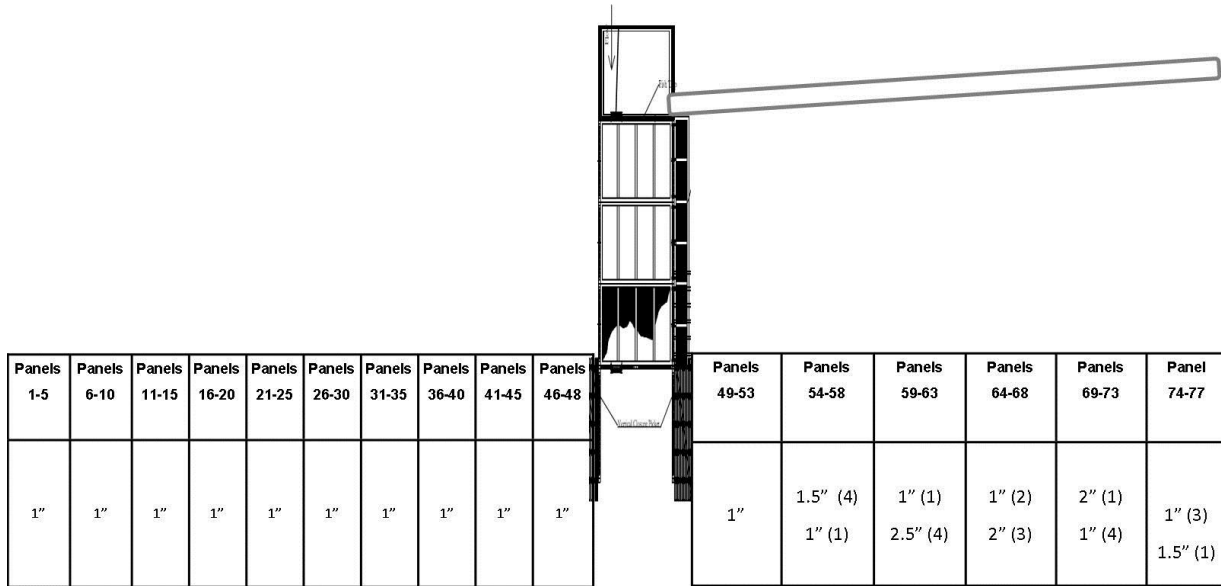


Figure 7. Conceptual diagram of picket (ABS pipe) spacing within each panel (or set of 4 panels) at the Lower Okanogan adult fish pilot weir in 2016.

A negative pressure transport tube, known as a Whooshh™ fish transport system, was installed to assist CCT with broodstock collection at the Okanogan weir (Figure 8). The 49 m tube was connected to an accelerator at the upstream side of the trap and at a mobile trailer fitted with a decelerator, tower, tube reel, blower housing, and accelerator entrance and exit mounts. A diesel generator provided remote power to run the pump that generated power for the pneumatic portions of the system.



Figure 8. Whooshh™ fish transport system installed at the Okanogan weir. Photo taken from the gangway at the trap.

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 during daylight hours, generally 0400-2000, under allowable temperature conditions ($\leq 22.5^\circ \text{C}$) from August 22 to September 22. 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. Sixteen natural origin Chinook were collected from the weir trap from September 9 to September 14, transported to a 2,500 gallon hatchery truck via the Whooshh™ fish transport system. The fish were then transported approximately 32 km to Chief Joseph Hatchery where they were held in the broodstock raceways until spawning in October. Otoliths were removed from spawned adults and read at the WDFW otolith lab in Olympia. Results were used to assess whether or not Priest Rapids Hatchery fish were included in the CJH integrated brood.

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.

Spawning Ground Surveys

The objectives for spawning surveys were to:

1. Estimate total spawning escapement based on the number of Chinook redds per reach
2. Estimate the proportion of natural spawners composed of hatchery-origin recruits (pHOS)
3. Estimate pre-spawn mortality and mean egg retention for wild- and hatchery-origin spawners
4. Determine the origin (rearing/release facility) of hatchery-origin spawners (HOS) in the Okanogan and estimate the spawner composition of out of population and out of ESU strays (immigration)
5. Estimate out-of-population stray rate for Okanogan hatchery Chinook and estimate genetic contribution to out-of-basin populations (emigration)
6. Determine age composition of returning adults through scale analysis
7. Monitor status and trends of demographic and phenotypic traits of wild- and hatchery-origin spawners (age-at-maturity, length-at-age, run timing, SAR)

REDD SURVEYS

A primary metric used to monitor the status and trends of salmonid populations is spawning escapement. Estimates of spawning escapement can be calculated based on redd counts and expanded by sex-ratios (Matthews and Waples 1991, Gallagher et al. 2007). This requires intensive visual survey efforts conducted throughout the spawning area and over the course of the entire spawning period. Visual redd surveys were conducted to estimate the number of redds per survey reach from the mouth of the Okanogan River to Zosel Dam (river km 124); the Similkameen River from its confluence with the Okanogan River upstream to Enloe Dam (river km 14); and in the mainstem Columbia River from the mouth of the Okanogan River upstream to Chief Joseph Dam (Table 3). Weekly surveys were timed to coincide with spawning in the basin, generally beginning the last week of September or the first week of October and ending approximately the second week of November. Redds were counted using a combination of fixed-wing aerial flight surveys and inflatable raft float surveys.

Aerial surveys occurred once weekly throughout the spawning season, each covering the entire survey area. Aerial surveys were flown at low elevation and at moderate speeds to accommodate visual identification of redds. From the aircraft, a trained observer recorded the number and GPS coordinates of all new redds as the plane passed overhead. All data were recorded directly into a YUMA rugged computer tablet (Trimble Navigation, Ltd.). Aerial surveys were primarily used to document redds in areas inaccessible to rafts, or in areas of low redd densities, such that they did not warrant weekly float surveys. All data points were visualized in

ArcGIS (ESRI, Inc.), and quality controlled to ensure that redd counts were not duplicated during float surveys. Aerial surveys also served a secondary function of informing research crews where to focus weekly carcass recovery efforts (see below section on Carcass Surveys).

Float surveys occurred once daily, 5 days per week throughout the spawning season. Float surveys consisted of three 2-person teams using inflatable rafts to count redds while floating downstream. Each team was responsible for covering one-third of the river width, (1) left bank, (2) center, and (3) right bank. Each individual redd was counted and its position recorded directly into a YUMA rugged computer tablet (Trimble Navigation, Ltd.).

Table 3. Reach names and locations for the Okanogan and Similkameen for summer/fall Chinook Salmon spawning and carcass surveys.

Stream	Code	Reach Description	River km
Okanogan	O1	Mouth to Malott Bridge	0.0-27.0
	O2	Malott Bridge to Okanogan Bridge	27.0-41.8
	O3	Okanogan Bridge to Omak Bridge	41.8-49.1
	O4	Omak Bridge to Riverside Bridge	49.1-65.1
	O5	Riverside Bridge to Tonasket Bridge	65.1-90.9
	O6	Tonasket Bridge to Zosel Dam	90.9-124.0
Similkameen	S1	Mouth to Oroville Bridge	0.0-8.0
	S2	Oroville Bridge to Enloe Dam	8.0-14.0
Canada	Cx	TBD	TBD

All redds were classified as either a:

1. *Test-redd* (disturbed gravel, indicative of digging by Chinook, but abandoned or without presence of Chinook; generally, this classification is reserved for early season redd counts, before substantial post-spawn mortalities have occurred as indicated by egg-voidance analysis of recovered carcasses). Test-redds do not contribute to annual redd counts.
2. *Redd* (disturbed gravel, characteristic of successful Chinook redd construction and/or with presence of Chinook).

Redds per reach were calculated for each week as the combined number of new redds counted during aerial- and float-surveys for a given week. Post-season analysis consisted of summing the

combined aerial- and float-survey weekly redd totals to calculate annual redd totals per reach, and per total survey area. Estimated total spawning escapement was then calculated by multiplying the total redd count by the expansion factor for the current year (2.01 for 2016). The expansion factor = 1 + the number of males per female as randomly collected for broodstock at Wells Dam (1.01:1.00 in 2016). Assumptions include:

- Assumption I – Each redd was constructed by a single female Chinook, and each female Chinook constructed only one redd
- Assumption II – The male: female ratio on the spawning grounds was the same for wild- and hatchery-origin Chinook, and is equal to the male: female ratio as randomly collected for broodstock at Wells Dam
- Assumption III - Every redd was observable and correctly enumerated

Escapement into Canada

Video systems operated by OBMEP and located in the fishways of Zosel Dam allow observation of salmonids passing over Zosel Dam and potentially into the British Columbia portion of the Okanogan River Basin. For detailed methods within a particular year please see the Okanogan Basin Monitoring and Evaluation Program (OBMEP) annual reports posted at (http://www.colvilletribes.com/obmep_publications.php).

Passage over Zosel Dam can occur via the fishways or through the open dam gates. OBMEP assumes that any gate level > 1 foot is high enough for fish to pass upstream through the open gate rather than through the fish ladders and video arrays. In high water years, Chinook have the opportunity to pass through the gates rather than through the fishways. The estimates of Chinook escapement past Zosel Dam do not account for fish moving through the gates rather than the fishways. 2014 PIT detections of Chinook in the fishways indicated that smaller fish were able to fall back through the small openings in the Zosel Dam gates and then reascend through the fishways. An ascension/fallback/ ascension rate (AFA) was calculated and applied to the total Zosel estimate in 2014. Fallback/reascension is likely an underestimate of actual fallback since not all fallback re-ascend. Actual fallback is unknown. Due to uncertainties regarding estimations of AFA as well as the limitations of the video observation methods, Chinook passage is reported unadjusted for all subsequent years. AFA was calculated as the ratio of the number of unique PIT tagged fish (N_{PIT}) ascending the fishways, divided by the total number of their ascensions:

$$AFA = \frac{N_{PIT}}{\sum_{i=1}^{N_{PIT}} a_i}$$

where,

N_{PIT} = number of unique PIT-tagged fish ascending the ladder(s),

a_i = number of ascents made by the i th PIT-tagged fish ($i = 1, \dots, N_{PIT}$).

The video count (C) multiplied by the AFA provided an estimate of the total passage abundance (N):

$$N = C \cdot AFA$$

There were times when the video system was inactive for routine maintenance and cleaning. To estimate missed fish observations during this period, an average was taken of passage events during the hour before and after the inactive period. Spring Chinook were also removed from the total estimate based on run timing at Zosel.

Data and discussion presented herein are intended to begin the process of understanding what is known, what is not known, and what the possibilities are for obtaining a reliable estimate of summer/fall Chinook spawners in the Canadian portion of the Okanogan River.

CARCASS SURVEYS

Carcass surveys provide important biological samples for evaluation of hatchery- and natural-origin fish on the spawning grounds, including:

- 1) Spawner composition
 - a. pHOS
 - b. out of population hatchery strays (immigration)
 - c. spatial distribution of natural- and hatchery origin spawners
- 2) Fish size
- 3) Sex-ratio
- 4) Age structure (CWT and scale analysis)
- 5) Pre-spawn mortality (i.e. egg retention)

The target sample size for carcass recovery efforts is 20% of the spawning population within each reach (Hillman et al. 2014). Carcass recovery efforts occurred simultaneously with redd float surveys. Recovered carcasses were transported within inflatable rafts downstream until a suitable site was found for processing. If a carcass was too degraded to sample for biological data, it was returned to the river, unsampled. All adipose absent carcasses were assumed to be of hatchery-origin, and all carcasses displaying an intact adipose fin were assumed to be of natural-origin³. Biological data collected from carcasses included sex, fork length (FL) and post-orbital hypural length (POH) to the nearest cm, and estimated egg

³There could have been some hatchery-origin fish with an intact adipose fin. Although all summer/fall Chinook hatchery programs in the Upper Columbia strive for a 100% adipose fin clip rate, a small percentage (~1%) may not receive the fin clip due to mechanical failure in the marking trailer. Additionally, not all fall Chinook programs, such as Priest Rapids Hatchery, clip the adipose fin of their releases.

retention for all females (0 to 5,000 max; visually estimated). All eggs that were not estimated to be within a carcass were assumed to have been successfully deposited. Any female carcass containing an estimated 5,000 eggs were considered a pre-spawn mortality. Forceps were used to remove five scale samples from all natural-origin Chinook. Scales were adhered to desiccant scale cards for preservation and identified by sample number and sample date. At the conclusion of spawning season, scales were sent to WDFW for post-hoc age analysis. Age analysis data were used to assess age-at-return (run-reconstruction), and combined with biological data to assess length-at-age. All Chinook were scanned for passive integrated transponder (PIT) tags and all PIT detections were recorded and later uploaded to PTAGIS. Carcasses were scanned with a T-wand (Northwest Marine Technology, Inc., Shaw Island, WA USA) for coded wire tags (CWT). If present, the snout portion was removed and individually bagged and labeled with species, origin, FL, river of recovery and date. After sampling each carcass, the caudal fin was removed before the carcass was returned to the river to avoid resampling on subsequent surveys. All data collected in the field were input directly into a YUMA rugged computer tablet (Trimble Navigation, Ltd.). Weekly carcass recovery totals were summed post-season to calculate annual carcass recovery totals per reach and per survey area.

Some key assumptions for carcass surveys included:

- Assumption I – All carcasses had the same probability of being recovered on the spawning grounds (despite differences in sex, origin, size or spawning location)
- Assumption II – The diagnostic unit in which a carcass is recovered is the same as the reach in which the fish spawned
- Assumption III – Sampled carcasses are representative of the overall spawning composition within each reach

pHOS and PNI

pHOS was first calculated using the straightforward method of calculation for the population-level pHOS by simply dividing the number of hatchery-origin spawners by the total spawners, such that:

$$pHOS = \frac{HOS_o}{HOS_o + NOS_o}$$

where HOS_o is the total recovered hatchery-origin carcasses and NOS_o is the total recovered natural-origin carcasses. This simple algorithm does not account for assumed deficiencies in hatchery fish effectiveness (*i.e.* relative reproductive success) nor does it account for spatial variation in pHOS and unequal sampling effort across reaches. For example, reach S1 tends to have a higher pHOS than other reaches because the Similkameen acclimation site is located in the reach. Likewise, the probability of recovering carcasses in low density spawning reaches is

lower than in reaches with high density spawning. We have attempted to account for each of these factors.

Relative reproductive success has not been estimated for summer/fall Chinook in the Okanogan. One of the key assumptions in the In-Season Implementation Tool was that first-generation hatchery fish are less effective natural spawners than natural-origin fish. Currently, the hatchery fish effectiveness assumption for the Okanogan population is that first generation hatchery-origin spawners are 80% as effective as natural-origin fish as contributing genes to the next generation⁴ This assumption is based on research conducted by Reisenbichler and McIntyre (1977) and Williamson et al. (2010). Therefore, the pHOS calculation was amended in 2013 to account for the reduction in hatchery spawner effectiveness, such that:

$$Effective\ pHOS = \frac{0.8\ HOS_o}{0.8\ HOS_o + NOS_o}$$

Further refinement of the pHOS calculation was needed to account for non-random sampling of carcasses and variable pHOS across reaches. This was done by weighting each reach's overall contribution to system-wide pHOS according to the overall proportion of summer/fall Chinook redds that occurred within that reach.

First, the proportion of redds that corresponded to each reach was calculated by the equation:

$$redd_{p,r} = \frac{redd_r}{redd_o}$$

where, $redd_r$ is the number of documented redds that occur within reach r , $redd_o$ is the total number of redds documented in the U.S. portion in the Okanogan River Basin, and $redd_{p,r}$ is the proportion of total redds that were documented in reach r .

Next, Effective pHOS was calculated separately for each sampled reach, r , so that:

$$pHOS_r = \frac{0.8HOS_r}{0.8\ HOS_r + NOS_r}$$

where $pHOS_r$ is the Effective pHOS calculation for reach r , and HOS_r and NOS_r are the total recovered carcasses of hatchery- and natural-origin within that reach. Finally, Effective pHOS was corrected for the proportion of redds in each reach to determine an adjusted Effective pHOS, such that:

$$Effective\ pHOS = \sum_{i=1}^n pHOS_r(redd_{p,r})$$

⁴ This 80% correction factor has also been suggested by the HSRG as a default value when no direct estimates are available (HSRG 2009). Also see HSRG 2014 for a discussion about the definition and calculation effective pHOS.

where n is the total number of sampled reaches that compose the Okanogan River Basin. These calculations assumed that sampled carcasses were representative of the overall spawning composition within each reach; that no carcasses were washed downstream into another reach; that all carcasses had an equal probability of recovery; and that all fish within origin types had equal fecundity. While it is unlikely that all of these assumptions were correct, the modified calculation results in a better representation of the actual census pHOS.

PNI was calculated as:

$$PNI = \frac{pNOB}{Effective\ pHOS + pNOB}$$

where $pNOB$ was the proportion of broodstock that were natural-origin Okanogan returns, and *Effective pHOS* was the reach weighted effective pHOS defined previously. To determine an Okanogan specific pNOB, we applied the results of a radio tracking study, which estimated that 90% of the natural-origin fish detected near the mouth of the Okanogan River in 2011 and 2012 ended up spawning in the Okanogan Basin (Mann and Snow 2013). Therefore, we assumed that 90% of the NOB collected in the purse seine (2010-2013) was of Okanogan origin.

In years prior to 2010 all of the broodstock for the Similkameen program were collected at Wells Dam. That program strived for 100% pNOB and did achieve >95% pNOB in 7 of the last 8 years (Hillman et al. 2014). However, the Wells Dam broodstock collection efforts composited natural-origin fish from the Okanogan and Methow populations as well as fish originating from downstream populations⁵. We made a correction for non-Okanogan NOB for all years when Wells Dam was used for brood collection using the formula:

$$Adjusted\ Wells\ Dam\ pNOB = Wells\ Dam\ pNOB * \left(\frac{Okanogan\ NOS}{Okanogan\ NOS + Methow\ NOS} \right)$$

where the *Adjusted Wells Dam pNOB* was estimated based on the proportion of natural-origin spawners (NOS) that were in the Okanogan compared to the Methow for that particular year. This correction was made for a portion of the broodstock in 2010 and 2011 and all of the broodstock previous to 2010. This correction did not account for stray NORs from downstream populations or NORs that would have remained in the Columbia River above Wells Dam. Although the radio tracking study provides an estimate of this for 2011 and 2012, there was uncertainty regarding the applicability of the radio tracking data for years prior.

Origin of Hatchery Spawners

Snouts from adipose fin clipped fish were removed, individually labeled, frozen, and delivered to the Chief Joseph Hatchery coded wire tag lab for CWT extraction and reading. The

⁵ A radio tracking study showed that fewer than 50% of the natural-origin fish tagged at Wells Dam ended up in the Okanogan in 2011 and 2012 (Mann and Snow 2013).

Regional Mark Information System (RMIS; <http://www.rmis.org/rmis>) was queried in July 2017 to assess the rearing facility of hatchery-origin Chinook recovered on the Okanogan spawning grounds, the in-to-basin stray rate, and the out-of-basin stray rates. RMIS data queries are described in detail in the 2013 CJHP Annual Report (Baldwin *et al.* 2016)

Smolt-to-Smolt Survival and Travel Time

Survival and travel time were assessed using the Data Acquisition in Real Time (DART) website analysis tools. DART calculates a survival estimate using a Cormack Jolly Seber mark recapture model, for full details on the analysis methods please see the DART website (http://www.cbr.washington.edu/dart/query/pit_sum_tagfiles). Each CJH release group with PIT tags were queried for survival from release to Rocky Reach Dam Juvenile bypass (RRJ) and McNary Dam Juvenile bypass (MCN). Although some recaptures were obtained further downstream than McNary Dam, survival through the entire hydropower system to Bonneville Dam could not be generated because there were not enough recaptures downstream to estimate the recapture probability. Survival estimates and travel time for nearby hatcheries and the wild summer Chinook captured in the RST and beach seine were also analyzed for comparison purposes.

Survival estimates are ‘apparent survival’ because they were not adjusted for residuals, tag failure, tag loss (shedding), or other factors which could result in fish not dying but not being detected at a downstream location. Due to these factors, actual survival would be higher than the apparent survival estimates provided in this report.

Migration timing from release to the lower Okanogan River was determined using a query of the PTAGIS database (<https://www.ptagis.org/data/quick-reports/small-scale-site-detections>) to determine the timing of PIT tag detections from releases of Summer Chinook at Omak Pond and Spring Chinook at Riverside Pond. No PIT tags were released from Similkameen Pond in 2016. The lower Okanogan River PIT tag interrogation site (OKL) is located at rkm. 25 and is within 2 km of the inundation effects of Wells Dam.

Smolt-to-adult Return

The smolt to adult return rate (SAR) was estimated as:

$$SAR = \frac{\text{expanded CWT recoveries}}{\text{CWT released}}$$

where expanded CWT recoveries included estimated expanded recoveries on the spawning grounds, at hatcheries and in fisheries. Two expansions were applied. First the number of recoveries was expanded to account for the proportion of the release group that wasn't tagged. For example, with a 99% CWT mark rate the recoveries would be increased by 1%. Second, the recoveries were expanded based on the proportion of the population that was sampled. For

example, if carcass surveys recovered 20% of the estimated spawners then the number of CWT recoveries was expanded by 80%. The number of CWT fish released were simply the hatchery release data including all tag codes for CWT released fish (CWT + Ad Clip fish and CWT-only fish).

Spring Chinook Presence and Distribution

Smolt releases of CJH 10(j) spring-Chinook did not occur in the Okanogan until April 2015. However, occasional occurrence of spring-Chinook was detected in the Okanogan, likely due to straying of individuals from other populations. Pre-reintroduction monitoring for spring Chinook consisted of environmental DNA (eDNA) (see Laramie et al 2015 for details of the eDNA sampling) and PIT tag sampling and analysis at tributary and mainstem Okanogan sites to determine the baseline distribution, prior to the 10(j) reintroduction. In order to target spring-Chinook specifically, rather than summer/fall Chinook, eDNA samples were collected in tributary habitats, which are not typically utilized by summer/fall Chinook. Additionally, monitoring programs throughout the Columbia Basin are implanting PIT tags into both hatchery- and natural-origin spring Chinook as juveniles that might stray to the Okanogan as returning adults. The monitoring programs at Bonneville and Wells dams tags returning adult spring Chinook, which greatly increases the probability of encountering a spring Chinook with a PIT tag in the Okanogan. In 2016, the spatial distribution of spring Chinook was evaluated using a combination of eDNA and PIT tag data. We queried the PTAGIS database using an interrogation summary for all PIT detection sites in the Okanogan and Similkameen Rivers, including Canada. Once a list of tag codes was obtained, a second query was run to determine if any of the fish had a final detection outside the Okanogan. 2016 was the first year for jacks (3 year old male) to return from the releases of PIT tagged juveniles as part of the CJH program.

Coded Wire Tag Lab Analysis

Coded wire tags (CWT) from broodstock, ladder surplus, purse seine harvest, creel and spawning ground surveys were extracted, read, and reported in the Chief Joseph Hatchery Lab from December 2016 to April 2017. The snouts were then interrogated for the presence of a CWT by using a V-reader or T-wand. After positive detection, the snout was cut bilaterally into symmetrical portions keeping the half that indicated detection and discarding the other half into the snout bag from which it came. This process was then repeated until only a small piece of tissue containing the CWT remains. The final piece of tissue was then smeared on a cutting mat exposing the CWT, then placed on its corresponding snout card and finally on to a cafeteria tray (groups of ~25 tags) to be read under a microscope.

Extracted tags were removed from the tray one-by-one to be cleaned, recorded and read. The CWT was cleaned by wetting a lint free cloth and rolling the tag between a finger and cloth

to remove all remaining tissue. The CWT was attached to a Northwest Marine Technologies (NMT) magnetic pencil and inserted into a jig to be read under a LCD microscope with the aid of an illuminator. Biological data was transcribed from the snout card to a final CWT datasheet. The CWT was attached to this datasheet with tape after the six digit code was read. Information from the datasheet was then transferred to an excel workbook which contains all applicable CWT code combinations.

CWTs were expanded based on their mark and sample rate to estimate total catch contribution for a specific fishery. For each fishery, every CWT recovered was grouped according to the hatchery from which it originated, and then divided by mark and sample rate to expand the number of fish caught. It was common to see many different tag codes from the same hatchery during a given brood year. These tags need to be summed together then multiplied by an adjustment factor to adjust for tags that are present, as well as lost and unreadable. This methodology is applied to all recovered CWTs in a given area, then summed together to represent the total number of fish harvested as well as their place of origin. The following equations are used to expand and adjust for CWT recoveries:

$$CWT_{Expansion} = \frac{Total\ Recovered}{Tag\ Rate} \cdot \left(\frac{1}{Sample\ Rate} \right) \cdot (XYZ)$$

where *Total Recovered* was the total number of recovered tags in the fishery, *Tag Rate* was the proportion of fish that are coded wire tagged in the tag group (expressed as a decimal percentage), *Sample Rate* was the proportion of the total catch that are sampled for CWTs, and *XYZ* was the total adjustment factor calculated from recoveries without a decoded tag.

Coded wire tag recoveries were also adjusted for tags not adhering to the normal recovery process. That process was: the snout arrives at the lab, the tag is extracted from the snout, the tag is readable, and the result matches the tag's release information. Recovery results fall into one of two general categories: with and without decoded tags. They were assigned one of the following CWT result codes after completing the snout recovery to tag reading procedure:

Recoveries with a decoded tag:

- 1 Code read from the wire tag matches a tag release and is consistent with release information.
- 9 The wire tag has no code (blank) or agency-only code.
- 7 Code read from the wire tag does not match a tag release, or it is not consistent with the release information.

Recoveries without a decoded tag:

- 4 Tag wire was present, but the code is unreadable.
- 3 Tag wire was present (dissected from the snout) but was lost prior to the reading process.
- 2 Tag was not present in snout.
- 8 Snout was determined in the field to be from a wire-tagged fish, but the snout was not processed in the Tag Recovery Lab.

Decoded recoveries were adjusted for CWT result code 8 (represented as *X* in the expansion formula), CWT result code 4 (represented as *Y* in the expansion formula), and CWT result code 3 (represented as *Z* in the expansion formula). The formulas for these adjustment factors were as follows and are applied to CWT result codes 1,7 and 9 recoveries:

- (1) The adjustment factor due to the presence of CWT result code 8 tags is

$$X = \frac{\text{Tags}_1 + \text{Tags}_2 + \text{Tags}_3 + \text{Tags}_4 + \text{Tags}_7 + \mathbf{\text{Tags}_8} + \text{Tags}_9}{\text{Tags}_1 + \text{Tags}_2 + \text{Tags}_3 + \text{Tags}_4 + \text{Tags}_7 + \text{Tags}_9}$$

- (2) The lost tag recoveries (code 3) are accounted for by the following formula:

$$Y = \frac{\text{Tags}_1 + \mathbf{\text{Tags}_3} + \text{Tags}_4 + \text{Tags}_7 + \text{Tags}_9}{\text{Tags}_1 + \text{Tags}_4 + \text{Tags}_7 + \text{Tags}_9}$$

- (3) The unreadable tag recoveries (code 4) are accounted for by the following formula:

$$Z = \frac{\text{Tags}_1 + \mathbf{\text{Tags}_4} + \text{Tags}_7 + \text{Tags}_9}{\text{Tags}_1 + \text{Tags}_7 + \text{Tags}_9}$$

- (4) Finally, any CWT result code 3, 4, or 8 recovery is assigned an expansion factor of zero, since its presence is accounted for in the decoded recoveries by the above adjustment equations. Decoded tags are not adjusted for CWT result code 2 "no tags".

RESULTS

Rotary Screw Traps

The rotary screw traps captured 13,321 Chinook juvenile out migrants, including 661 hatchery- and 12,660 natural-origin. Pulses of high catch rates coincided with periods of increased streamflow in mid- and late-April (Figure 9). The mean length of Chinook increased throughout the trapping season, but the number of natural-origin smolts that were large enough (>65 mm) to PIT tag was small (n=280) (Figure 10). Unlike previous years, no fish were captured that were likely yearling Chinook. Dorsal fin clips were removed and archived on a portion of tagged fish, including all presumed yearlings, for genetic identification to determine if they were spring or summer/fall Chinook at a future date.

Following Chinook, the next most abundant species captured in the RST was mountain whitefish (

Table 4). Notably, only 16 sockeye were detected, which is far lower than in previous years. Twenty-seven adipose fin present⁶ steelhead and 43 adipose fin absent (hatchery-origin) steelhead were removed from the trap and released immediately into the river. There were seven juvenile steelhead mortalities (three adipose fin present and four adipose clipped) at the trap resulting in a 10% juvenile trapping and handling mortality rate. The encounter of 43 adipose clipped and 27 adipose present (assumed natural-origin) and mortality of three (3) assumed natural-origin steelhead are within the take limits identified in the authorizing ESA Section 10(a)(1)(A) Permit for the rotary screw trap operation (Permit 16122).

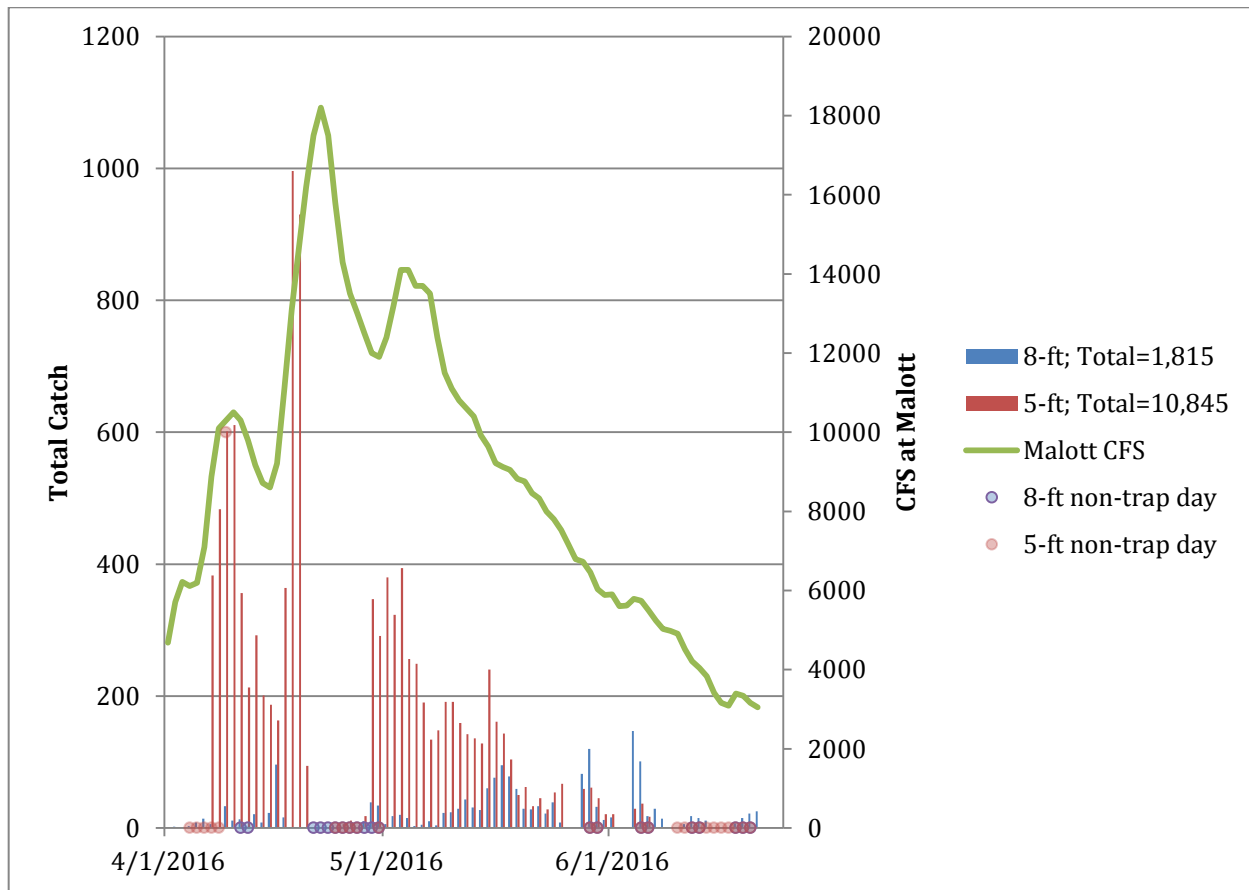


Figure 9. Daily natural-origin sub-yearling Chinook catch within an 8 foot and 5 foot rotary screw trap in the Okanogan River in 2016.

⁶ Not all hatchery steelhead released in the Okanogan receive an adipose fin clip. In 2016, 20,349 steelhead were released into the Similkameen River with an adipose clip, and 451 unclipped steelhead were released. In Omak Creek, 32,763 unclipped steelhead were released and in Salmon Creek, adipose clipped steelhead and 6,477 unclipped steelhead were released.

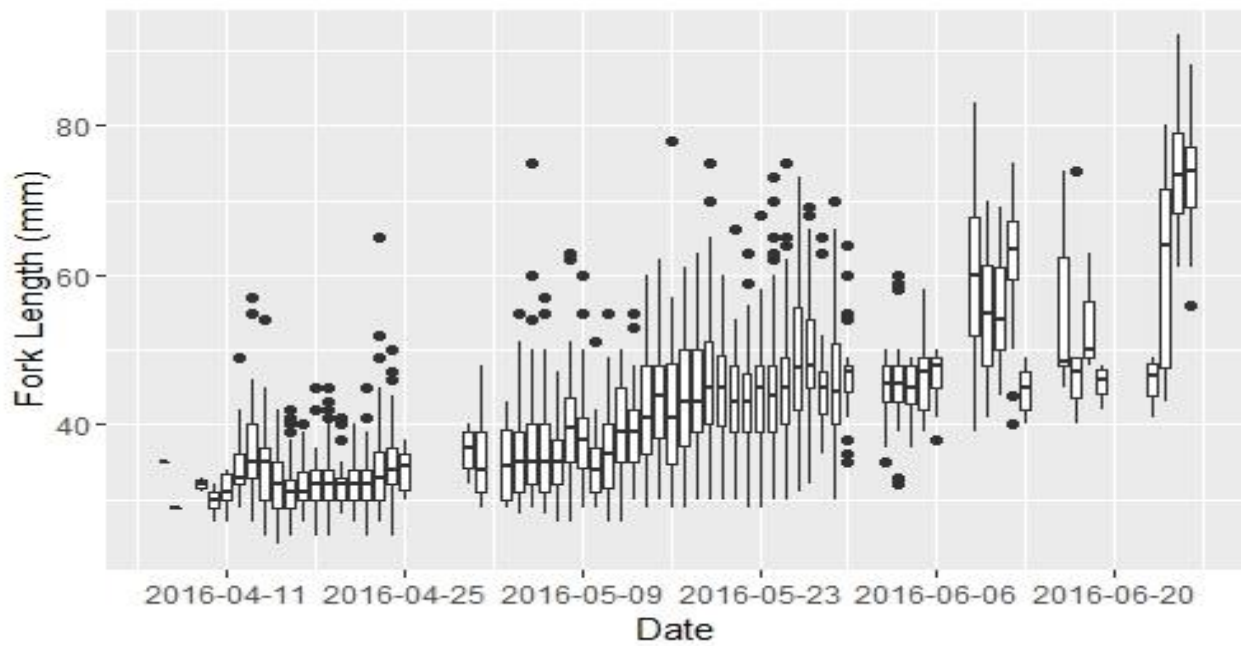


Figure 10. Natural-origin sub-yearling Chinook size distribution (n= 3,694) from the rotary screw traps on the Okanogan River in 2016. Boxes encompass the 25th to 75th percentiles of measured fish, the mid-line in the box is the median fish length.

Table 4. Number of juvenile fish trapped at the Okanogan River rotary screw traps in 2016.

Species	Total Trapped
Pumpkinseed sunfish	2
Bluegill	82
Bridgelip Sucker	2
Common Carp	16
Longnose Dace	2
Mountain Whitefish	452
Northern Pikeminnow	22
Largemouth Bass	41
Sculpin (<i>Cottus</i> spp.)	12
Smallmouth Bass	45
Three Spine Stickleback	1
Peamouth	1
Redside shiner	1
Speckled dace	1
Bullhead (<i>Ameiurus</i> spp.)	15
Yellow Perch	121
Non-salmonid	816
Adipose Clipped Steelhead	43
Adipose Present Steelhead	27
Hatchery Chinook	661
Sockeye	16
Wild Chinook Subs	12,660
Wild Chinook Yearling	0
Salmonid	13,402

Four efficiency trials were conducted with juvenile Chinook (three with natural-origin subyearlings and one with hatchery-origin yearlings) between 9,920-13,200 cfs (Table 5.). RST efficiency and Okanogan River flow were not correlated in 2016 ($p = 0.78$, adjusted $r^2 = -0.43$). As such, the WDFW smolt abundance calculator was not used.

Table 5. Efficiency trials conducted on natural-origin Chinook sub-yearlings at the Okanogan rotary screw traps in April and May, 2016.

Trap Date	River Flow @ USGS Malott	Total Chinook Marked and Released	Age Class / Origin	Total Chinook Recaptured	Trap Efficiency
4/13	10,400	1,410	1+ / Hatchery	3	0.002
5/5	13,400	1,075	0+ / Wild	0	0.00
5/11	12,200	1,482	0+ / Wild	4	0.003
5/17	9,730	1,615	0+ / Wild	0	0.00
Total		1,733	1,733	10	0.001

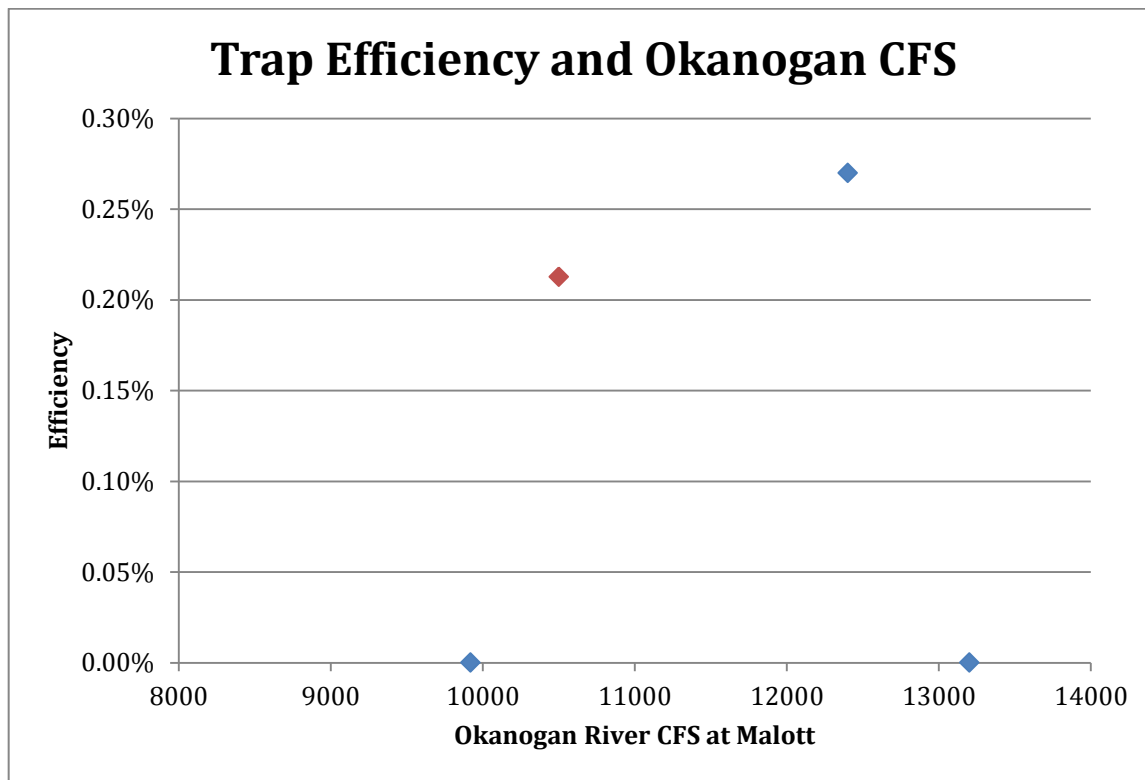


Figure 11. Okanogan River CFS was not predictive of RST efficiency, and so was excluded as a variable from juvenile production estimates. Efficiency trials conducted with natural-origin subyearlings are marked in blue, trials conducted with hatchery-origin yearlings are marked in red.

An efficiency trial was conducted on April 13 using hatchery yearlings from the Omak Pond (Table 6.). In the past, such trials have been used to explore the possibility of using hatchery-origin yearlings as a surrogate for natural-origin subyearlings, but significant differences in capture efficiency ultimately led to the abandonment of this idea. Nevertheless, a trial with hatchery-origin yearlings was conducted in 2016. Three hatchery-origin yearlings out of 1,410 released were recaptured (.21% efficiency).

Since streamflow did not affect trapping efficiency, efficiency trials were pooled to calculate overall trap efficiency for both natural- and hatchery-origin fish (Table 7). Overall efficiency estimates for natural- and hatchery-origin fish were low as were total catches, leading to a relatively imprecise estimate of total emigration (Table 8).

Table 6. Efficiency trial conducted on hatchery-origin Chinook smolts at the Okanogan rotary screw traps in 2016

Trap Date	River Flow @ USGS Malott	Total Chinook Marked	Total Chinook Released	Total Chinook Recaptured	Trap Efficiency
4/13	10,400	1,410	1,410	3	0.02
Total		1,410	1,410	3	0.02

Table 7. Pooled efficiency trail results for all trap configurations. Whenever fish were released, each trap was operational. Efficiency was calculated based on recaptures for each individual trap, as well as the combined efficiency of both traps.

		Mark-Released	Recaptured	Efficiency
2.4 m Trap	Hatchery Chinook	1,410	1	0.071%
	Wild Chinook	4,172	3	0.072%
1.5 m Trap	Hatchery Chinook	1,410	2	0.14%
	Wild Chinook	4,172	1	0.024%
Combined Traps	Hatchery Chinook	1,410	3	0.213%
	Wild Chinook	4,172	4	0.096%

Table 8. Population estimates for hatchery- and natural-origin juvenile Chinook salmon in the Okanogan River Basin.

Species	Population Estimate	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Hatchery-origin Chinook*	233,520	29,739	437,300
Natural-origin Chinook	10,566,870	2,118,348	19,015,391

* A total of 867,679 hatchery-origin Chinook were released into the Okanogan River system upriver from the screw trap site in 2016. 203,311 were released from the Riverside acclimation pond from April 15-21; 256,294 were released from the Similkameen hatchery from April 15 – April 22; 232,353 were released from the Omak acclimation pond on April 15-22; and 175,721 were released from Omak Pond from May 23-26.

Juvenile Beach Seine and Pit Tagging

In 2016, 15,802 natural-origin juvenile salmonids were collected in 202 sets for a total catch per unit effort of 78 per seine haul (Table 9). Out of the 15,802 juvenile salmonids collected, 13,650 (86%) sub-yearling Chinook were PIT tagged and released (Figure 12). Pre- and post-tag mortality was 2.0% and 3.9% respectively. Seventy-three shed tags were recovered from the net pens prior to release. Thirteen of the sheds were from post-tag mortalities, the other 60 were ejected from fish that were later released alive, but without a tag. All recovered tags were removed from the tagging file before upload to PTAGIS. Fish size increased through time (Figure 13), but the number of available fish to tag decreased (Table 9). By mid-June, Columbia River temperatures had risen to above 14° C. We suspect that sub-yearling Chinook may have migrated downstream, or to deeper, cooler water making it difficult to collect them via beach seine, as has presumably happened in past years. Overall size distribution for tagged fish was skewed towards smaller size ranging from 47-122 mm in length (Figure 14.). Bycatch included hatchery-origin juvenile Chinook, three-spine stickleback, carp, mountain whitefish, pumpkinseed, redbside shiner, smallmouth bass, dace species, and sculpin species.

Table 9. Summary of juvenile Chinook beach seining effort at Gebber’s Landing (Geb.) and Washburn Island (W.I.) in 2016. CPUE represents total Chinook per set.

Week start	Geb. sets	Geb. collected	Geb. CPUE (total/set)	W.I. sets	W.I. collected	W.I. CPUE (total/sets)
5/8/2016	1	13	13.0	0	0	-
5/15/2016	2	198	99.0	0	0	-
5/22/2016	2	256	128.0	0	0	-
5/29/2016	24	4729	197.0	0	0	-
6/5/2016	25	7606	304.2	0	0	-
6/12/2016	55	558	10.1	9	50	5.6
6/19/2016	21	936	44.6	24	1411	58.8
6/26/2016	25	44	1.8	4	1	.25
7/3/2017	10	0	0.0	0	0	-
Total	165	14,340	107	37	1,462	58
Mean	18	1,593	87	4	162	40

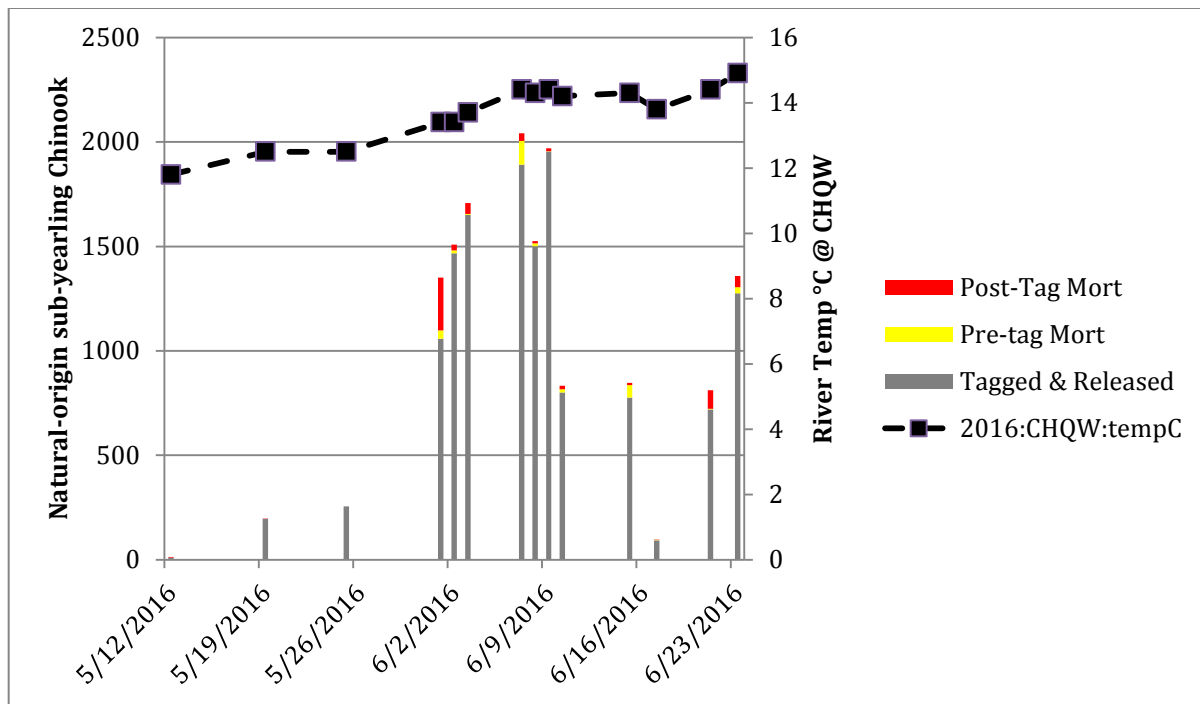


Figure 12 Total mortality and number of released natural-origin sub-yearling Chinook in 2016.

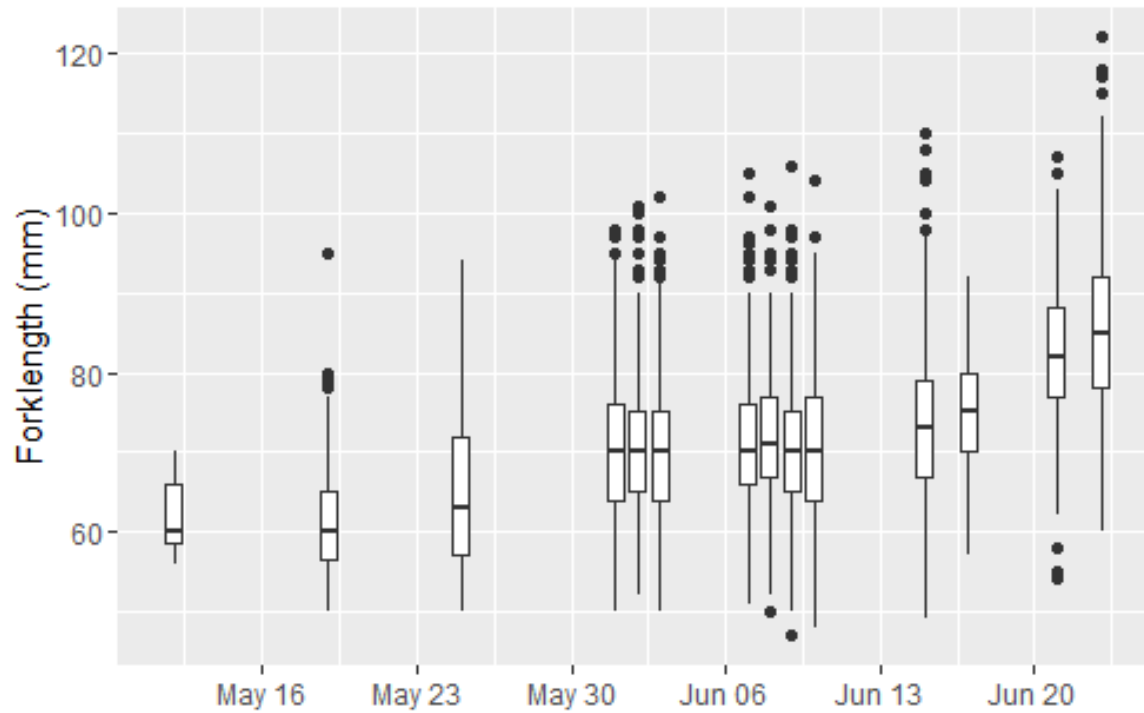


Figure 13. Size distribution of PIT tagged juvenile Chinook by release date from the beach seine effort in 2016. Boxes encompass the 25th to 75th percentiles of measured fish, the mid-line in the box is the median fish length.

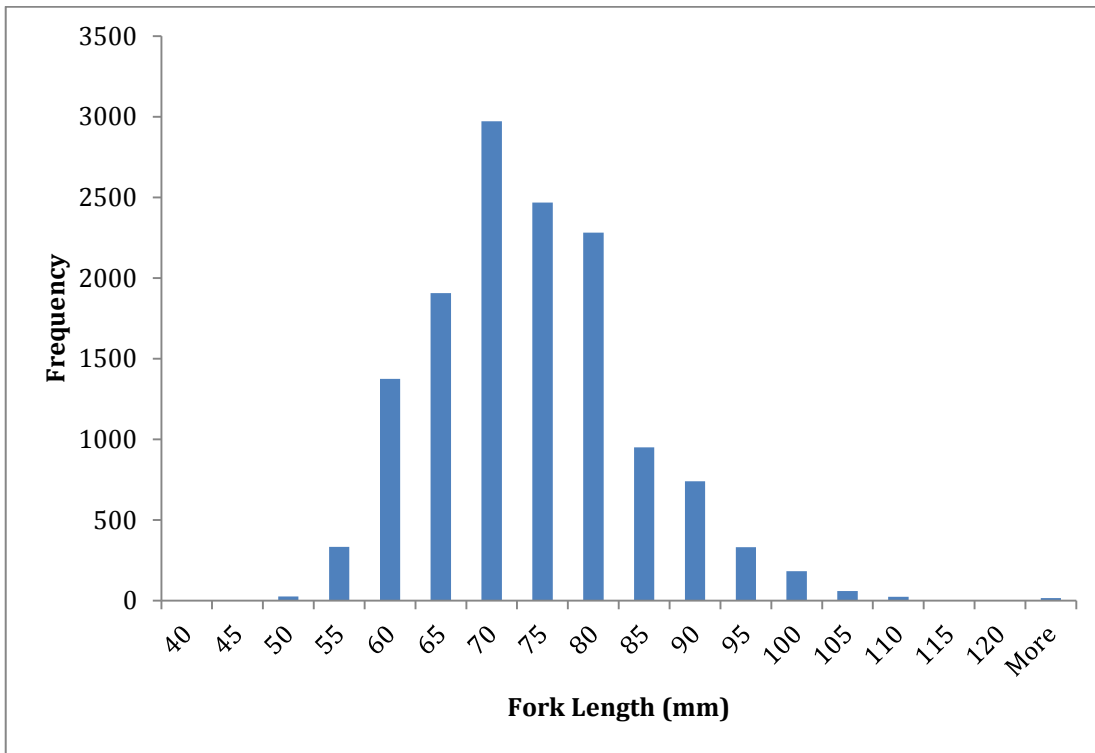
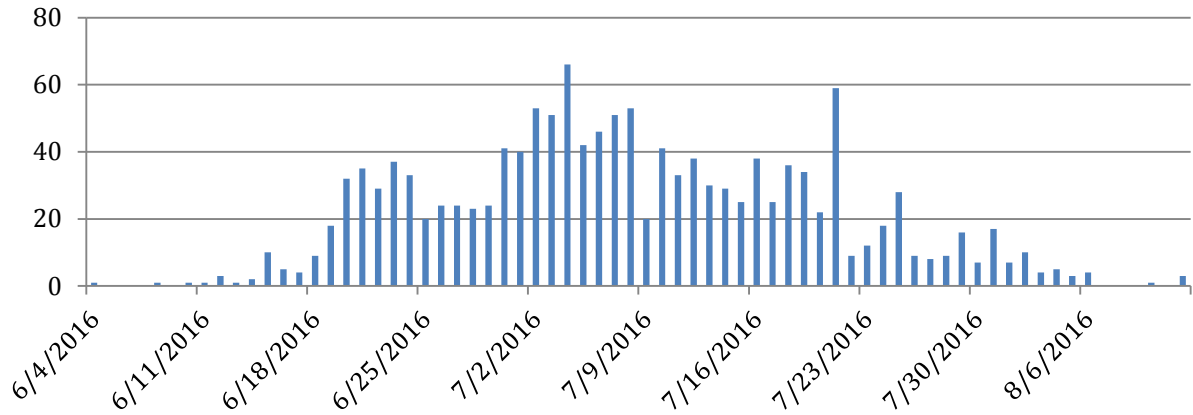


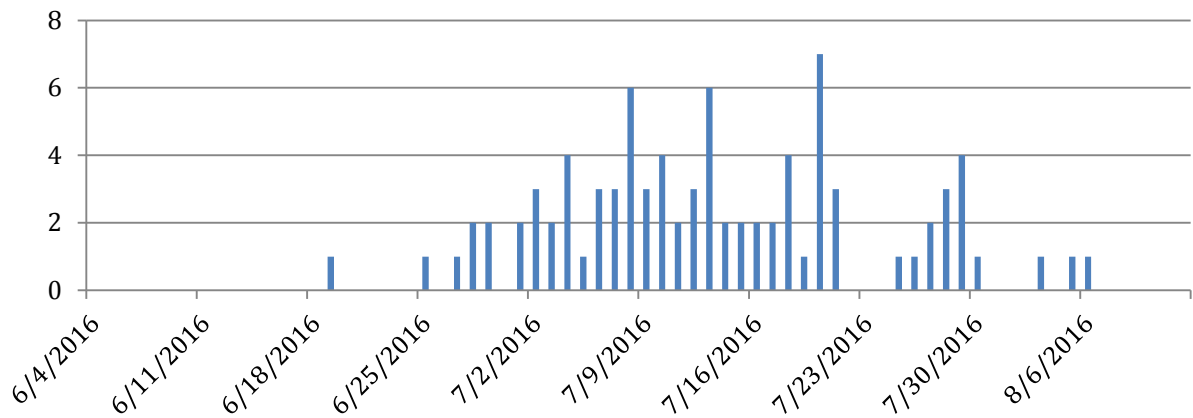
Figure 14. Size distribution of natural origin sub-yearling Chinook tagged during the beach seining effort in 2016

1,378 PIT tagged juvenile Chinook were detected at the Rocky Reach juvenile bypass system, which was 10.1% of total fish tagged and released. Eighty (0.6%), 31 (0.2%) and 16 (0.1%) were detected at the McNary, John Day and Bonneville Dams respectively. Detections for sub-yearlings occurred primarily in July at all downriver dams (Figure 15). There were no detections in the lower river dams from September through December.

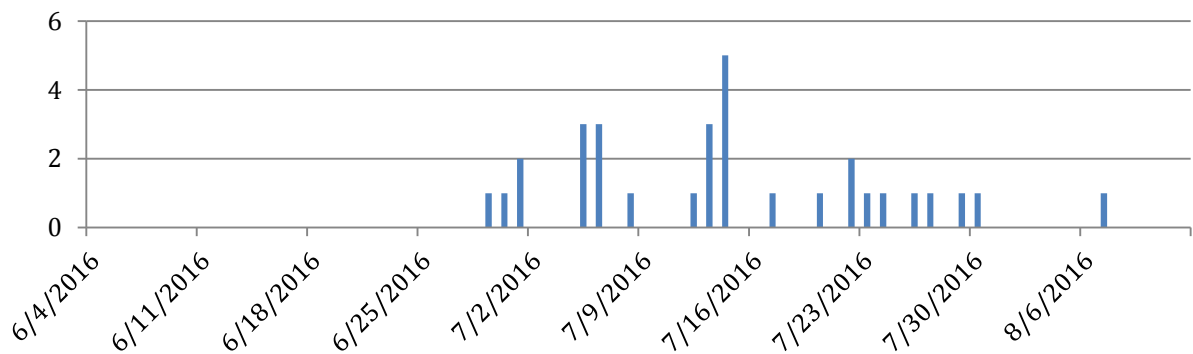
a) Rocky Reach Passage



b) McNary Passage



c) John Day Passage



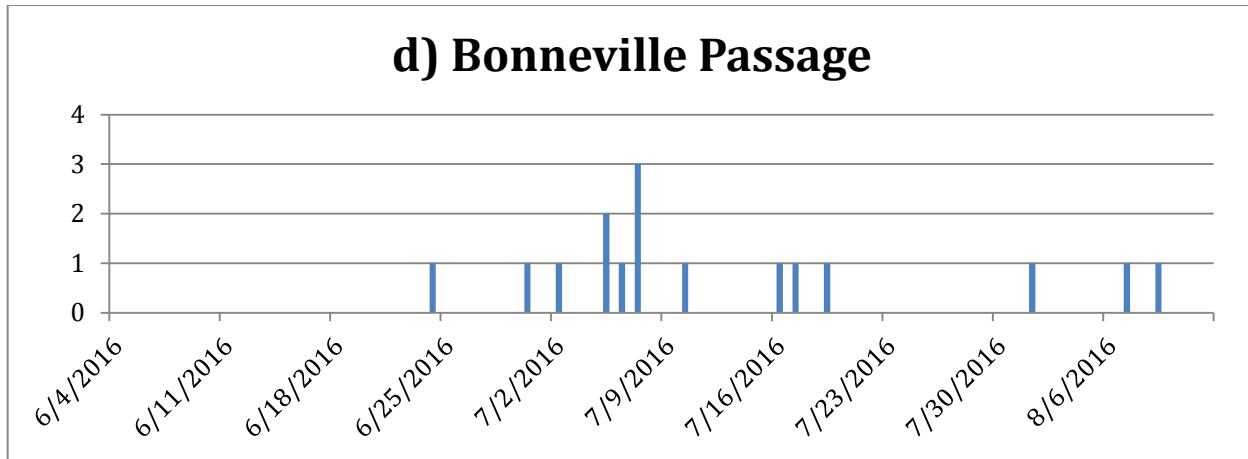


Figure 15. Daily distribution of detections of PIT-tagged sub-yearling Chinook at Rocky Reach, McNary, John Day, and Bonneville Dams in 2016. Note differences in scale. The y axes denote the numbers of PIT-tagged fish encountered daily at each of the mainstem project arrays.

Travel time from release to Rocky Reach Dam was the slowest compared to travel time from release to the other lower river dams (Table 10). Larger fish travelled faster to Rocky Reach Dam (Figure 16). This is similar to what was reported in 2011-2013 by Douglas County PUD.

Table 10. Mean travel time (d) and rate (km/d) for PIT tagged sub-yearling Chinook released near Gebber’s Landing and detected at Columbia River dam PIT arrays.

	Rocky Reach (762)		McNary (470)		John Day (347)		Bonneville (235)	
Location (River KM)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)
Release (856)	28.8 (SE = 0.33; n=1380)	3.3	36.1 (SE = 1.03; n=85)	10.7	40.3 (SE = 1.71; n=31)	12.6	36.2 (SE= 2.32; n=17)	17.5
Rocky Reach (762)			10.5 (SE = 0.55; n=34)	27.8	14.8 (SE = 1.73; n=11)	28.0		

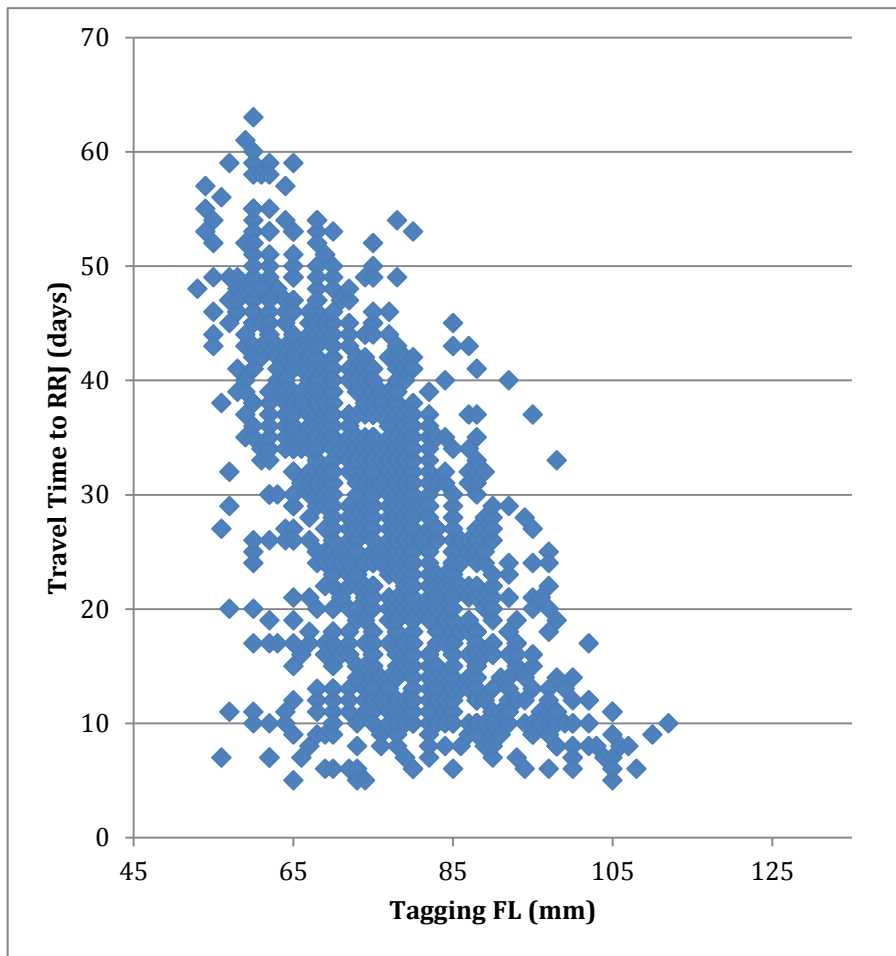


Figure 16. Fish size (fork length) and travel time of tagged Chinook to Rocky Reach Dam.

Lower Okanogan Adult Fish Pilot Weir

The Okanogan River (at Malott) discharge was below normal in 2016 and was below 1,800 cfs for the trapping season. Staff were able to safely enter the river and begin installation on August 8 when discharge was 1,530 cfs (Figure 17). Discharge continued to drop throughout the installation period until August 31 when levels increased rapidly up to 1,760 cfs due to Okanogan water management objectives) before dropping again on September 6. After September 9, discharge stayed between 800-1,000 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 ($\geq \sim 22$ °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 2016, temperatures were similar to, though occasionally higher than the median daily temperatures from the last 10 years (Figure 18).

Temperature was above 22.5 °C on July 1 when flow was 3,530 cfs. Temperatures stayed above 22.5 °C until July 4, when they began to drop and stayed below 22.5 °C until July 24. From July 24 to August 3 temperatures increased above 22.5 °C. Temperature varied again between 26.6°C and 20.6 °C from August 3-30. After August 30 temperatures stayed below 22.5 °C for the rest of the season.

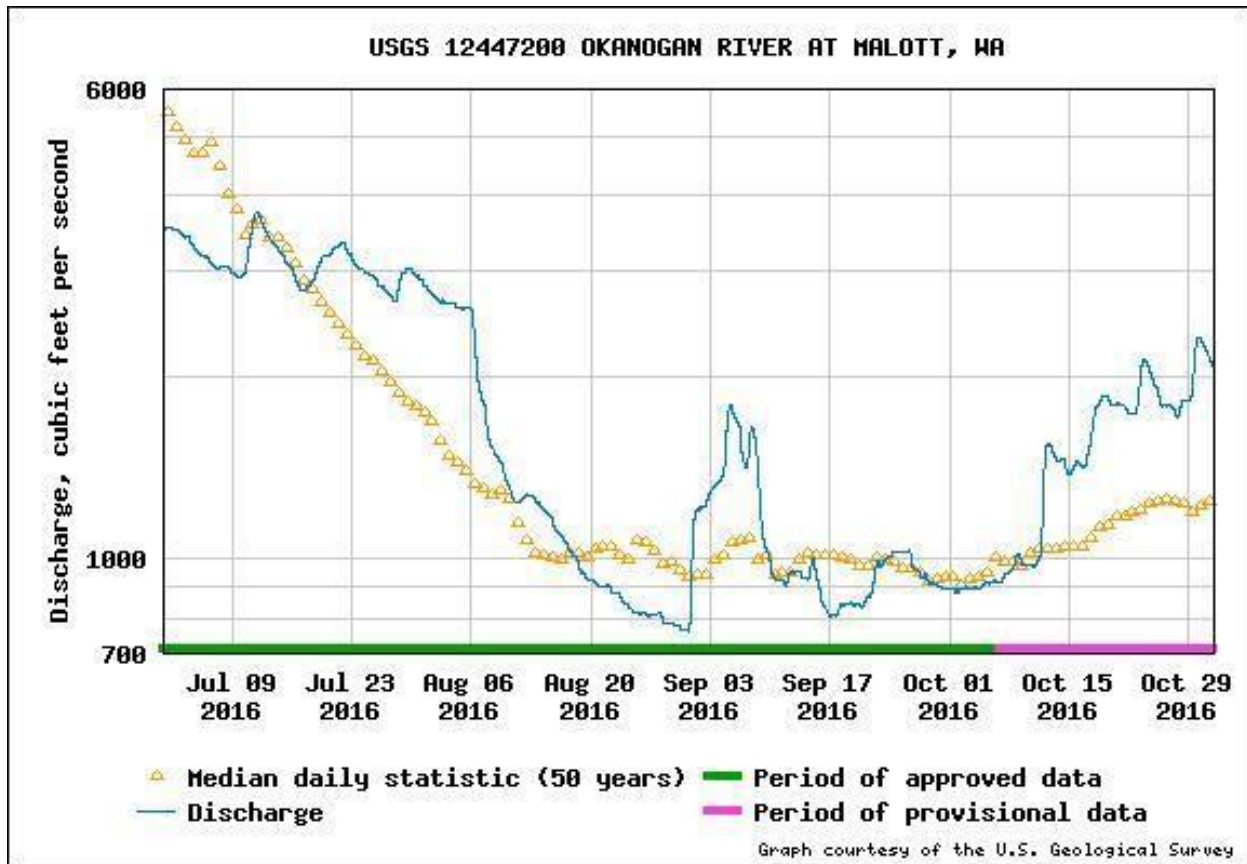


Figure 17. Discharge of the Okanogan River between July 1 and October 31, 2016. This figure was copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

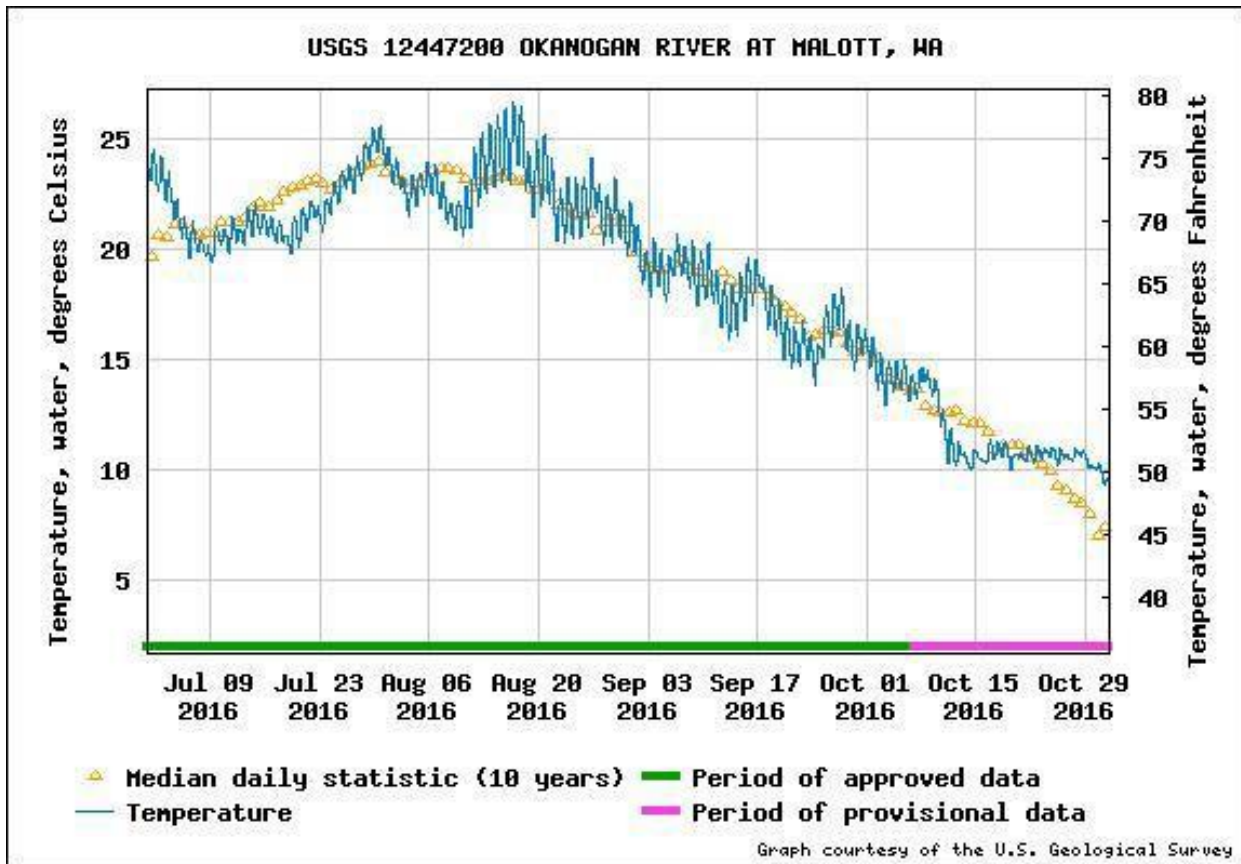


Figure 18. Temperature of the Okanogan River between July 1 and October 31, 2016. This figure was copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

Dissolved Oxygen varied from 5.7 to 10.1 mg/L, total dissolved solids varied from 120-141 ppm and turbidity varied from 0.7 and 4.6NTUs (Table 11). The head differential ranged from 0-3 cm across the weir panels (Table 12). The maximum water velocity measured was 2.7 ft./sec. (Table 13).

Table 11. Water quality data at or near the lower Okanogan weir in 2016. 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)
8/18	2.2	6.3	131	1.1
8/19	2.2	6.4	128	1.8
8/22	2.1	5.8	132	1.1
8/23	2.1	5.8	132	1.1
8/24	2.1	5.8	133	1.1
8/25	2.0	6.1	137	1.0
8/26	2.0	6.2	137	1.0
8/27	2.0	6.5	139	0.8
8/28	2.0	5.7	134	1.3
8/29	2.0	5.8	135	1.7
8/30	2.0	7.4	141	1.1
8/31	2.0	9.7	141	1.1
9/1	2.3	8.0	130	1.7
9/2	2.3	9.0	124	1.9
9/3	2.4	9.8	126	2.1
9/4	2.5	9.3	128	2.2
9/5	2.7	9.8	122	4.6
9/6	2.6	10.0	125	3.5
9/7	2.4	10.1	126	4.3
9/8	2.5	9.5	125	4.4
9/9	2.2	7.9	123	1.8
9/10	2.1	7.8	128	1.9
9/11	2.1	8.0	129	1.3
9/12	2.1	7.8	124	1.0
9/13	2.2	8.6	122	1.0
9/14	2.1	8.2	120	3.0
9/15	2.1	9.2	125	1.6
9/16	2.1	8.6	129	0.8
9/19	2.1	7.5	127	1.2
9/20	2.1	8.7	125	0.7
9/21	2.1	8.7	124	0.8
9/22	2.1	8.0	123	1.2
Min	2.0	5.7	120	0.7
Max	2.7	10.1	141	4.6

Table 12. Head differential across the different picket spacings. If differential exceeded 10 cm, pickets were cleaned immediately. Measurements are in cm. Daily mean gage height is included in feet. Gage height is copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

Date	1.0" Picket Spacing (cm)	1.5" Picket Spacing (cm)	2.0" Picket Spacing (cm)	2.5" Picket Spacing (cm)	3.0" Picket Spacing (cm)	Gage Height (ft.).
8/18	0.5	1.0	1.0	0.5	0.0	3.1
8/19	0.5	1.0	1.0	0.5	0.0	3.1
8/22	1.0	1.0	1.0	1.0	0.0	3.1
8/23	0.5	1.5	1.0	1.5	0.0	3.0
8/25	1.0	1.5	1.0	1.0	0.0	3.0
8/30	1.5	0.0	0.5	1.0	0.0	3.0
8/31	1.0	1.5	0.5	0.5	0.0	3.0
9/1	1.0	1.0	1.0	2.0	0.0	2.9
9/2	3.0	1.0	1.0	1.0	0.0	2.9
9/3	1.0	1.0	2.0	3.0	0.0	2.9
9/5	1.0	1.0	1.0	2.0	0.0	2.9
9/6	1.0	1.0	2.0	1.0	0.0	2.9
9/7	2.0	2.0	2.0	2.0	0.0	2.9
9/8	0.5	0.5	1.0	1.5	0.0	3.0
9/9	1.5	1.5	1.5	1.0	0.0	3.3
9/10	1.5	1.5	1.0	1.0	0.0	3.4
9/11	1.0	1.5	1.0	1.0	0.0	3.5
9/12	1.5	1.5	1.0	1.0	0.0	3.6
9/13	1.5	1.5	1.0	1.0	0.0	3.9
9/14	1.0	1.0	1.0	0.5	0.0	3.7
9/15	2.0	2.0	2.0	1.0	0.0	3.7
9/19	1.0	1.0	0.5	0.0	0.0	3.6
9/20	1.0	1.0	0.5	1.0	0.0	3.2
9/21	1.0	1.0	1.0	1.0	0.0	3.1
9/22	1.0	1.0	1.0	1.0	0.0	3.1
Min	0.5	0.0	0.5	0.0	0.0	2.9
Max	3.0	2.0	2.0	3.0	0.0	3.9

Table 13. 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
8/18	2.3	1.5	1.3	1.3	2.0	2.6	1.3
8/19	1.6	1.3	2.3	1.7	1.8	1.8	0.7
8/22	1.7	1.2	1.4	1.0	1.7	1.2	0.5
8/23	1.9	0.9	1.3	1.8	2.0	1.1	0.6
8/24	1.9	0.9	1.2	1.0	1.1	0.9	0.9
8/25	1.6	0.6	0.9	0.6	0.8	1.6	0.9
8/26	1.8	0.8	1.1	0.8	0.5	1.6	1.9
8/27	2.0	0.9	0.9	0.7	1.9	1.3	1.2
8/28	2.0	0.7	0.6	0.6	1.6	1.4	0.3
8/29	2.0	1.1	1.2	1.3	1.7	2.1	0.5
8/30	1.3	1.3	1.5	2.0	1.7	1.3	0.2
8/31	1.8	1.0	1.3	1.0	1.3	1.9	0.2
9/1	1.1	1.4	1.5	1.5	1.8	2.5	0.3
9/2	2.3	1.5	1.4	2.2	1.8	0.7	1.0
9/3	2.3	1.0	1.3	1.3	1.7	1.8	0.5
9/5	2.5	1.5	1.9	1.3	2.1	2.3	1.3
9/6	2.3	1.4	1.3	1.4	1.9	1.9	0.2
9/8	1.7	1.4	1.6	1.5	1.7	2.5	0.1
9/9	2.2	1.0	1.6	1.6	1.1	1.0	1.4
9/10	1.8	1.1	1.4	1.9	1.1	0.2	1.2
9/11	2.7	1.2	1.4	0.6	1.4	2.0	0.8
9/12	2.0	1.3	1.2	1.0	1.3	1.9	1.6
9/13	1.7	1.1	1.6	1.2	1.4	1.0	1.3
9/14	1.9	1.0	1.0	1.1	1.5	1.8	0.7
9/15	1.9	0.7	1.0	0.9	1.3	1.6	1.6
9/16	2.0	1.0	1.1	1.0	1.4	2.0	1.4
9/19	1.8	1.2	1.6	0.7	1.8	1.6	1.3
9/20	1.8	0.7	1.1	0.1	1.2	1.2	1.2
9/21	1.9	1.2	1.3	0.5	0.9	1.3	0.9
9/22	1.9	1.0	1.0	0.4	1.2	1.0	0.8
Min	1.1	0.6	0.6	0.1	0.5	0.2	0.1
Max	2.7	1.5	2.3	2.2	2.1	2.6	1.9

Fifty four dead fish were removed from the weir between August 17 and September 22 (Table 14). Chinook Salmon were the most commonly encountered species (74%). There were no steelhead mortalities removed from the weir in 2016. All mortalities were impinged on the upstream side of weir indicating that they had most likely died upstream and floated down onto the weir. The majority of the Chinook carcasses were observed a week before the majority of Chinook were encountered in the trap (Figure 19). 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 14. Date and species of fish mortalities observed at the lower Okanogan fish weir in 2016. All fish mortalities were considered “wash downs” and collected on the upstream panels of the weir.

Date	Black Bullhead	Chinook	Mountain Whitefish	Smallmouth Bass	Sockeye	Unknown Sucker
08/17		1				
08/22		2				
08/23		2				
08/24		3				
08/25		6				
08/26		6				
08/27		1				
08/28		1				
08/29		5				1
09/01		1				
09/02		1				
09/04		1				
09/05	1		2	1		1
09/06		1				
09/07		3			1	
09/08					1	
09/10		1	1			
09/12		2				
09/13					1	1
09/15				1	1	
09/20		1				
09/22		2				
Total	1	40	3	2	4	4

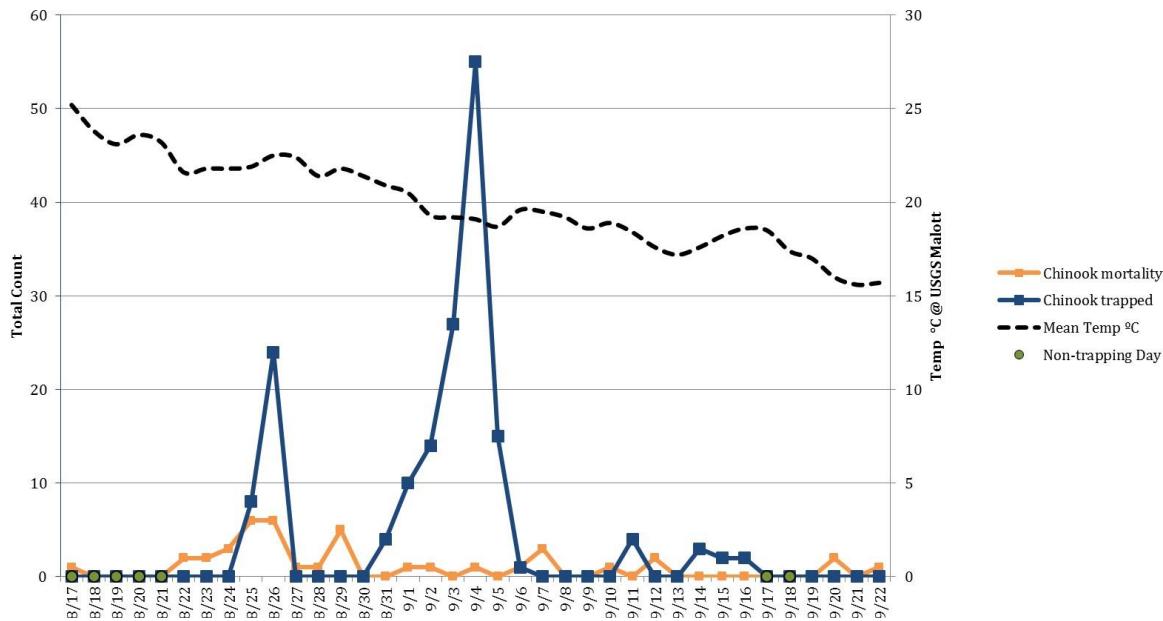


Figure 19 . Total number of Chinook trapped and total number of Chinook carcasses collected off the weir panels. The majority of the Chinook carcasses occurred a week before most Chinook were encountered in the trap.

Tower observations showed that most fish were equally distributed across the river, milling in the river right, left and center sections (looking downstream). Estimates were highest during the last week of August and the first week of September when river temperatures were below 22.5 °C. Bank observations showed that the number fish observed holding in the lower pool, 0.8 km below the weir, was highest about four days after the thermal barrier breakdown (Figure 20.). Trapping operations were conducted after August 22nd when river temperature was ≤ 22.5 °C. The total fish trapped at the weir in 2016 was 190 with 89% of them being Chinook Salmon (Figure 21). Seventy percent of the Chinook trapped were released back into the river (Figure 22). Two steelhead were trapped between 9/10-9/20 and released in good condition within 30 minutes of observation. The TOG was notified when steelhead were trapped, including the total number, origin and condition after release. To reduce handling of fish, trap attendants opened the gate of the crowder and the upstream gate of the trap to allow for complete passage. Fish that were passed upstream were classified as having a vigorous condition, swimming away unharmed.

Prior to collecting broodstock we conducted several tests using hatchery origin fish brought to the weir via the hatchery truck. Eight adults and two jacks were manually carried to the weir in a boot (inner-tube) which took approximately 90 seconds each. These fish were sent back to the hatchery truck via the Whooshh™ transport tube in approximately eight seconds. This process was repeated three times over a several hour period. There were no immediate mortalities, although two fish were dead upon arrival at the hatchery that

evening (nearly 10 hours after their initial capture in the hatchery ladder). This test was considered a success and the mortalities were not a concern because the fish had been handled much more extensively than the natural origin brood would be.

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

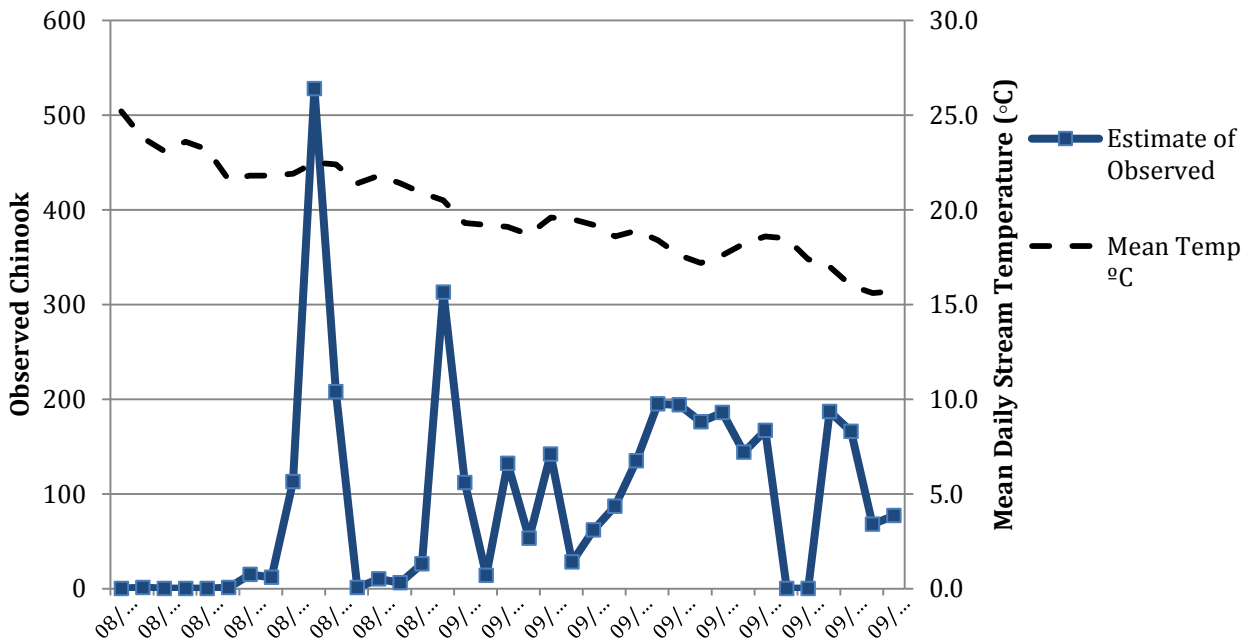
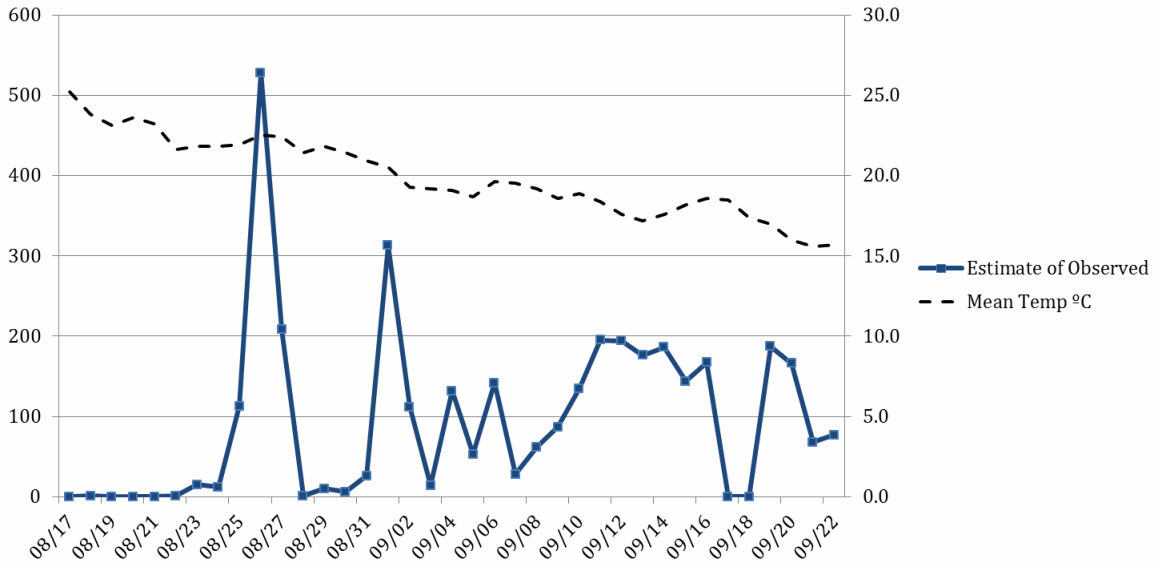


Figure 20. Estimate of Chinook observed from the bank at the lower pool, 0.8 km downstream of the weir.

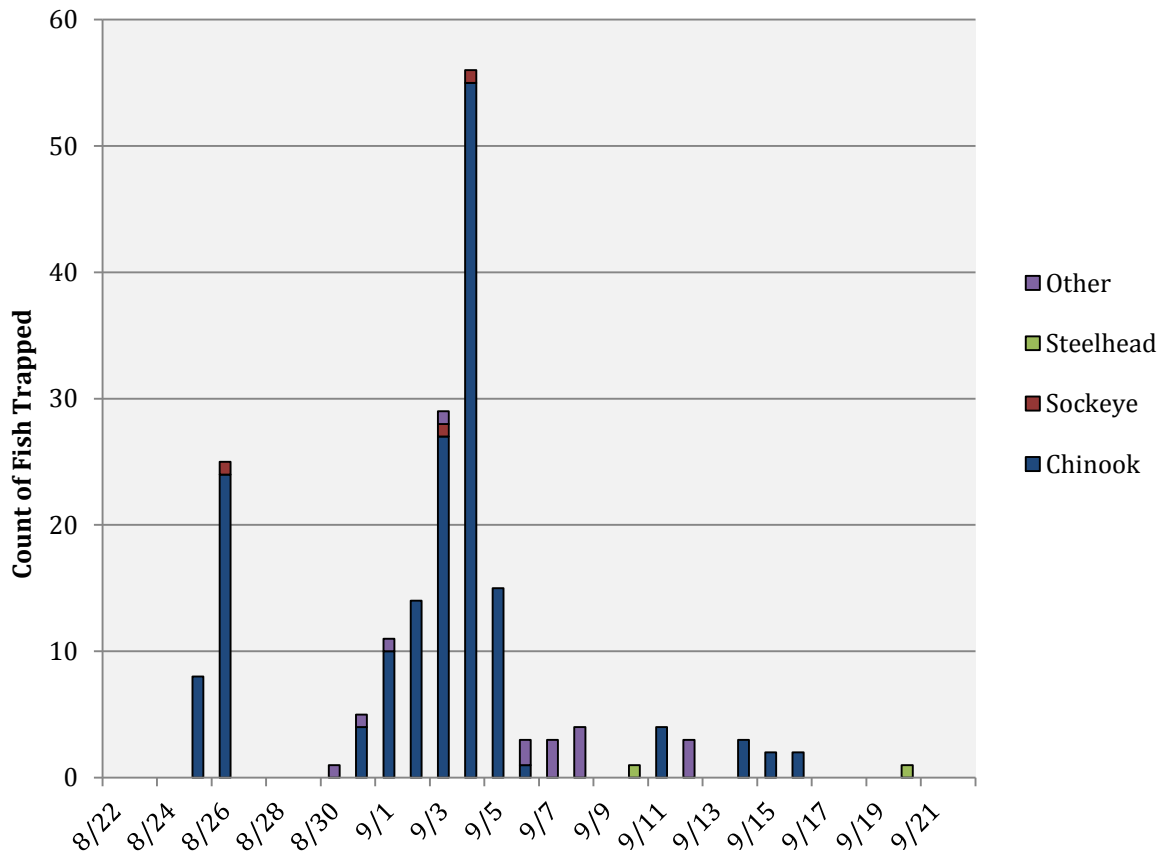


Figure 21. Total number of fish trapped at the Okanogan weir in 2016.

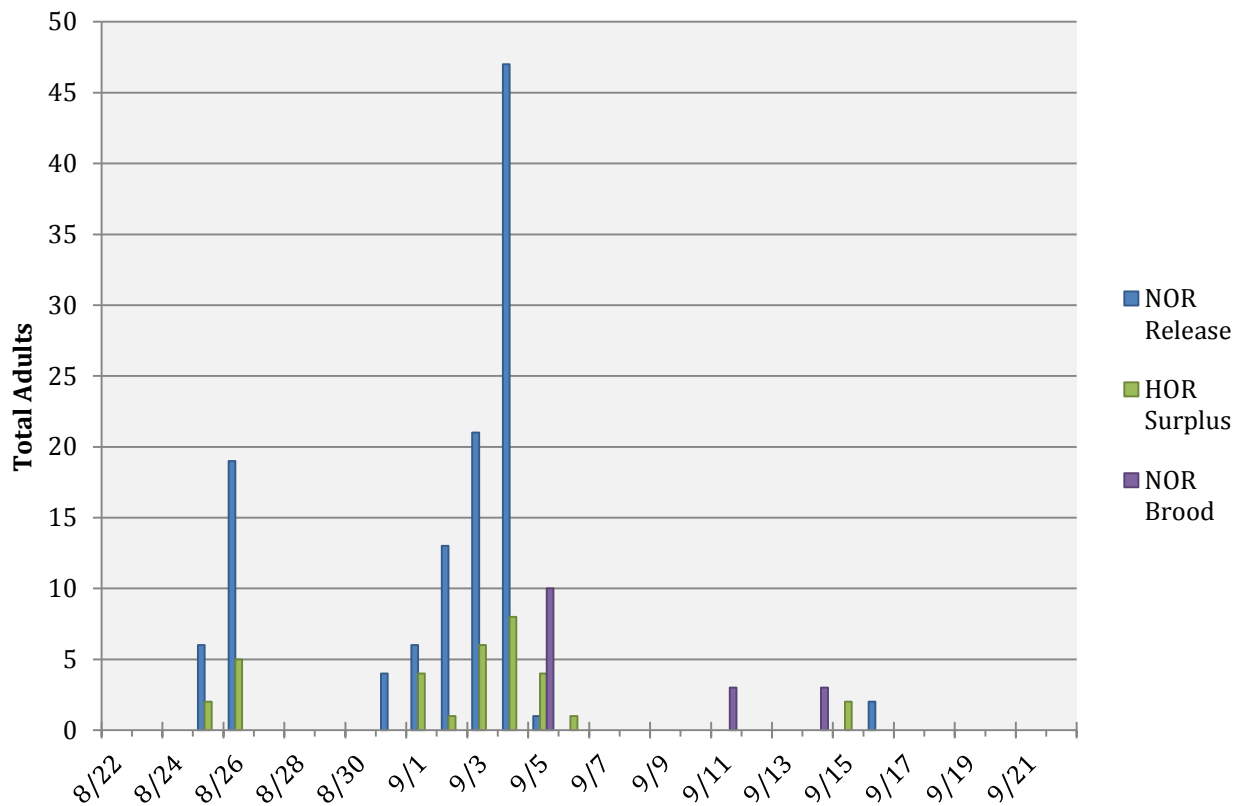


Figure 22. Final destination of Chinook adults captured in the weir trap during trapping operations in 2016.

In 2016, 0.014 of total spawning escapement was detected in the trap (i.e., weir efficiency) (Table 15). The potential weir effectiveness (if we had been removing all of the HOR encountered) was 0.016.

Table 15. The number of hatchery and natural origin Chinook Salmon encountered at the lower Okanogan weir in 2016. 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
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

^a Estimates for weir efficiency are adjusted for prespawm mortality and include Chinook adults that are harvested, released, and collected for brood.

^b Estimates for weir effectiveness are adjusted for prespawm mortality and include Chinook adults that are harvested or removed for pHOS management.

^c Estimates do not include Chinook Zosel Dam counts.

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

Redd Surveys

In 2016, 5,276 summer/fall Chinook redds were counted in the Okanogan and Similkameen rivers using a combination of ground and aerial surveys (Table 16, Figure 23). The number of redds counted in 2016 was higher than the long-term or more recent 5-year average (Table 16). The majority of Chinook redds were located in O6 (44.3%) and S1 (31.2%). The overall redd distribution across the reaches was similar to previous years with the majority of spawning taking place in the upper Okanogan reaches (O5 and O6) and lower Similkameen (S1) (Table 17, Figure 24).

Estimated spawning escapement was 10,605 (5,276 redds × 2.01 fish per redd) (Table 18). During the survey period 1989 through 2016, the summer/fall Chinook spawning escapement within the U.S. portion of the Okanogan River Basin averaged 5,872 and ranged from 473 to 13,857 (Table 18).

The majority of summer/fall Chinook redds were counted during spawning ground surveys between October 3 - 30 (Table 19). No spawning ground surveys were conducted after November 6.

Table 16. Total number of redds counted in the Okanogan River Basin, 1989-2016 and the averages for the total time series and the most recent 5-year period.

Survey Year	Number of summer Chinook redds		
	Okanogan River	Similkameen River	Total Count
1989	151	370	521
1990	99	147	246
1991	64	91	155
1992	53	57	110
1993	162	288	450
1994	375*	777	1,152
1995	267*	616	883
1996	116	419	535
1997	158	486	644
1998	88	276	364
1999	369	1,275	1,644
2000	549	993	1,542
2001	1,108	1,540	2,648
2002	2,667	3,358	6,025
2003	1,035	378	1,413
2004	1,327	1,660	2,987
2005	1,611	1,423	3,034
2006	2,592	1,666	4,258
2007	1,301	707	2,008
2008	1,146	1,000	2,146
2009	1,672	1,298	2,970
2010	1,011	1,107	2,118
2011	1,714	1,409	3,123
2012	1,613	1,066	2,679
2013	2,267	1,280	3,547
2014	2,231	2,022	4,253
2015	2,379	1,897	4,276
2016	3,486	1,790	5,276
<i>Average</i>	1,191	1,050	2,179
<i>5-yr Average</i>	2,395	1,611	4,006

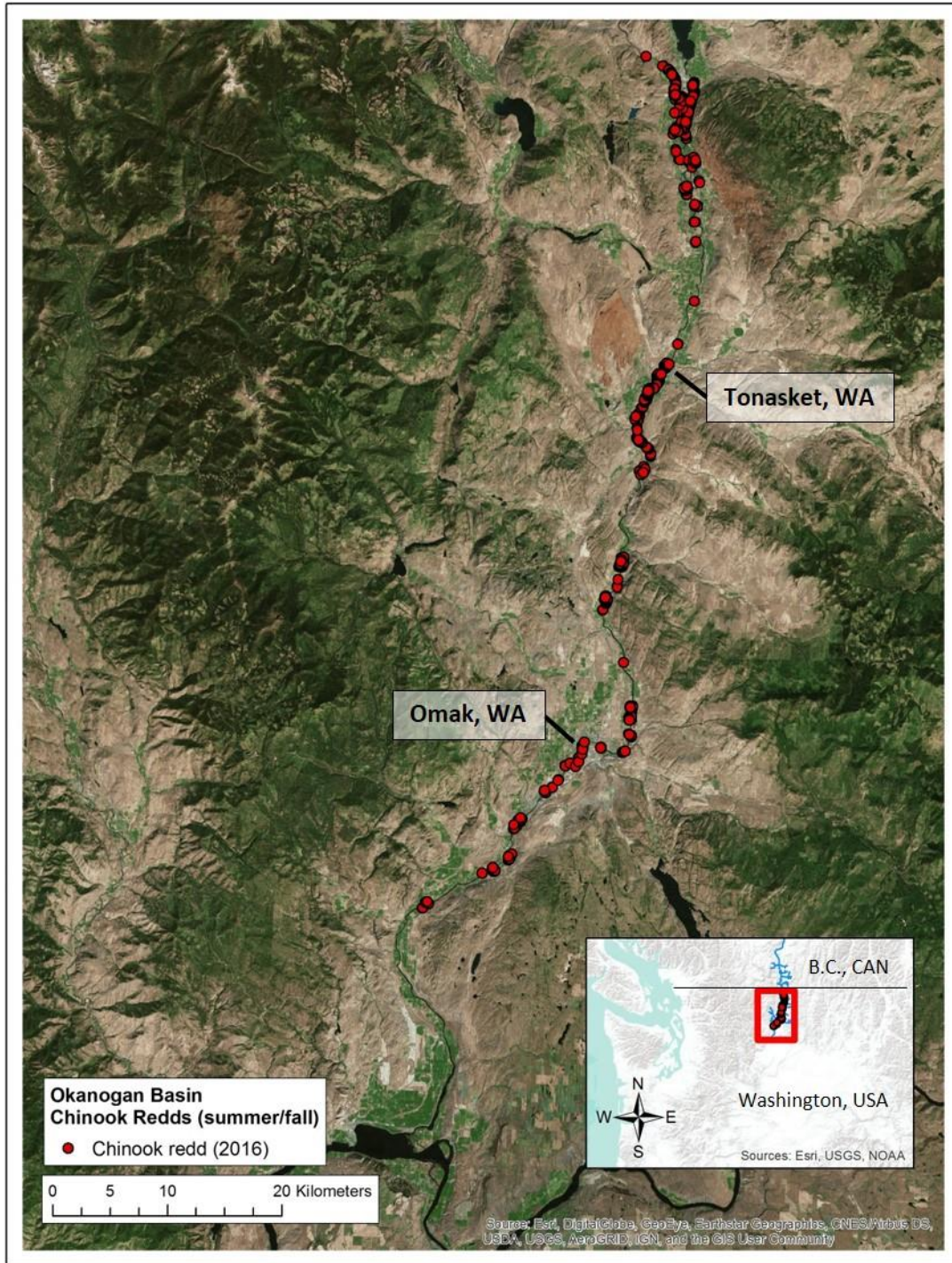


Figure 23. Distribution of summer/fall Chinook redds in 2016. Individual redds are identified by red circles. Horizontal coordinate information are referenced to the North American Datum of 1983 (NAD 83).

Table 17. Annual and average abundance of summer/fall Chinook redds in each reach of the Okanogan (O1-O6) and Similkameen (S1-S2) Rivers from 2006-2016.

Return Year	Number of Summer Chinook Redds								
	Okanogan						Similkameen		Total
	O1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
2006	10	56	175	145	840	1366	1277	405	4274
2007	3	16	116	63	549	554	624	86	2011
2008	4	51	59	96	374	561	801	199	2145
2009	3	32	91	138	619	787	1091	207	2968
2010	9	58	67	89	357	431	895	212	2118
2011	3	20	101	55	593	942	1217	192	3123
2012	12	54	159	68	555	765	914	152	2679
2013	3	2	158	46	397	1661	1254	26	3547
2014	11	57	191	111	851	1010	1737	285	4253
2015	36	113	284	79	1008	859	1611	286	4276
2016	2	57	52	130	907	2338	1645	145	5276
<i>Average</i>	<i>9</i>	<i>47</i>	<i>132</i>	<i>93</i>	<i>641</i>	<i>1025</i>	<i>1188</i>	<i>200</i>	<i>3334</i>

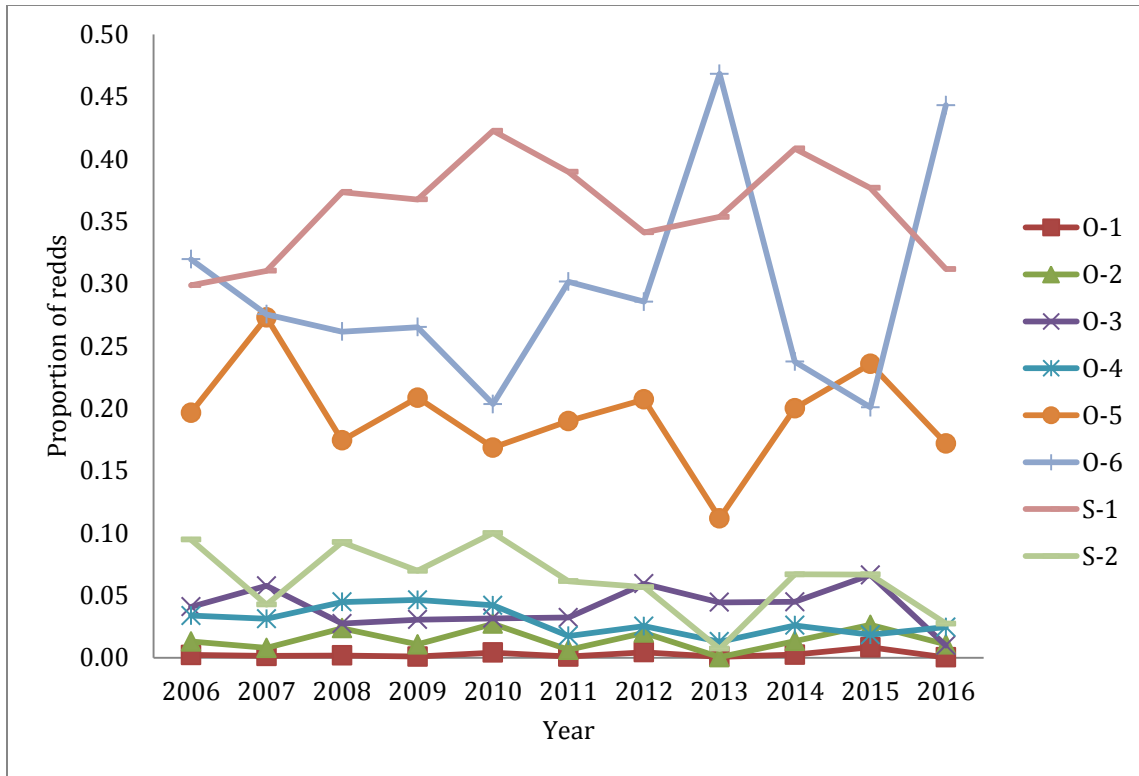


Figure 24. Proportion of redds in each reach of the Okanogan and Similkameen Rivers from 2006 to 2016.

Table 18. Spawning escapements for summer/fall Chinook in the Okanogan and Similkameen Rivers for return years 1989-2016.

Return Year	Fish/Redd Ratio	Spawning Escapement		
		Okanogan	Similkameen	Total
1989*	3.3	498	1,221	1,719
1990*	3.4	337	500	837
1991*	3.7	237	337	574
1992*	4.3	228	245	473
1993*	3.3	535	950	1,485
1994*	3.5	1,313	2,720	4,033
1995*	3.4	908	2,094	3,002
1996*	3.4	394	1,425	1,819
1997*	3.4	537	1,652	2,189
1998	3	264	828	1,092
1999	2.2	812	2,805	3,617
2000	2.4	1,318	2,383	3,701
2001	4.1	4,543	6,314	10,857
2002	2.3	6,134	7,723	13,857
2003	2.4	2,505	915	3,420
2004	2.3	2,986	3,735	6,721
2005	2.9	4,720	4,169	8,889
2006	2	5,236	3,365	8,601
2007	2.2	2,862	1,555	4,417
2008	3.3	3,725	3,250	6,975
2009	2.5	4,247	3,297	7,544
2010	2.8	2,841	3,111	5,952
2011	3.1	5,313	4,368	9,681
2012	3.1	4,952	3,273	8,225
2013	2.3	5,237	2,957	8,194
2014	2.9	6,381	5,783	12,164
2015	3.2	7,660	6,108	13,769
2016	2.01	7,007	3,598	10,605
Average	2.95	2990	2881	5872
5-Year Average	2.70	6247	4344	10591

* Spawning escapement was calculated using the "Modified Meekin Method" (i.e., 3.1 × jack multiplier).

Table 19. Number and timing of summer Chinook redd counts in reaches of the Okanogan and Similkameen Rivers in 2016.

Reach	River mile	Sept 19-25	Sept 26-Oct 2	Oct 3-9	Oct 10-16	Oct 17-23	Oct 24-30	Oct 31-Nov 6	Redd Count	Percent
Okanogan River										
O1	0.0-16.9	0	0	0	0	2	0	0	2	0%
O2	16.9-26.1	0	0	2	22	20	12	1	57	2%
O3	26.1-30.7	0	0	6	28	16	1	1	52	1%
O4	30.7-40.7	0	0	10	57	34	26	3	130	4%
O5	40.7-56.8	0	0	127	447	240	91	2	907	26%
O6	56.8-77.4	0	9	646	643	498	537	5	2338	67%
Total		0	9	791	1197	810	667	12	3486	100%
Similkameen River										
S1	0.0-1.8	2	15	518	434	447	229	0	1645	92%
S2	1.8-5.7	0	0	46	31	51	17	0	145	8%
Total		2	15	564	465	498	246	0	1790	100%

Escapement into Canada

In 2016 there were 1,823 adult summer/fall Chinook counted in the fishways of Zosel Dam (Table 20). While not the highest count on record, 2016 continued a trend showing increasing escapements above Zosel. 13% of the Chinook observed at Zosel Dam had a clipped adipose fin (i.e., hatchery-origin).

Table 20. Count of run escapement of adult summer/fall Chinook at Zosel Dam using video monitoring in the fishways.

Chinook Passage at Zosel Dam		
Year	Video Count	% Hatchery
2006	481	1%
2007	455	40%
2008	267	29%
2009	256	17%
2010	359	29%
2011	1415	36%
2012	826	24%
2013	2275	14%
2014 ^a	1188	10%
2015	1206	7%
2016	1823	13%
Average	959	20%

^a2014 data were adjusted for fallback/re ascension, down camera time, and differentiation of spring Chinook from summer/fall Chinook.

Carcass Surveys

In 2016, 2,755 carcasses were recovered including 2,171 natural-origin and 584 hatchery-origin⁷. The overall carcass recovery rate was 26% of the total spawning escapement. Genetic samples (tissue punches) were collected from a portion of the summer/fall Chinook carcasses in 2016. Samples are archived at the USGS Snake River Field Station Genetics Lab in Boise, ID. The majority of carcasses ($n = 2,289$; 83%) were collected from reaches O6 and S1 (Figure 25, also see Appendix C). The proportion of natural-origin carcasses recovered in 2016 was slightly lower in reach O5 compared to the 10-year average (Figure 25, panel A). The proportion of hatchery-origin carcasses recovered in 2016 was lower in O5 and O6 and higher in S1 compared to the 10-year averages (Figure 25, panel B).

⁷Origin assignments take into account all scale, ad-mark, coded wire tag and PIT tag information available at time of publication. Values may be updated in future annual reports depending on availability of data.

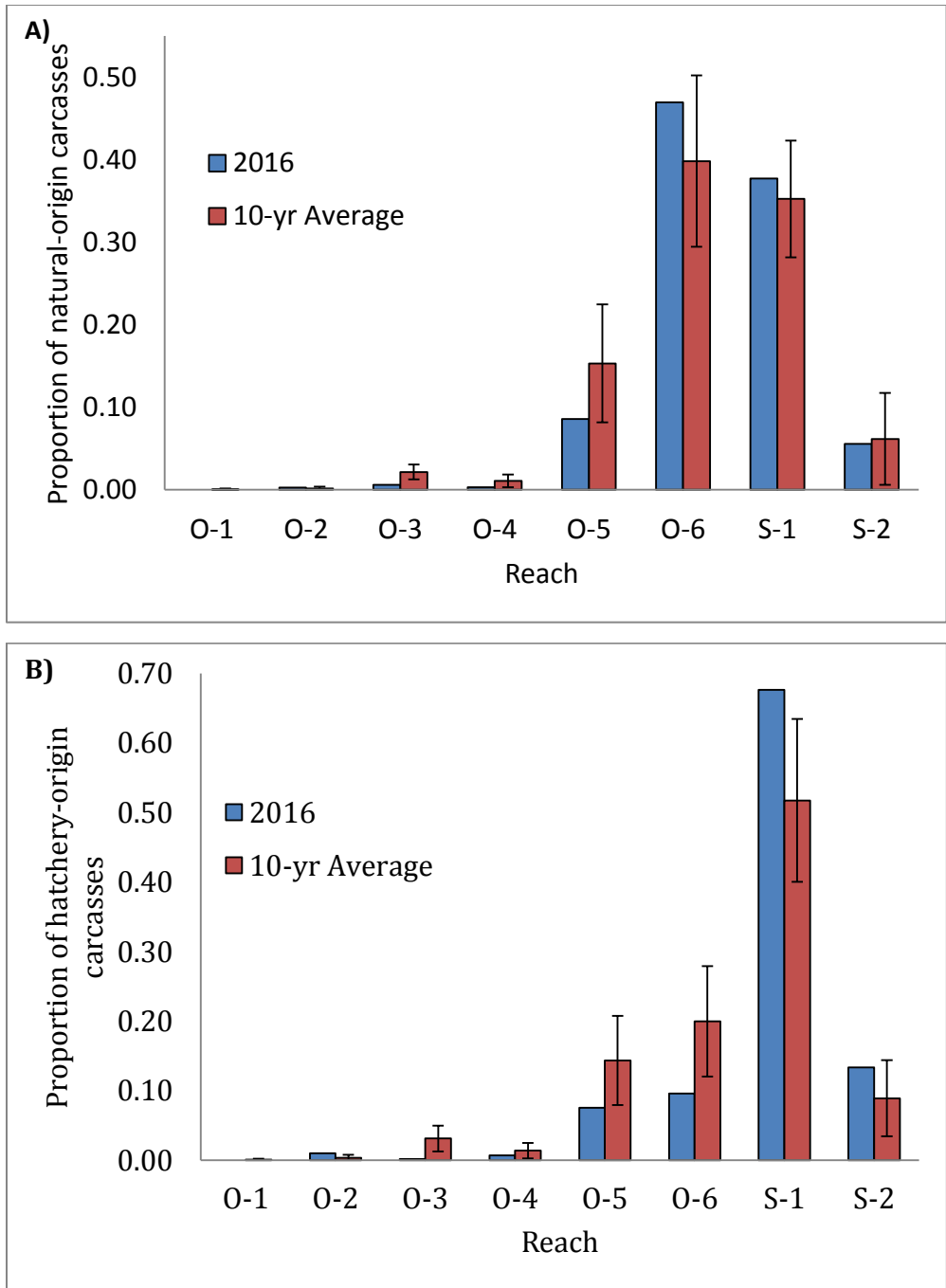


Figure 25. Distribution of natural-origin (A) and hatchery-origin (B) summer/fall Chinook carcasses recovered in the Okanogan (O1-O6) and Similkameen (S1-S2) Rivers in 2016 and the 10-year average (2007-2016).

In the Okanogan basin, 59 of the 1,804 sampled female carcasses were estimated to have all their eggs. Therefore pre-spawn mortality (for fish that survived to the spawn period) was estimated to be 3.4% for natural-origin females and 2.8% for hatchery-origin females (Table 21). Overall egg retention of all fish sampled (including fish that had expelled a portion of their eggs) was 4.1%.

Table 21. Egg retention and pre-spawn mortality of sampled summer/fall Chinook carcasses in the Okanogan Basin.

Year	Origin	Total carcasses sampled	Female carcasses sampled	Potential egg deposition	Eggs retained	^a Egg retention rate	^b Pre-spawn mortality rate
2013	Natural-origin	613	326	1,630,000	6,152	0.40%	0.00%
	Hatchery-origin	297	237	1,185,000	10,970	0.90%	0.00%
	Total	910	563	2,815,000	17,122	0.60%	0.00%
2014	Natural-origin	2123	1136	5,680,000	373,708	6.60%	1.40%
	Hatchery-origin	329	166	830,000	81,105	9.80%	1.80%
	Total	2452	1302	6,510,000	454,813	7.00%	1.50%
2015	Natural-origin	2554	981	4,905,000	609,869	12.40%	10.90%
	Hatchery-origin	738	340	1,700,000	96,354	5.70%	5.00%
	Total	3292	1321	6,605,000	706,223	10.70%	9.40%
2016	Natural-origin	2171	1370	6,850,000	300,046	4.38%	3.43%
	Hatchery-origin	584	434	2,170,000	66,254	3.05%	2.76%
	Total	2755	1804	9,020,000	366300	4.06%	3.27%

^aAssuming fecundity of 5,000 eggs per female, egg retention rate is calculated as: (# eggs estimated remaining in sampled female carcasses) / (# female carcasses sampled * 5,000 eggs each)

^bA pre-spawn mortality is determined when a female retains the assumed 5,000 eggs on the spawning grounds.

PHOS AND PNI

There was a decrease in the proportion of hatchery-origin spawners (pHOS) across most reaches in the Okanogan and Similkameen rivers in 2016 compared to the 10-year average with the exception of reach O2 and O4 (Figure 26), which were based on the recovery of only 12 and 11 carcasses, respectively. No carcasses were recovered in reach O1 and only 2 redds were observed in this reach. Hatchery-origin spawners comprised 18% of the spawn escapement estimate in the U.S. portion of the Okanogan, which was the second lowest pHOS observed since 1992 (Table 22). After corrections for hatchery fish effectiveness assumptions (0.80 relative reproductive success rate for hatchery-origin spawners) the effective pHOS for 2016 was 0.15, which was considerably less than the five-year average (0.23) (Table 23). The five-year average is currently meeting the biological objective for pHOS (<0.3), and continues to trend toward the program objective of reduced pHOS (Figure 27).

The proportion of natural-origin broodstock (pNOB) in 2016 was 100% and the pNOB for Okanogan origin fish was 90% (Table 23). The resulting PNI for 2016 was 0.87, with a 5-year average PNI of 0.82, both meeting the Biological Objective (>0.67)(Figure 28).

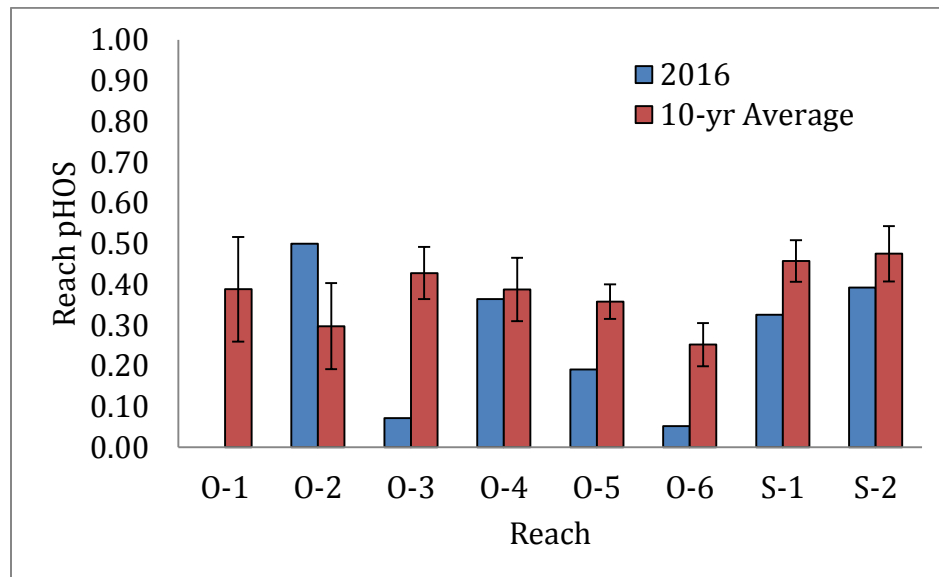


Figure 26. Okanogan (O1-O6) and Similkameen River (S1-S2) summer/fall Chinook unadjusted pHOS by reach for 2016 and 10-year average (2007-2016). Reaches with fewer than 10 carcasses recovered were not shown. Error bars represent standard error of the mean.

Table 22. Natural- (NOS) and hatchery- (HOS) origin spawner abundance and composition for the Okanogan River Basin, brood years 1989-2016.

Brood Year	Spawners			
	NOS	HOS	pHOS	Effective pHOS [^]
1989	1,719	0	0	0
1990	837	0	0	0
1991	574	0	0	0
1992	473	0	0	0
1993	915	570	0.38	0.33
1994	1,323	2,710	0.67	0.62
1995	979	2,023	0.67	0.62
1996	568	1,251	0.69	0.64
1997	862	1,327	0.61	0.55
1998	600	492	0.45	0.40
1999	1,274	2,343	0.65	0.60
2000	1,174	2,527	0.68	0.63
2001	4,306	6,551	0.60	0.55
2002	4,346	9,511	0.69	0.64
2003	1,933	1,487	0.43	0.38
2004	5,309	1,412	0.21	0.18
2005	6,441	2,448	0.28	0.23
2006*	5,507	3,094	0.21	0.18
2007*	2,983	1,434	0.37	0.32
2008*	2,998	3,977	0.60	0.54
2009*	4,204	3,340	0.46	0.40
2010*	3,189	2,763	0.47	0.41
2011*	4,642	5,039	0.52	0.47
2012*	4,840	3,385	0.45	0.40
2013*,a	5,520	2,674	0.31	0.27
2014*	10,402	1,762	0.14	0.12
2015*	10,350	3,398	0.25	0.21
2016*	8,661	1,944	0.18	0.15
Average	3,466	2,405	0.39	0.35
5-year Average	7,981	2,607	0.27	0.23

^a 2013 data have been updated to reflect age and origin data acquired from scale reading since the publication of the 2013 annual report.

* Indicates that pHOS has been reach-weighted by # of redds per reach.

[^] Effective pHOS assumes 0.80 HOS effectiveness

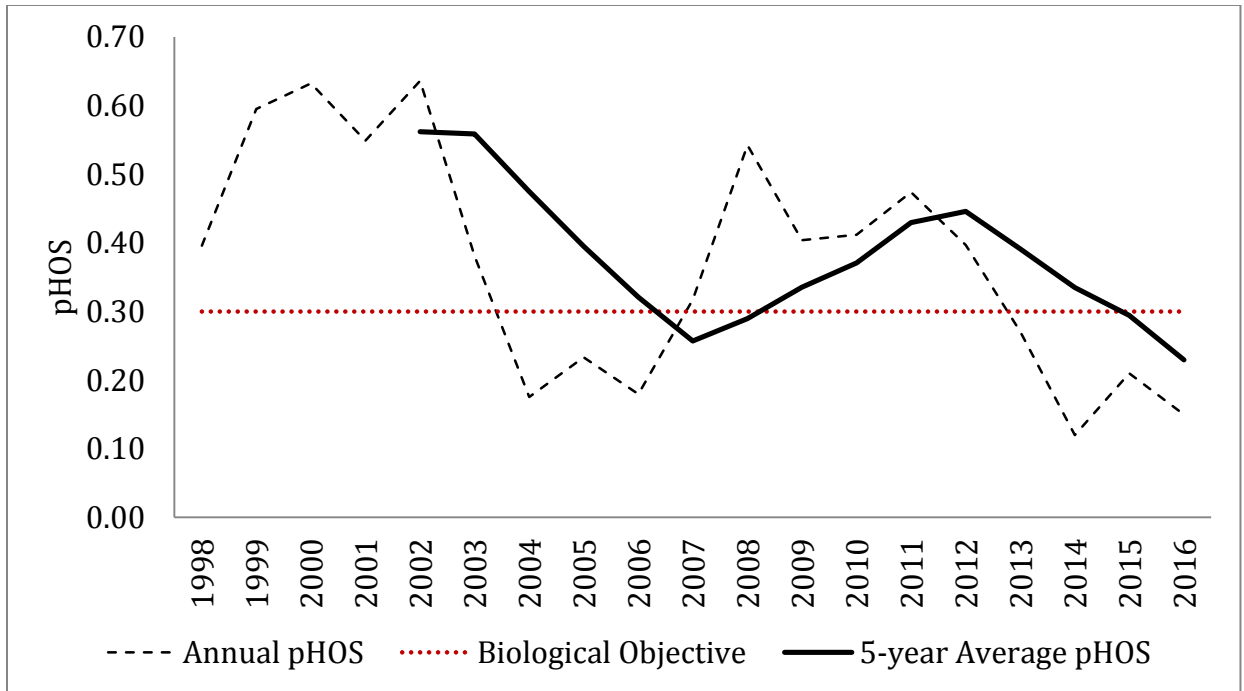


Figure 27. Annual and 5-year average proportion of hatchery-origin spawners (pHOS) in the Okanogan and Similkameen River (combined) from 1998-2016. pHOS values represent the effective pHOS.

Table 23. Okanogan River summer Chinook spawn escapement and broodstock composition, and calculated pHOS and PNI for Brood Years 1989-2016.

Brood Year	Spawners			Broodstock					PNI	Okan. PNI
	NOS	HOS	Effective pHOS	NOB	Okan. NOB	HOB	pNOB	Okan. pNOB		
1989	1,719	0	0.00	1,297		312	0.81		1.00	
1990	837	0	0.00	828		206	0.80		1.00	
1991	574	0	0.00	924		314	0.75		1.00	
1992	473	0	0.00	297		406	0.42		1.00	
1993	915	570	0.33	681		388	0.64		0.66	
1994	1,323	2,710	0.62	341		244	0.58		0.48	
1995	979	2,023	0.62	173		240	0.42		0.40	
1996	568	1,251	0.64	287		155	0.65		0.50	
1997	862	1,327	0.55	197		265	0.43		0.44	
1998	600	492	0.40	153	77	211	0.42	0.21	0.51	0.35
1999	1,274	2,343	0.60	224	112	289	0.44	0.22	0.42	0.27
2000	1,174	2,527	0.63	164	82	337	0.33	0.16	0.34	0.21
2001	4,306	6,551	0.55	12	46	345	0.03	0.13	0.06	0.19
2002	4,346	9,511	0.64	247	124	241	0.51	0.25	0.44	0.29
2003	1,933	1,487	0.38	381	191	101	0.79	0.40	0.67	0.51
2004	5,309	1,412	0.18	506	253	16	0.97	0.48	0.85	0.73
2005	6,441	2,448	0.23	391	196	9	0.98	0.49	0.81	0.68
2006	5,507	3,094	0.18	500	250	10	0.98	0.49	0.85	0.73
2007	2,983	1,434	0.32	456	228	17	0.96	0.48	0.75	0.60
2008	2,998	3,977	0.54	359	202	86	0.81	0.45	0.60	0.46
2009	4,204	3,340	0.40	503	254	4	0.99	0.50	0.71	0.55
2010	3,189	2,763	0.41	484	242	8	0.98	0.49	0.70	0.54
2011	4,642	5,039	0.47	467	332	26	0.95	0.67	0.67	0.59
2012	4,840	3,385	0.40	107	96	0	1.00	0.90	0.72	0.69
2013	5,627	2,567	0.27	353	318	0	1.00	0.90	0.79	0.77
2014	10,402	1,762	0.12	499	449	5	0.99	0.89	0.89	0.88
2015	10,350	3,398	0.21	421	379	9	0.98	0.88	0.82	0.81
2016	8,661	1,944	0.15	584	526	0	1.00	0.90	0.87	0.86
Average	3,466	2,406	0.35	423	229	152	0.74	0.52	0.68	0.56
5-Year Average	7,976	2,611	0.23	393	354	3	0.99	0.89	0.82	0.80

pHOS values are effective from 1989-2006 and Effective, Reach-weighted pHOS from 2006-2016

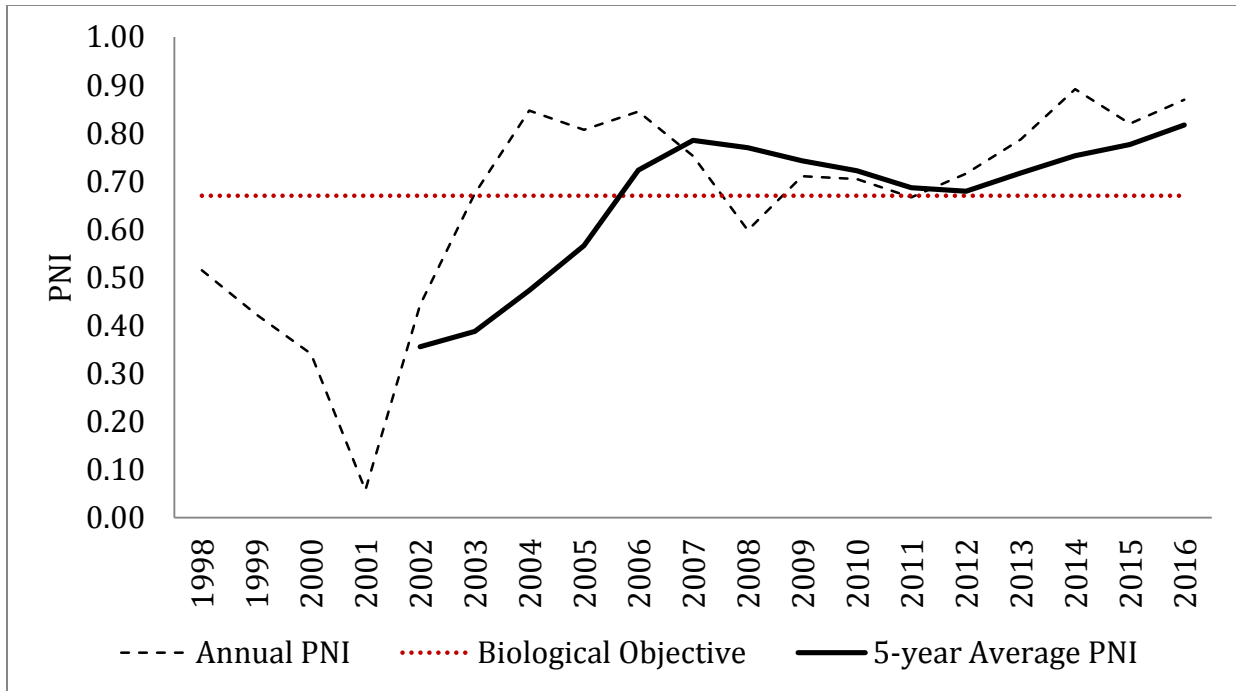


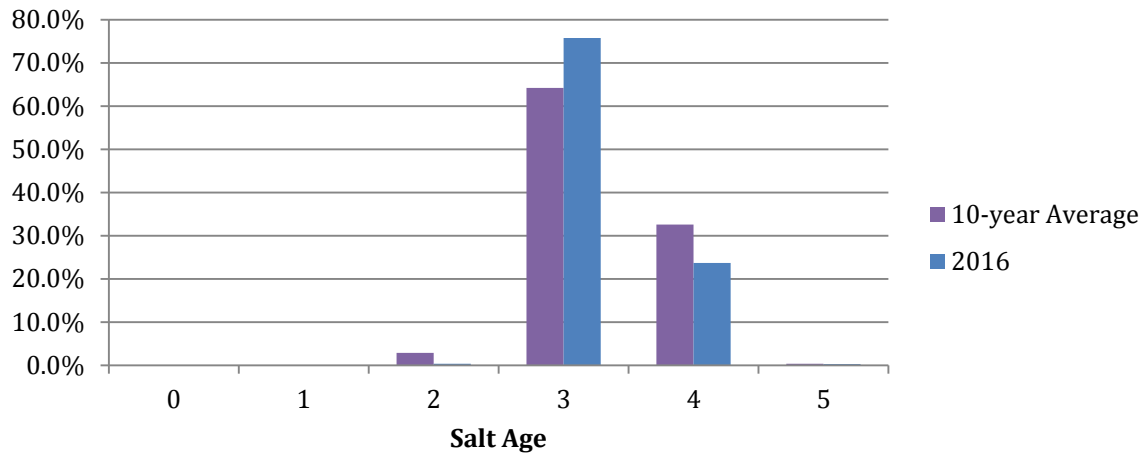
Figure 28. Annual and 5-year average proportionate natural influence (PNI) in the Okanogan and Similkameen Rivers (combined) from 1998 to 2016.

AGE STRUCTURE

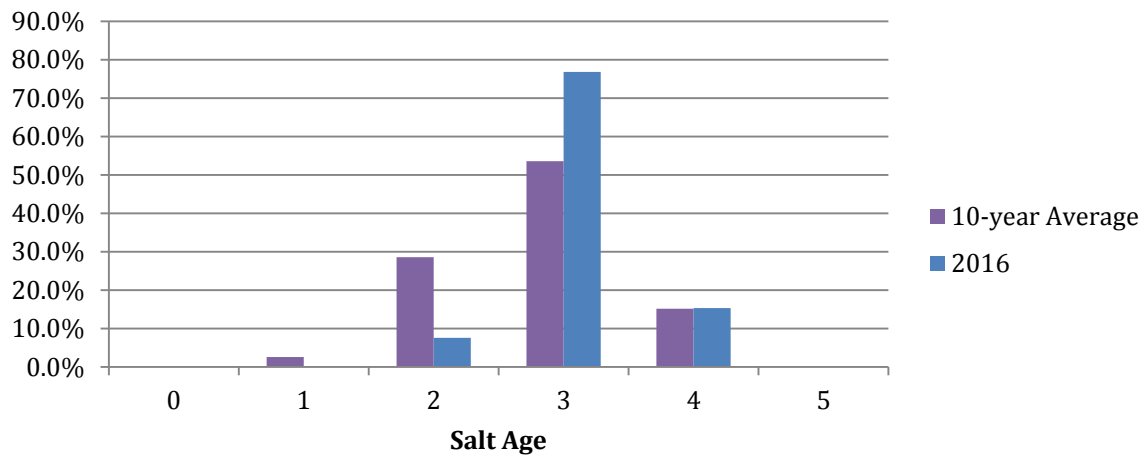
Attempts were made to age all carcasses recovered on the spawning grounds, either by reading scales on natural-origin fish or by extracting and reading coded wire tags for hatchery-origin fish. Historically, most natural-origin summer Chinook migrate as sub-yearlings, while the majority of hatchery-origin releases in the Okanogan river basin have been released as yearlings. To account for this difference, the number of winters a fish spent in the marine environment – salt age – is the format of reported data.

In 2016, both male and female natural- and hatchery-origin fish were more apt to return as 3-salt fish than the 10-year average – the pool of spawners in brood year 2016 were older than average (Figure 29).

Natural-origin Female Age Structure



Natural-origin Male Age Structure



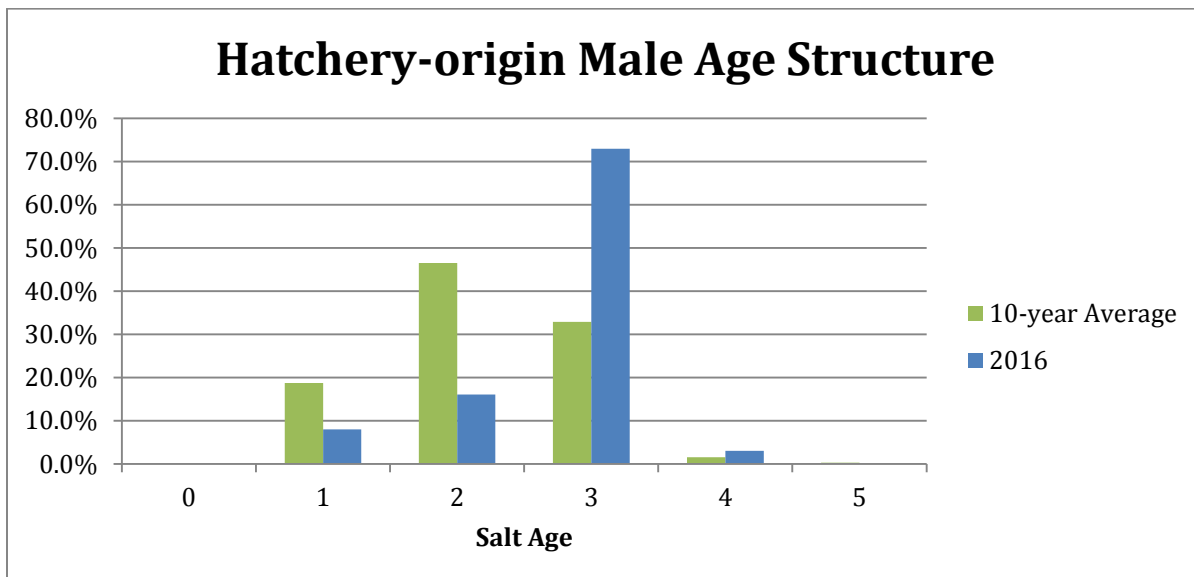
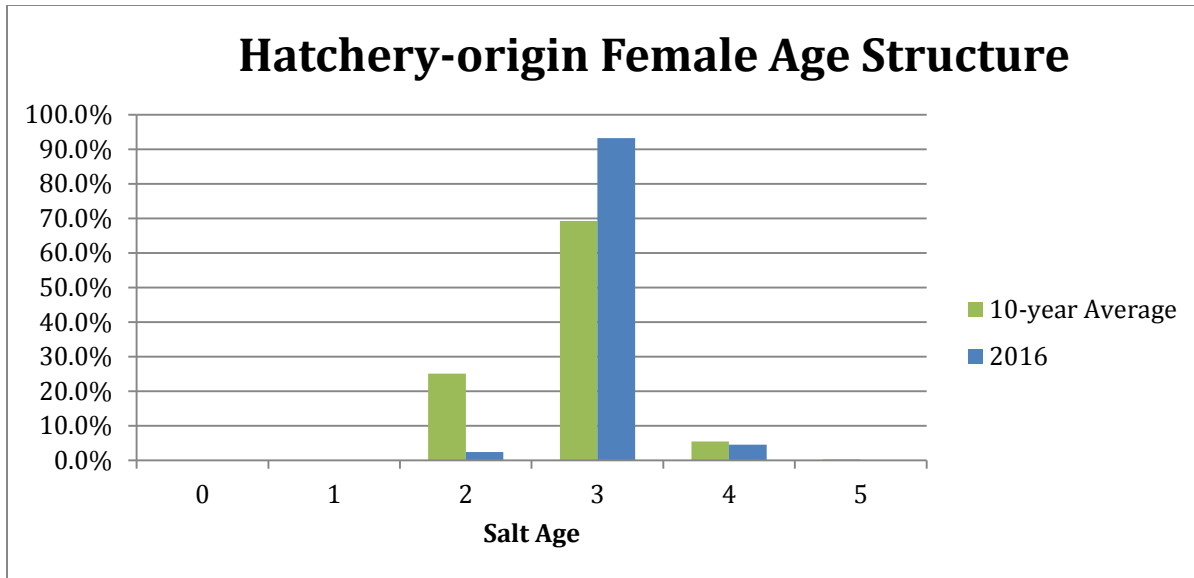


Figure 29. The salt ages of carcasses collected on the spawning grounds of the Okanogan and Similkameen Rivers in 2016 and 10-year averages (2007-2016).

HATCHERY-ORIGIN STRAY RATES

Strays within the Okanogan.—The majority (95%) of hatchery-origin spawners recovered on the spawning grounds in 2016 were from Similkameen (91%) and Okanogan (4%) River releases (Table 24). This was very similar to the average (95%) of recent years (2006-2016). Strays from outside the Okanogan but within the Upper Columbia summer/fall Chinook ESU consisted of fish from Dryden Pond, Carlton Pond, Entiat NFH, Chelan Falls Hatchery, and Wells Hatchery (4%). Strays from outside the ESU were from releases into the Yakima River (1%). Stray hatchery fish from outside the Okanogan comprised less than 1% of total (hatchery plus natural-origin) Okanogan spawner

composition (i.e., stray pHOS) (Table 25). This was less than the recent (2006-2016) average of 1.9% and well under the biological target of < 5%.

Strays outside the Okanogan.— The most recent brood year that could be fully assessed (through age 5) for stray rate of Okanogan fish to spawning areas outside the Okanogan was 2011. The 2011 brood year had a stray rate of 1.1%, which was similar to the long term and recent five year averages (Table 26). RMIS queries revealed an estimate of 14 Okanogan hatchery-origin CWT codes from spawning ground recoveries in non-target spawning areas in 2016 (Table 26). Okanogan basin hatchery program strays comprise $\leq 1\%$ to other basin population's spawner composition (in 2016 as well as long term average). (Table 27).

Table 24. Estimated number (and percent of annual total) of hatchery-origin spawners from different release basins recovered on the Okanogan/Similkameen spawning grounds, based on CWT recoveries and expansions, for return years 2006-2016.

Return Year	Release Site									
	Summer Chinook Run								Spring and Fall Chinook Run	
	Homing Fish		Straying Fish							
	Okanogan River Basin		Within ESU Stray					Out of ESU Stray		
	Okanogan River ^a	Similkameen River ^b	Methow River ^c	Wenatchee River ^d	Entiat River ^e	Chelan River ^f	Mainstem Columbia River ^g	Mainstem Columbia River ^h	Snake River ⁱ	Other ^j
2006	0 (0%)	709 (87%)	12 (2%)	12 (2%)	0 (0%)	0 (0%)	81 (10%)	0 (0%)	0 (0%)	0 (0%)
2007	0 (0%)	1121 (95%)	17 (1%)	5 (0%)	0 (0%)	0 (0%)	42 (4%)	0 (0%)	0 (0%)	0 (0%)
2008	0 (0%)	3224 (95%)	11 (0%)	24 (1%)	0 (0%)	4 (0%)	133 (4%)	3 (0%)	0 (0%)	0 (0%)
2009	0 (0%)	2733 (95%)	14 (0%)	14 (0%)	0 (0%)	9 (0%)	99 (3%)	0 (0%)	5 (0%)	4 (0%)
2010	4 (0%)	2165 (89%)	44 (2%)	35 (1%)	0 (0%)	110 (5%)	75 (3%)	0 (0%)	4 (0%)	0 (0%)
2011	219 (5%)	4196 (93%)	44 (1%)	5 (0%)	0 (0%)	34 (1%)	22 (0%)	0 (0%)	6 (0%)	0 (0%)
2012	379 (13%)	2397 (83%)	29 (1%)	23 (1%)	0 (0%)	17 (1%)	52 (2%)	0 (0%)	0 (0%)	0 (0%)
2013	254 (14%)	1437 (81%)	10 (1%)	54 (3%)	0 (0%)	0 (0%)	10 (1%)	0 (0%)	0 (0%)	0 (0%)
2014	55 (5%)	1023 (90%)	16 (1%)	0 (0%)	6 (1%)	12 (1%)	29 (3%)	0 (0%)	0 (0%)	0 (0%)
2015	38 (1%)	2562 (91%)	70 (3%)	17 (1%)	19 (1%)	33 (1%)	33 (1%)	4 (0%)	4 (0%)	21 (1%)
2016	81(4%)	1963 (91%)	42 (2%)	7 (0%)	3 (0%)	31 (1%)	14 (1%)	0 (0%)	0 (0%)	17(1%)
Avg.	94 (4%)	2139 (90%)	28 (1%)	18 (1%)	3 (0%)	23 (1%)	54 (3%)	1 (0%)	2 (0%)	4 (0%)

^a Includes releases from Omak and Bonaparte Pond. Three spring Chinook recovered in 2008 from an Omak Creek release were excluded from analysis.

^b Includes releases from Similkameen Pond

^c Includes releases from Carlton Acclimation Pond

^d Includes releases from Dryden Pond and Eastbank Hatchery

^e Includes releases from Entiat NFH

^f Includes releases from Chelan PUD Hatchery, Chelan River NFH, and Chelan Hatchery

^g Includes releases of summer Chinook from Wells Hatchery, Turtle Rock Hatchery, and Grant County PUD Hatchery

^h Includes releases of fall Chinook from Hanford Reach

ⁱ Includes Releases from NPT Hatchery

^j Includes releases from Marion Yakama Tribal, Cle Elum Hatchery, and Prosser Hatchery

Table 25. Estimated percent of spawner composition of hatchery-origin spawners from different release basins recovered on the Okanogan/Similkameen spawning grounds, based on CWT recoveries and expansions, for return years 2006-2016.

Return Year	Release Site										HOS Stray Contribution to Total Spawning Escapement	pHOS
	Summer Chinook Run							Other Chinook Run				
	Okanogan River Basin		Within ESU Stray					Out of ESU Stray				
	Okanogan River ^a	Similkameen River ^b	Methow River ^c	Wenatchee River ^d	Entiat River ^e	Chelan River ^f	Mainstem Columbia River ^g	Mainstem Columbia River ^h	Snake River ⁱ	Other ^j		
2006	0.0%	15.6%	0.3%	0.3%	0.0%	0.0%	1.8%	0.0%	0.0%	0.0%	2.3%	0.18
2007	0.0%	30.0%	0.5%	0.1%	0.0%	0.0%	1.1%	0.0%	0.0%	0.0%	1.7%	0.32
2008	0.0%	51.5%	0.2%	0.4%	0.0%	0.1%	2.1%	0.1%	0.0%	0.0%	2.8%	0.54
2009	0.0%	38.4%	0.2%	0.2%	0.0%	0.1%	1.4%	0.0%	0.1%	0.1%	2.0%	0.40
2010	0.6%	40.71%	0.84%	0.67%	0.0%	2.1%	1.43%	0.0%	0.08%	0.0%	4.54%	0.41
2011	2.52%	48.26%	0.51%	0.06%	0.0%	0.39%	0.25%	0.0%	0.07%	0.0%	1.27%	0.47
2012	5.38%	34.05%	0.41%	0.33%	0.0%	0.24%	0.74%	0.0%	0.0%	0.0%	1.72%	0.40
2013	3.4%	19.5%	0.1%	0.7%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	1.29%	0.24
2014	0.7%	12.99%	0.21%	0.0%	0.0%	0.15%	0.37%	0.0%	0.0%	0.0%	0.72%	0.11
2015	0.34%	22.69%	0.58%	0.15%	0.16%	0.27%	0.27%	0.03%	0.03%	0.17%	1.67%	0.21
2016	0.32%	17.37%	0.26%	0.09%	0.0%	0.12%	0.04%	0.0%	0.0%	0.09%	0.59%	0.19
Avg.	1.2%	30.1%	0.4%	0.3%	0.0%	0.3%	0.9%	0.0%	0.0%	0.0%	1.9%	31.5%

^a Includes releases from Bonaparte Pond. Three spring Chinook recovered in 2008 from an Omak Creek release were excluded from analysis.

^b Includes releases from Similkameen Pond

^c Includes releases from Carlton Acclimation Pond

^d Includes releases from Dryden Pond and Eastbank Hatchery

^e Includes releases from Entiat NFH

^f Includes releases from Chelan PUD Hatchery, Chelan River NFH, and Chelan Hatchery

^g Includes releases of summer Chinook from Wells Hatchery, Turtle Rock Hatchery, and Grant County PUD Hatchery

^h Includes releases of fall Chinook from Hanford Reach

ⁱ Includes Releases from NPT Hatchery

^j Includes releases from Marion Yakama Tribal, Cle Elum Hatchery, and Prosser Hatchery

Table 26. Number and percent (%) of hatchery-origin Okanogan summer/fall Chinook that were recovered at target spawning areas or were captured at en route hatcheries (Wells and Chief Joseph Hatchery), and number and percent that strayed to non-target spawning areas and non-target hatcheries, brood years 1989-2010. As fish continue to return through time and the RMIS database is continually updated, reported data from recent brood years may change.

Brood Year	Homing				Straying			
	Target Stream		En Route Hatchery		Non-target Streams		Non-target Hatchery	
	Number	%	Number	%	Number	%	Number	%
1989	3,132	69.7%	1,328	29.6%	2	0.0%	31	0.7%
1990	729	71.4%	291	28.5%	0	0.0%	1	0.1%
1991	1,125	71.3%	453	28.7%	0	0.0%	0	0.0%
1992	1,264	68.5%	572	31.0%	8	0.4%	1	0.1%
1993	54	62.1%	32	36.8%	0	0.0%	1	1.1%
1994	924	80.8%	203	17.7%	16	1.4%	1	0.1%
1995	1,883	85.4%	271	12.3%	52	2.4%	0	0.0%
1996	27	100.0%	0	0.0%	0	0.0%	0	0.0%
1997	11,659	97.1%	309	2.6%	35	0.3%	2	0.0%
1998	2,784	95.4%	102	3.5%	31	1.1%	2	0.1%
1999	828	96.7%	18	2.1%	10	1.2%	0	0.0%
2000	2,091	93.8%	29	1.3%	94	4.2%	15	0.7%
2001	105	98.1%	2	1.9%	0	0.0%	0	0.0%
2002	702	96.2%	17	2.3%	11	1.5%	0	0.0%
2003	1,580	96.2%	47	2.9%	16	1.0%	0	0.0%
2004	4,947	94.4%	206	3.9%	85	1.6%	2	0.0%
2005	606	93.2%	22	3.4%	22	3.4%	0	0.0%
2006	5,210	97.6%	60	1.1%	68	1.3%	0	0.0%
2007	1,330	97.9%	19	1.4%	10	0.7%	0	0.0%
2008	3,673	96.5%	111	2.9%	19	0.5%	4	0.1%
2009	1,149	80.8%	256	18.0%	14	1.0%	2	0.1%
2010	1,058	61.4%	646	37.5%	9	0.5%	10	0.6%
2011	4,449	79.9%	873	18.9%	10	0.6%	25	0.5%
Total	51,309	86.3%	5,867	12.5%	512	1.0%	97	0.2%

Table 27. Number and percent (%) of spawning escapements that consisted of hatchery-origin Okanogan summer/fall Chinook within other non-target basins, return years 1994-2016.

Return Year	Wenatchee		Methow		Chelan		Entiat	
	Number	%	Number	%	Number	%	Number	%
1994	0	0.0%	0	0.0%	-	-	-	-
1995	0	0.0%	0	0.0%	-	-	-	-
1996	0	0.0%	0	0.0%	-	-	-	-
1997	0	0.0%	0	0.0%	-	-	-	-
1998	0	0.0%	0	0.0%	0	0.0%	0	0.0%
1999	0	0.0%	0	0.0%	0	0.0%	0	0.0%
2000	0	0.0%	6	0.5%	30	6.4%	0	0.0%
2001	12	0.1%	0	0.0%	10	1.0%	0	0.0%
2002	0	0.0%	3	0.1%	4	0.7%	5	1.0%
2003	0	0.0%	8	0.2%	22	5.3%	14	2.0%
2004	0	0.0%	0	0.0%	5	1.2%	0	0.0%
2005	5	0.1%	27	1.1%	36	6.9%	7	1.9%
2006	0	0.0%	5	0.2%	4	1.0%	2	0.4%
2007	0	0.0%	3	0.2%	4	2.1%	0	0.0%
2008	0	0.0%	9	0.5%	46	9.3%	4	1.3%
2009	15	0.2%	3	0.2%	11	1.8%	18	7.1%
2010	6	0.1%	0	0.0%	33	3.0%	0	0.0%
2011	0	0.0%	0	0.0%	45	3.5%	0	0.0%
2012	7	0.1%	5	0.2%	18	1.4%	0	0.0%
2013	0	0.0%	0	0.0%	0	0.0%	0	0.0%
2014	0	0.0%	4	0.2%	11	1.0%	0	0.0%
2015	4	0.1%	5	0.1%	4	0.3%	0	0.0%
2016	0	0.0%	4	0.2%	4	0.5%	0	0.0%
Total	49	0.0%	82	0.2%	283	2.4%	50	0.7%
5-year Total	11	0.0%	18	0.1%	37	0.6%	-	0.0%

Homing Fidelity

Based on 370 coded-wire tags recovered during spawning grounds surveys in fall of 2016, an estimated 67 and 1858 (CWT-expanded) spawners originated from Omak Pond and Similkameen Pond acclimation sites, respectively. Of those spawners, the majority of the fish originating from the Omak Pond acclimation site spawned in the Okanogan River (Table 28). Those fish tended to spawn in habitat upstream of the Omak Pond site, with the

majority CWT's recovered in the reach O5. Only a single CWT was recovered below reach O4, from a fish originally acclimated at Omak Pond, which was recovered in reach O2 (Figure 30). Only an estimated 18 fish that were acclimated at Omak Pond chose to spawn in the Similkameen River. These returns would consist only of ≤ 3 year olds for fish released from Omak Pond. Future return years will include additional age classes and should provide greater insight into homing fidelity for fish acclimated at Omak Pond. Fish acclimated at the Similkameen Pond site spawned primarily in reach S1, with substantial numbers of fish also spawning in habitat within reaches O5 and O6 (Figure 30). Overall, Similkameen pond-origin fish tended to home to the Similkameen River (Table 28).

Table 28. Spawning distribution by river, for fish acclimated at Omak Pond and Similkameen Pond acclimation sites.

Spawning location	Acclimation site (origin)	
	Omak Pond	Similkameen Pond
Okanogan River	73%	45%
Similkameen River	27%	55%

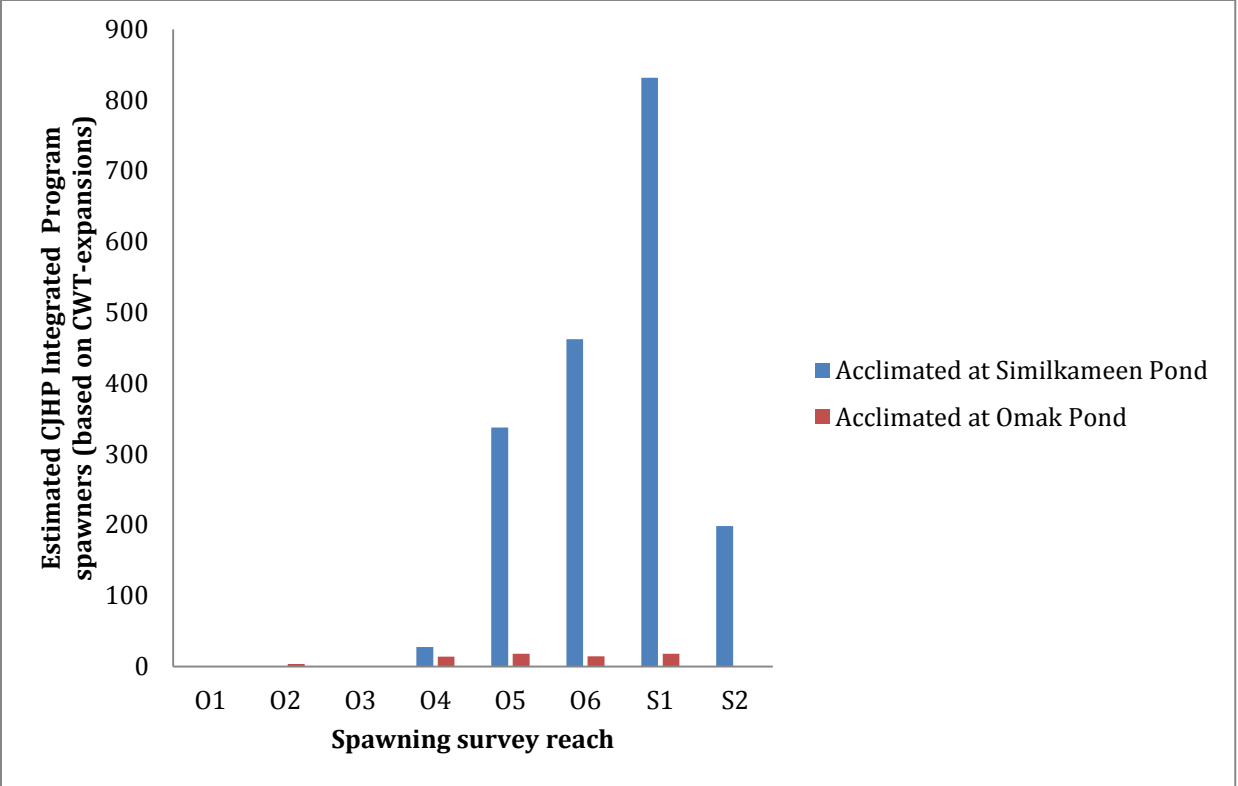


Figure 30. Spatial distribution of CJH integrated program Chinook spawners originally reared at the Similkameen Pond and Omak Pond acclimation sites.

Smolt-to-Smolt Survival and Travel Time

2016 was the second year of PIT tagged releases from the CJH. Apparent survival of yearlings to RRJ was generally between 75-80% with the exception of integrated yearlings from Omak Pond that was 57% (Tables 28-29). Apparent survival of yearlings to MCN was generally 50-60% regardless of species or release location (Tables 28-29). Apparent survival to RRJ for sub-yearling summer Chinook was 35-44% for fish released from CJH facilities, 51% for Wells Fish Hatchery releases and 25% for wild subyearlings captured in a beach seine near the mouth of the Okanogan (Table 30).

Statistical tests were not conducted to evaluate if the CJH releases were significantly different than nearby hatcheries or previous years. The guidance from the Annual Program Review was to wait until a multi-year assessment could be conducted with at least 4 or 5 years of data to more accurately evaluate patterns between years and programs.

Table 29. Apparent survival estimates for PIT tagged Spring Chinook Salmon smolts released from Chief Joseph hatchery (CJH), Winthrop National Fish Hatchery (WNFH) and Leavenworth National Fish Hatchery (LNFH) in 2016.

Spring Chinook Release Group	# PIT tags		Reach	Survival	Survival	Capture Prob.	Capture Prob. (SE)
	Released	Recap.			Standard Error (SE)		
Yearlings released at CJH	4967	1040	Release to RRJ	0.74	0.03	0.28	0.01
		703	Release to MCN	0.48	0.03	0.29	0.02
Yearlings released at Riverside (10j)	4959	1054	Release to RRJ	0.81	0.03	0.26	0.01
		673	Release to MCN	0.63	0.04	0.22	0.02
Yearlings released at WNFH	17361	3896	Release to RRJ	0.75	0.02	0.30	0.01
		2170	Release to MCN	0.58	0.02	0.22	0.01
Yearlings released at LNFH	19679						
		2596	Release to MCN	0.49	0.02	0.27	0.01

Table 30. Apparent survival estimates for PIT tagged Summer Chinook Salmon released in 2016 from Chief Joseph Hatchery (CJH) and other nearby hatcheries.

Summer Chinook Release Group	# PIT tags		Reach	Survival	Survival Standard Error (SE)	Capture Prob.	Capture Prob. (SE)
	Released	Recap.					
Yearlings released at CJH	4951	1069	Release to RRJ	0.78	0.04	0.28	0.01
		521	Release to MCN	0.53	0.04	0.20	0.02
Yearlings released at Omak Pond	4193	459	Release to RRJ	0.57	0.04	0.19	0.02
		295	Release to MCN	0.44	0.05	0.16	0.02
Yearlings released at Carlton Pond	4992	977	Release to RRJ	0.81	0.04	0.24	0.01
		505	Release to MCN	0.63	0.06	0.16	0.02
Yearlings released at Dryden Pond	20786						
		2381	Release to MCN	0.79	0.03	0.15	0.01
Subyearlings released at CJH	4983	425	Release to RRJ	0.44	0.08	0.19	0.04
		70	Release to MCN	0.14	0.05	0.10	0.04
Subyearlings released at Omak	4979	465	Release to RRJ	0.35	0.05	0.27	0.04
		64	Release to MCN	0.14	0.06	0.09	0.04
Wells Fish Hatchery Subyearlings	5983	686	Release to RRJ	0.51	0.05	0.22	0.02
		158	Release to MCN	0.25	0.05	0.11	0.02

Table 31. PIT tag survival estimates for juvenile wild Summer Chinook Salmon captured in a beach seine in Wells Pool, primarily near the mouth of the Okanogan River. 2015a and 2016a were only the fish captured in the beach seine and 2015b and 2016b were the beach seined fish pooled with those tagged at the rotary screw trap in the Okanogan River as well as in a side-channel at Conservancy Island.

Wild Summer Chinook Release Group	# PIT tags		Reach		Survival Standard Error (SE)	Capture Prob.	Capture Prob. (SE)
	Released	Recap.	Release to:	Survival			
	2011	13,221	1,200	RRJ			
	920		MCN	0.30	0.02	0.23	0.02
2012	15,311	912	RRJ	0.54	0.04	0.11	0.01
		795	MCN	0.40	0.03	0.13	0.01
2013	17,760	1,988	RRJ	0.44	0.02	0.26	0.01
		747	MCN	0.39	0.04	0.11	0.01
2014	8,226	845	RRJ	0.35	0.03	0.29	0.02
		240	MCN	0.19	0.04	0.16	0.03
2015a	5,823	519	RRJ	0.26	0.06	0.342	0.077
		13	MCN	NE	NE	NE	NE
2015b	7,787	569	RRJ	0.25	0.05	0.288	0.0628
		19	MCN	NE	NE	NE	NE
2016a	13,651	1,378	RRJ	0.25	0.03	0.40	0.04
		80	MCN	NE	NE	NE	NE
2016b	14,674	1,411	RRJ	0.24	0.03	0.40	0.04
		81	MCN	NE	NE	NE	NE

NE = No Estimate due to small sample size and low recapture probability

The travel time of fish released from CJH facilities to RRJ in 2016 varied from 18 days (6.4 km/day) for sub-yearlings released from the hatchery to 12 days (13.7 km/day) for the 10j Spring Chinook released from Riverside Pond (Table 32). As in 2015, sub-yearling summer Chinook from the Omak Pond had one of the fastest migration speeds (11.2 km/day) of all release groups, outpacing all of the yearling summer Chinook groups (Table 32). Direct comparisons of migration speed may not be applicable because not all fish are released at the same time and location and therefore do not experience the same water conditions (e.g., temperature, velocity). Most notably, the sub-yearlings were released approximately 1-1.5 months later than the

yearlings and the wild juveniles were not tagged until June and July. Consequently, arrival timing at RRJ was substantially earlier for yearlings than sub-yearlings (

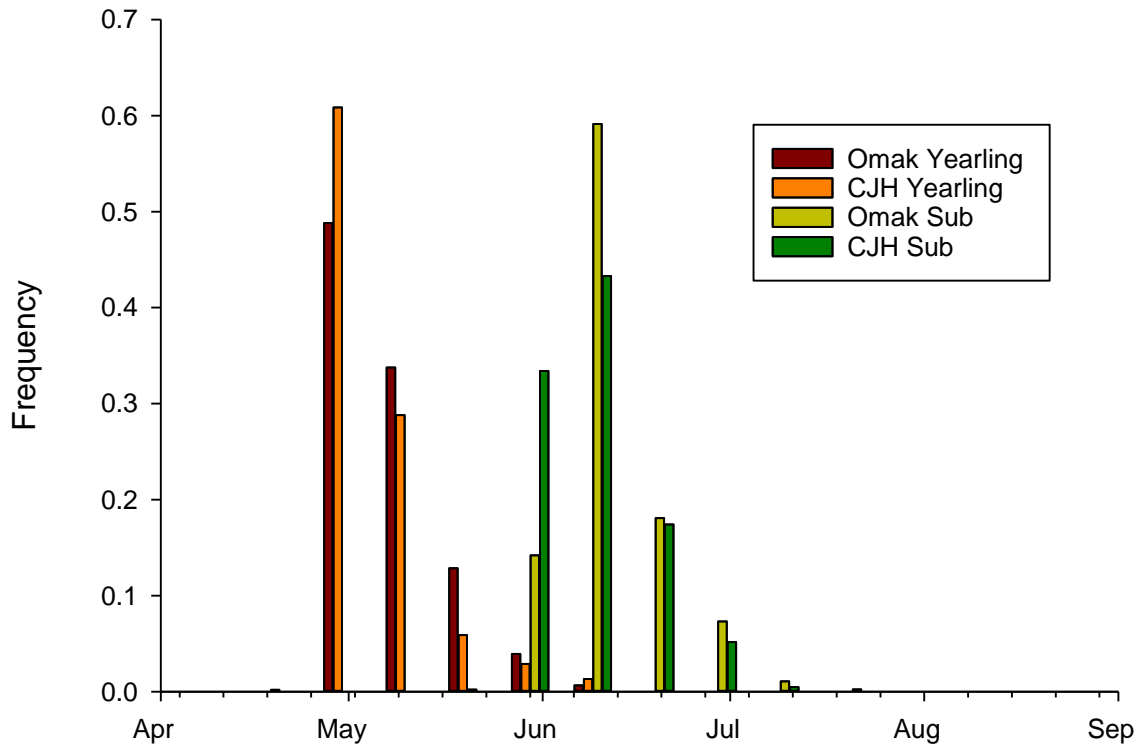


Figure 31). Summer Chinook arrived at Rocky Reach over a 5-6 week period; late April to early June for yearlings and early June to mid- July for sub-yearlings. The majority of Spring Chinook from CJH and Riverside Pond arrived at RRJ during the first two weeks in May (Figure 32). The migration speed increased substantially in reaches downstream of Rocky Reach Dam for all release groups, although downstream reach estimates could not be estimated for all groups due to small sample sizes ($n < 10$) (Table 31.).

Table 32. Travel time and migration speed for various Chinook release groups in 2016

Release Group	First Day of Release 2016	Last Day of Release 2016	Forced or Volitional	Release to RRJ		RRJ to MCN	MCN to BON
				Mean Travel Time (d)	Travel Rate (km/day)	Travel Rate (km/day)	Travel Rate (km/day)
CJH Summer subs	16-May	16-May	F	18.1	6.4	35.9	a
Omak Pond subs	23-May	24-May	F	13.4	11.2	32.0	a

Wells FH subs	14-May	17-May	F	22.0	3.1	28.4	57.2
Wild subs	12-May	23-Jun	NA	28.4	3.4	28.3	^a
CJH Summer yearlings	15-Apr	22-Apr	V	14.7	7.9	27.4	59.0
Omak Pond yearlings	15-Apr	22-Apr	V	16.2	9.3	28.5	58.5
Carlton yearlings	18-Apr	18-Apr	F	14.5	8.6	21.9	56.6
Dryden yearling	18-Apr	27-Apr	V	NA	NA	17.0 ^b	60.4
CJH Spring Chk	15-Apr	22-Apr	V	13.9	8.3	28.3	57.6
RivP Spr Chk (10j)	15-Apr	21-Apr	V	11.9	13.7	30.2	64.0
Winthrop Spring Chk	11-Apr	11-Apr	F	14.7	11.1	25.4	57.5
Leavenworth Spr Chk	21-Apr	21-Apr	F	NA	NA	17.6 ^b	59.8

^a sample size too small (<10) to calculate an estimate

^b Release to McNary, not Rocky Reach to McNary

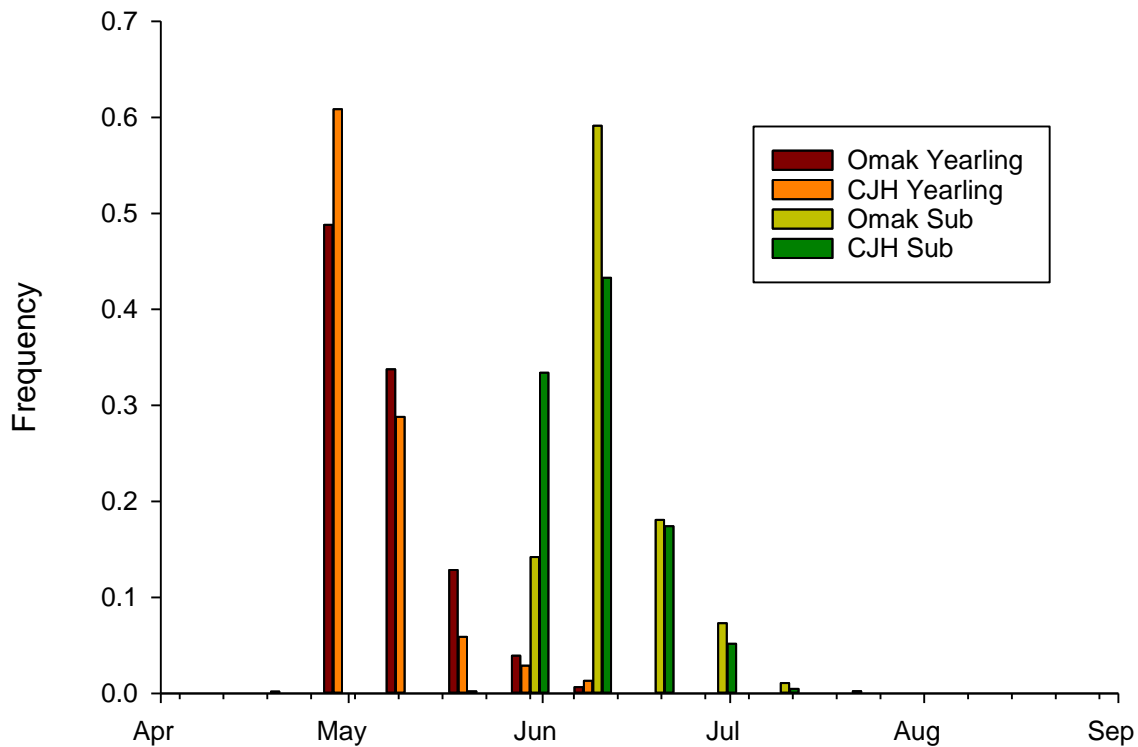


Figure 31. Arrival timing at Rocky Reach Juvenile bypass (RRJ) of PIT tagged summer Chinook released from the Chief Joseph Hatchery and Omak Pond in 2016.

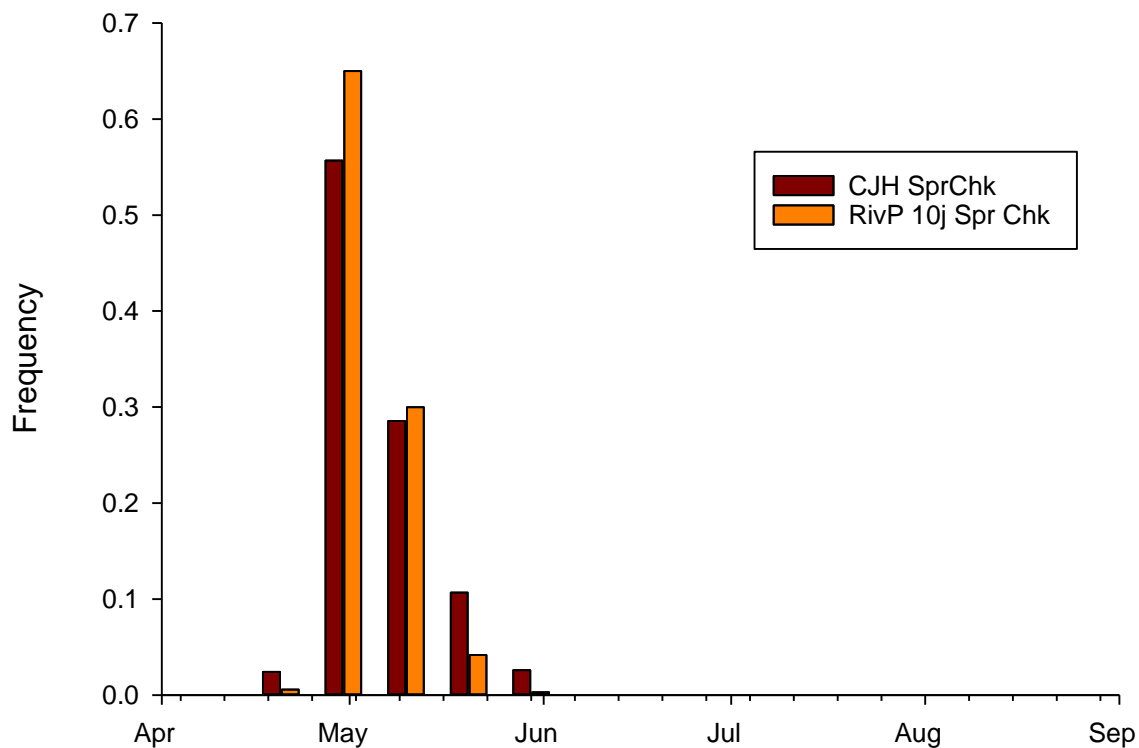


Figure 32. Arrival timing at Rocky Reach Juvenile bypass (RRJ) of PIT tagged Spring Chinook released from the Chief Joseph Hatchery (CJH) and Riverside Pond (RivP) in 2016.

One hundred ninety four (194) hatchery smolts with a PIT tag were detected at OKL between April 19 and September 17, 2016. Omak Pond sub-yearling Summer Chinook moved out the fastest, with 96% of the PIT detections within three days of release (Table 33). The majority (71%) of yearling summer Chinook from Omak Pond were detected at OKL within 8 days of release, but it was approximately three weeks before 95% of the fish had passed (Table 32). For yearling Spring Chinook released from Riverside Pond, 95% of the PIT detections occurred within eight days of release. One subyearling was not detected at OKL until September 17, it was unclear if this fish was precocial and had residualized or if it was expressing a fall migrant life history. Two yearlings (not included in Table 32) migrated to below Bonneville Dam in the spring and returned and were detected at OKL in September and therefore should be considered a minijack, not a residual.

Table 33. Detections of PIT tags at the lower Okanogan PIT array (OKL) from release groups of hatchery smolts on the Okanogan River in 2016.

Release Group	Detection Date	Number Detected	Percent Detected	Cumulative % Detected
Omak Pond Subyearlings Release Date 23 May 2016 Forced	5/11/2016	1	4%	4%
	5/23/2016	16	62%	65%
	5/24/2016	6	23%	88%
	5/25/2016	1	4%	92%
	5/26/2016	1	4%	96%
	9/17/2016	1	4%	100%
Omak Pond Yearling Summer Chinook Release Period 15-22 April, 2016 Volitional	4/19/2016	1	2%	2%
	4/20/2016	5	8%	10%
	4/21/2016	13	21%	31%
	4/22/2016	16	26%	56%
	4/23/2016	9	15%	71%
	4/24/2016	4	6%	77%
	4/25/2016	3	5%	82%
	4/26/2016	2	3%	85%
	5/1/2016	1	2%	87%
	5/2/2016	1	2%	89%
	5/3/2016	1	2%	90%
	5/5/2016	1	2%	92%
	5/6/2016	2	3%	95%
5/9/2016	1	2%	97%	
5/11/2016	2	3%	100%	
Riverside Pond Spring Chinook Yearlings Release Period 15-21 April, 2016 Volitional	4/19/2016	2	2%	2%
	4/20/2016	31	30%	32%
	4/21/2016	44	42%	74%
	4/22/2016	18	17%	91%
	4/23/2016	4	4%	95%
	4/25/2016	1	1%	96%
	4/29/2016	1	1%	97%
	5/4/2016	2	2%	99%
	5/5/2016	1	1%	100%

Smolt-to-Adult Return (SAR)

The most recent brood year that could be fully assessed (through age 5) for SAR was 2010. Based on expanded CWTs, the 2010 brood year had a SAR of 1.3%, which was above the long-term average, but below the 5-year averages. However, this number may change as more adult captures from BY 2010 are uploaded to the RMIS database, and this table changes in the coming years to reflect those data (Table 34).

Table 34. Smolt-to-adult return rate (SARs) for Okanogan/Similkameen summer/fall Chinook, brood years 1989-2010.

Brood Year	Number of tagged smolts released^a	Estimated adult captures^b	SAR
1989	202,125	4,293	2.1%
1990	367,207	972	0.3%
1991	360,380	975	0.3%
1992	537,190	2,282	0.4%
1993	379,139	117	0.0%
1994	212,818	1,528	0.7%
1995	574,197	2,851	0.5%
1996	487,776	31	0.0%
1997	572,531	18,600	3.2%
1998	287,948	7,687	2.7%
1999	610,868	2,776	0.5%
2000	528,639	6,762	1.3%
2001	26,315	424	1.6%
2002	245,997	1,975	0.8%
2003	574,908	3,489	0.6%
2004	676,222	12,896	1.9%
2005	273,512	1,660	0.6%
2006	597,276	13,626	2.3%
2007	610,379	4,758	0.8%
2008	604,064	14,932	2.5%
2009	673,372	8,547	2.2%
2010	650,137	8,504	1.3%
<i>Total</i>	<i>10,053,000</i>	<i>111,181</i>	<i>1.2%</i>
<i>5-year Total</i>	<i>3,135,228</i>	<i>41,863</i>	<i>1.8%</i>

^a Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

^b Includes estimated recoveries (spawning grounds, hatcheries, all harvest - including the ocean and Columbia river basin, etc.) and observed recoveries if estimated recoveries were unavailable.

Spring-Chinook Presence and Distribution

ENVIRONMENTAL DNA

CJHP collaborates with USGS to conduct Environmental DNA (eDNA) sampling and as one approach to monitor status and trends in spring-Chinook spatial distribution throughout the Okanogan basin in response to the reintroduction of the experimental population. Monitoring began prior to the reintroduction in an attempt to assess the pre-management action spatial distribution of spring-Chinook, allowing CJHP to assess the status and progress of the 10(j) reintroduction efforts. While spring-Chinook were listed as extirpated within the Okanogan ESU, analysis of eDNA samples from tributaries (i.e. stream-type Chinook habitat) revealed that the basin likely does have a limited distribution of spring-Chinook. Additionally, PIT tag detections confirm the presence of occasional strays from out of basin (*see PIT Tag Detections Section below*).

As a proof of concept, sampling was initiated in 2012 with five mainstem Okanogan River sites and 11 Okanogan tributary sites as well as 32 sites throughout the Methow basin (See Laramie et al. 2015a and CJHP 2013 Annual Report). Sampling was conducted in June and August 2012 at all sites. In 2013, sampling was conducted only in the Okanogan basin, at eight additional tributary sites not visited during the proof of concept study. These sites were sampled in June and were located in tributary streams with potential for spring-Chinook recolonization. In 2014, all previously sampled sites in the Okanogan basin were re-visited and sampled (U.S. sites on 12-13 July, 2014, and Canada sites on 2 October 2014). All sampling was conducted following the methods and protocols described in Laramie et al 2015b, and available as PNAMP Method ID# 5476 (www.monitoringresources.org/Document/Method/Details/5476). See Appendix C for results from 2012 thru 2014 eDNA analyses. Several tributaries have produced consistent annual detection of Chinook eDNA, including Shingle Creek, Vaseux Creek, Salmon Creek and Omak Creek. No sampling was conducted in 2015. In 2016, 15 sites were re-sampled to monitor status and trends in spatial distribution during the early stages of the reintroduction effort (Table 35).

Table 35. eDNA results for sampling conducted in Okanogan basin tributaries from 2012-2016.

Site	2012	2013	2014	2015	2016
Loup Loup Creek		-	+		+
Omak Creek (above falls)	-				+
Omak Creek (near mouth)	+		+		+
Salmon Creek	+		+		+
North Fork Salmon Creek	-		-		
West Fork Salmon Creek	-		-		
Wanacut Creek		-			-
Tunk Creek		-			+
Aeneas Creek		-	-		-
Bonaparte Creek	+		-		-
Siwash Creek		+			
Tonasket Creek		+			-
Antoine Creek		-	+		+
Similkameen River		+	+		
Ninemile Creek	-		-		+
Inkaneep Creek	+		-		-
Vaseux Creek	+		+		+
Shuttleworth Creek	-		-		-
Shingle Creek	+		+		-
Okanogan River (near mouth)	+		+		
Okanogan River (above Salmon Cr.)	+		+		
Okanogan River (above Siwash Cr.)	+		+		
Okanogan River (Inkaneep Cr.)	+		+		
Okanogan River (at Shuttleworth Cr.)	-		+		

Indicates Presence +
Indicates not-detected -

PIT TAG DETECTIONS

PTAGIS contained 65 unique records of adult and jack spring-Chinook detected in the Okanogan basin in 2014 (Table 36). One tag was filtered out of the summary because it appeared to be a fish harvested in Icicle Creek and discarded in Omak Creek. Of the 64 remaining unique detections in the Okanogan and Similkameen, the majority (n=45; 70%) were hatchery fish that had been tagged at Wells Dam as an adult then detected in the Okanogan, primarily at the lower Okanogan array. Twelve of the fish (19%) detected in the Okanogan were re-detected in the Methow basin at a later date.

Adult spring Chinook were detected at the Lower Okanogan array between April 10 and September 30, 2016 with a median run timing of June 5. Eight fish were detected at Zosel Dam between June 9 and September 22, with four of those fish being detected at a later date in a Canadian tributary (Shingle and Shuttleworth creeks), the array at Vertical Drop Structure #3 on the Okanogan upstream of Lake Osoyoos, and at Skaha Dam (Table 36). None of the fish tagged and classified as spring Chinook appeared to be mis-classified summer Chinook (there were 3 such fish in 2014). We did not evaluate fish tagged as summer Chinook or Chinook with undetermined race to assess if they might be spring Chinook.

Thirteen fish from the Riverside Pond release in 2015 (BY 2013) were detected in the Okanogan. These fish were all 3 year old jacks. Five of them (38%) were detected in Omak Creek, one in Tunk Creek and two at Zosel Dam (Table 36).

There were 12 PIT detections in the tributaries of the Okanogan in 2016. Omak Creek had eight detections (67%), Loup Loup Creek had two (17%) and Salmon and Tunk creeks had one each (8%).

Six of the 64 fish (9%) had been tagged and released as juveniles somewhere outside the Okanogan, including four that were released from hatchery facilities in the Methow, one natural origin fish from the Methow and one natural origin fish from the Entiat (Table 36).

Table 36. Final PIT tag detections in the Okanogan for spring-Chinook in 2016. OKC/VDS3 is at vertical drop structure 3 in British Columbia upstream of Lake Osoyoos and OKL is the detection array in the lower Okanogan River near Malott, Washington.

Origin	Release Location	Final Detection Location(s)								
		Okan. then Methow	Okan then Other (besides Methow)	OKL	Salmon Ck.	Omak Ck.	Other U.S. Trib	Zosel Dam	OKC / VDS-3	B.C. Trib
Hatchery Spring Chinook	Methow/Winthrop Juvenile			4						
	Wells Dam Adult	12		22	1	3	2	2	1	2
	Bon Dam Adult									
	CJH									
	RivP (10j)			5		5	1	2		
	Other									
Natural Spring Chinook	Wells Dam Adult									
	Twisp R. Juv.									
	Entiat R. Juv.									1
	Rock Isl. Dam Juv.									
	Methow R. Juv.			1						
	Okan R. Juv.									
Summer Chinook (mis-classified)	NA									
	NA									
	Total	12	0	32	1	8	3	4	1	3

*note: : one tag (3D9.1C2DF32F76) was excluded from this summary because it appeared to be a fish harvested in Icicle Creek and discarded in Omak Creek.

DISCUSSION

Rotary Screw Traps (RST)

The pooled trap efficiency of approximately 0.1% is lower than in previous years (Rayton and Arterburn 2008, Johnson and Rayton 2007; https://static1.squarespace.com/static/56f45574d51cd42551248613/t/57c06a21e58c62290279a3d7/1472227873603/2006_Screw_Trap_Report_Final.pdf; <https://static1.squarespace.com/static/56f45574d51cd42551248613/t/57c06a12e58c62290279a376/1472227860447/2007RstReportFinal.pdf>), and remains insufficient to precisely estimate juvenile production for the basin. Additionally, the 95% confidence interval for hatchery-origin population did not capture the total known number of hatchery-origin fish released upstream of the RST (867,679). This indicates that, due to the difficulties in accurately estimating trap efficiency and juvenile production, the results of screw trapping activities in 2016 are unlikely to provide an accurate estimate of juvenile production.

NOAA Fisheries suggested a goal for precision of juvenile outmigration monitoring was to achieve a coefficient of variation (CV) of 15% or less (Crawford and Rumsey 2009). It is not clear that this level of precision is attainable in any large river system using conventional sampling methods such as a rotary screw trap (see Scofield and Griffith, 2014). Still, improving trap efficiency and narrowing juvenile emigration estimates remains the goal of CJHP such that informed management decisions can be made. Environmental factors such as river discharge, configuration, and trap size influenced the efficiencies of these trials. In order to mitigate these confounding variables, we will attempt to conduct more frequent efficiency trials with large release groups ($n \geq 500$).

Again, no relationship between Okanogan River flow and trapping efficiency was observed, and the flow regression model used by other agencies in other river systems (Murdoch et al. 2012) was not applied to estimate outmigration. The CJHP will continue to assess methods to improve capture techniques to increase the precision of juvenile production estimates.

Differing efficiency rates for trials involving yearling and sub-yearling fish indicate that using hatchery releases of yearling fish, as a surrogate to measure natural production would be inappropriate. However, in future years when wild spring Chinook yearlings are present, this possibility could be reexamined. This should be especially relevant once integrated, §10(j) spring Chinook, first released from the Riverside Acclimation pond in April 2015, begin to return and presumably spawn.

Finally, Pacific lamprey (*Entosphenus tridentatus*) were captured in the RST in both 2006 and 2007, but were not observed from 2008 to 2016. The status of this fish, an

important cultural and ecological resource in the Okanogan River Basin is not examined in this report, but its disappearance from the RST is notable.

Juvenile Beach Seine

The CJHP took over the beach seining effort in 2014, adopting methods used by Douglas County PUD and Biomark in 2011-2013. Given the low catch rate of taggable summer/fall Chinook from the RST, beach seining appeared to be a more reliable opportunity to capture large numbers of taggable summer/fall Chinook juveniles. Again in 2016, PIT tags deployed at the beach seine far outnumbered tags deployed at the RST.

Mortality related to capture, handling and tagging was lower than in past years (5.3%, compared to 13% in 2015). Maintaining water temperatures below 18 °C, reducing MS-222 concentrations in the anaesthetizing solution, and further limiting handling time during tagging and capture likely decreased our post tagging mortality. Although mortality rate has decreased, the hope for future years is to continue to reduce it.

Fish size increased through the tagging period, but the number of fish captured and CPUE began to decrease in mid-June, earlier than in previous years. Similarly, dates of detection at downstream PIT arrays occurred earlier in 2016 than in previous years. This may be explained in part by the size of tagged fish, differences in flow regime, or other factors that can be examined in future years when a more robust, multiyear dataset has been developed.

Although capture locations in 2016 were limited to areas near the confluence of the Okanogan and Columbia Rivers, fish were captured in areas that could also be used by juveniles originating from Methow and Columbia River spawning areas. Therefore, future analyses of returning adults will need to take this into account by recognizing that some fish may not be destined for the Okanogan. In the future, stable isotope analysis may be used to determine which proportion of tagged fish have an origin in the Okanogan basin, and which come from the mainstem Columbia or other river systems.

Lower Okanogan Adult Fish Pilot Weir

Discharge conditions on the Okanogan River in 2016 were higher than in 2015, delaying installation and operation of the weir until early August, which was a couple weeks later than 2015. Temperatures on the Okanogan River were fairly normal, compared to the 10 year median. Because temperatures stayed below 22.5 °C during daylight hours throughout the season, trapping operations were not suspended. Tower and bank fish observations were generally higher after the thermal barrier broke on August 22. During this time, 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 gauge height was less than 3 feet, Chinook were more likely to mill in deeper pools. Continued monitoring of Chinook passage through the weir with respect to temperatures should continue in order to better refine weir operations and future expectations for weir effectiveness. The number of Chinook handled at the weir (n = 169) was more than in 2015 (n= 54) when wild fires prevented operation of the weir during and immediately after the thermal barrier break and but less than 2014 (n= 2,324). Configuration and operation of the weir was similar in 2014 and 2016 and it is unclear why more fish did not enter the trap in 2016, as they did in 2014, given the number of fish observed in the pools downstream of the weir. We intend to modify the trap entrance in 2017 to attempt to improve trapping 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 (54) of dead fish at the weir was lower in 2016 than previous years. Mortality was highest a week before the peak trapping period, indicating that trap operation and handling were not the 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 117 adult natural-origin Chinook at the weir trap. Two of them were collected as mortalities at the weir, which is less than 1.7% of all trapped, marked and released fish. Additionally 4 of them were collected as carcasses on the spawning grounds (3.4%) and 2 were collected as broodstock for the integrated program (1.7%). We recommend additional mark-recapture studies to continue to assess indirect mortality at the weir in future years.

There were few observations of Sockeye at the weir during daylight hours and only three were trapped in 2016. Most sockeye passed the weir before trapping began on August 22. We did observe a few sockeye (~20) pass through the weir trap during night hours (2000-0400) during the first couple weeks of trapping operations. It is likely that more sockeye moved through the weir panels at night when observations did not occur. An estimated 164 jack and small adult Chinook escaped through the 2.5" weir panels that were

intended to allow Sockeye passage. We recommend testing a weir configuration that does not include the 2.5 inch weir panels to increase the efficiency of Chinook trapping without causing too many Sockeye to also use the trap. In 2016, there were very few Sockeye observations during daylight hours, but in past years we did have observations of sockeye passing through the 2.0" picket spacing. We will continue to document passage of Sockeye and Chinook through all picket spacings.

There was no way to know exactly how many fish escaped past the weir before it was installed or how many fish swam through, around or jumped over the wings after it was installed (jumping over the wings has never been observed). The potential weir effectiveness measure of 1.39% was low because, after reviewing PIT detection at the Okanogan Instream Lower array, we suspect that about 40-50% of the fish had migrated past the weir before deployment in August. There were two thermal barrier breakdowns that occurred before the weir was fully functional. The first breakdown occurred in mid-July and a second, smaller one occurred a week before weir deployment. Although the second breakdown only occurred over a few days before the temperature increased above 22.5°C again. Unfortunately river discharge was too high ($\geq 2,500$ cfs) during the thermal barrier breakdown to install the weir under its current design, thus limiting the weir as an effective tool for pHOS management in 2016. Fortunately, this did not hinder fish management objectives in 2016 because pHOS was already low and only 20% of the Chinook trapped were hatchery origin. In the future, with larger returns of hatchery fish due to CJH releases we anticipate a much higher pHOS at the weir resulting in higher weir effectiveness. Continuing these evaluations in future years will be critical to determining the long-term viability of the weir as a fish management tool for summer Chinook.

The broodstock collection protocol at the weir was to get 15% ($n = 85$) of the integrated program from the later arriving fish (in September, post thermal barrier). The weir failed to meet its broodstock goal, collecting only 16 fish, or 19% of the broodstock collection protocol, through the trap post thermal barrier breakdown period. The Whooshh™ transport tube worked well and initial mortality was low, indicating that further use and testing of this system should be continued in the future.

Although the weir was not very successful at trapping Chinook in 2016, CCT F&W staff were able to safely and successfully deploy, operate, and monitor the weir and add to the multi-year evaluation of the weir as a fish management tool for the CJH program. The weir'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.

RECOMMENDED WEIR AND TRAP CHANGES FOR 2017.— In December 2016, the CJHP Science Program staff convened a post- season review group to discuss operations and recommendations for improvements/changes. The entire season was reviewed and subsequently, data were reviewed with results appearing in the text of this document. A summary of the 2016 weir operations was presented at the 7th Annual Chief Joseph Hatchery Program’s Annual Review. This presentation is posted on the programs website at: <https://www.cct-fnw.com/annual-program-review/>

The following list of changes has been built into this Plan and the CCT/GPUD/BPA Funding Agreement 430-3128 - Amendment No. 3. We envision both pre and post-season weir meetings being called in the same manner as 2015 and 2016, to occur this year. The following recommendations are derived from the 2016 post- season analysis and the subsequent findings from CCT’s research, monitoring and evaluation activities:

1. Trap entrance chute (similar to Washougal design)
2. Whooshh™ system air hose support structures
3. Trap fyke restraint brackets
4. Consider alternative power source locations
5. Consider alternative trap locations
6. Add two more sections of trap walkway
7. Additional side apron support tripods
8. Trap access ladder for personnel
9. Recessed video and lighting housings
10. Trap leveling attachments
11. Crowder extension
12. Install weir panels adjacent to trap box and direct water velocity through the trap

Redd Surveys

Summer Chinook spawning activity was high again in 2016, with the highest redd count observed in the Okanogan River Basin since 2002 and above average redd counts in five out of the eight survey reaches (Table 17).

The redd count in reach O-6 was the highest on record, and spawning in reach S-1 was the second highest on record. These two adjacent reaches continue to provide the primary spawning habitat for summer Chinook in the Okanogan/Similkameen basin. One objective of the CJHP is to increase the spatial distribution of spawning into the lower reaches of the Okanogan, where historically, a low proportion of the spawning activity has occurred. 2016 redd counts showed substantial increase in spawning in the lower Okanogan reaches (O-1 thru O-3), but 2016 counts were a return to the lower average. As we begin to see returns from CJHP Chinook reared at the Omak pond acclimation site, we anticipate that those fish will provide increased spawning in lower reaches through natal homing. Continued monitoring of redd and carcass distribution will be critical to evaluation of this metric.

Spawn timing was similar to previous years, with the intensive spawning beginning the first week of October, coinciding with mean water temperatures dropping below 15°C. Few redds were constructed in November (Table 19), suggesting that, if extant, a late-arriving fall-run population of Chinook is contributing minimally to the population at large. Although aerial surveys contribute a relatively small portion of the observed redds compared to ground or float surveys, they remain an important tool for documenting spawning, or lack of, in areas not accessible by ground crews.

The fish per redd expansion was based on the sex ratio of fish passing Wells Dam. This method has been used since at least 1998 (Hillman et al. 2014) and is still being applied to both the Methow and Okanogan populations. However, there is uncertainty that the combined sex ratio of hatchery and wild summer Chinook at Wells Dam is representative of the Okanogan population because it includes Methow returns as well as mainstem released hatchery fish and downstream hatchery and wild fish. If the Okanogan has a different ratio of precocial males (jacks) than that of the Wells count, then the Okanogan abundance estimate would be biased. We suggest exploring other approaches to estimating the number of fish per redd in the Okanogan and Similkameen Rivers.

ESCAPEMENT INTO CANADA

Escapement of summer/fall Chinook into Canada had been largely overlooked until recently, when the video counts of Chinook passing over Zosel Dam increased to a level where OBMEP staff brought the results to the attention of CJHP staff. Spawning escapement in Canada is still unknown, as the video counts represent run escapement and the relationship between run escapement and spawn escapement is not clear. However, a

substantial number of Chinook have been counted passing Zosel Dam, 1,823 in 2016 (Table 20). No formal Chinook spawning grounds surveys are currently being conducted, but surveys for Sockeye (*O. nerka*) occur annually. Biologists in Canada have observed small numbers (i.e., substantially fewer than the Zosel Dam video counts) of Chinook spawners building redds in the Canadian portion of the Okanogan River (R. Bussanich, ONA, pers. comm., 2014). This discrepancy has at least three possible explanations that need to be further explored in the coming years.

- 1) Chinook can migrate downstream through Zosel Dam without being detected in the fishways video monitoring system.
- 2) Chinook are making it to spawning areas in the Canadian Okanogan and not being detected by Canadian spawning ground surveys. These surveys currently target sockeye, but the spawn timing and potential spawning areas are similar.
- 3) High pre-spawn mortality kills fish between passage at Zosel Dam and potential spawning grounds somewhere in Canada.

Some possible solutions to exploring these explanations include:

- a) Evaluate PIT tag results for fish that might ascend through the fishways multiple times (this will not account for fish that fall back once and do not re-ascend).
- b) Conduct surveys in the Canadian portions of the Okanogan River targeting Chinook spawning grounds (i.e. larger substrate) during peak spawning (mid-October).
- c) Conduct carcass surveys above Zosel Dam, throughout Lake Osoyoos and the Canadian Okanogan looking for pre-spawn mortality.
- d) Capture and radio tag fish in the Zosel fishways.

Until a definitive method is developed for estimating spawn escapement in Canada, the CJHP will continue to monitor and report run escapement via video monitoring. However, we will not add run escapement past Zosel Dam to spawn escapement in the U.S. because this could overestimate total spawners if explanation 1 or 3 (see list above) are true.

Carcass Surveys

2,755 carcasses were recovered out of an estimated 10,605 spawners, which exceeded the target carcass recovery rate of 20%. Zhou (2002) reported fish length as a significant factor in carcass recovery probability, with larger fish recovered at a higher rate than smaller fish. This is especially important as it relates to precocious males, or jacks, which are expected to occur with higher frequencies in hatchery-origin Chinook. Failing to assess and correct for biases and population discrepancies could lead to potential underestimation of hatchery-origin Chinook survival (resulting in inflated hatchery production) or over-estimation of wild-origin Chinook survival (masking potentially negative effects of the hatchery program) (Murdoch et al. 2010). We are considering methods (e.g. mark-recapture) to assess and quantify potential size bias in our carcass recovery efforts.

Surveys in September revealed few carcasses attributable to pre-spawn mortality (PSM) and October surveys found few PSM as well (~3%). It is likely that the majority of PSM occurs earlier in the season while water temperatures are higher and are a greater risk to fish attempting to travel to or hold near the spawning grounds. If this were true, the current design of our redd/carcass surveys would provide an underrepresentation of actual PSM. Therefore, egg retention and pre-spawn mortality results should be interpreted cautiously. The carcasses of fish that died prior to the onset of spawning and before sampling began may have been carried downstream of recovery floats, consumed by scavengers, or covered with sediment, making them unavailable for sampling or harder to detect and collect. This could result in an underestimation of pre-spawn mortality. The protocol assumes that each female may contain 5,000 eggs and were only considered pre-spawn mortality if they retained all 5,000 eggs. A static fecundity assumption may not be the best approach because younger and smaller females will likely have fewer eggs. Additionally, the current assumption used by the CJH during in-hatchery spawning activities for average fecundity is 4,600 eggs. We expanded the assessment to include an evaluation of fish that retained greater than 1,000 eggs as an attempt to capture some of the variability in fecundity and situations where fish died before depositing a biologically important portion of their eggs. We are not sure that 1,000 eggs are biologically important, but clearly there should be some amount of egg retention that matters besides 100%. We suggest continued review and modification of the egg retention estimation methods/protocol in the future.

PHOS AND PNI

The biological target for CJHP is to maintain a 5- year average pHOS <0.3. 2015 was the first year since the CJHP began monitoring the population that the 5-year average (0.30) met this objective. 2016 pHOS (0.15) further reduced the 5-year average to 0.23. The program met the biological target for PNI (>0.67) for the second year in a row. The 5-year

mean (0.87) met the objective, and PNI continues to improve. In the future, we suggest that continued aggressive removal of hatchery fish through selective fisheries and adult management at the weir and hatchery ladder given the uncertainty regarding the adequacy of the objectives to meet long-term population conservation goals. Exceeding the targets whenever possible also provides a buffer for years when goals may not be achieved due to low run size or challenging environmental conditions.

ORIGIN OF HATCHERY SPAWNERS

Hatchery-origin fish recovered on the spawning grounds in the Okanogan Basin were predominantly (95%) from the Okanogan Basin releases. Stray hatchery-origin fish from outside the Okanogan made up only 1% of total estimated spawners. Likewise, Okanogan Basin hatchery-origin fish strayed to other areas at a low rate (0.7%) and were a small percentage of the spawner composition in other Upper Columbia tributaries. Eight fish released from Similkameen Pond were detected on spawning grounds surveys at the Methow and Chelan Rivers in 2016 (Table 27). Stray rates and hatchery spawner composition were within the target levels for the program both within and outside the Okanogan Basin. Fish released within the Okanogan River basin have consistently homed to their natal stream, and 2016 was not an exception.

SMOLT TO SMOLT SURVIVAL AND TRAVEL TIME

The survival results for each release group provide a useful index of annual survival for comparison between release groups and, in the future, between years. Statistical tests were not conducted to determine if observed differences were statistically valid because we believe this should be done with a multi-year data set. Targets for post release survival have not been established, but it was encouraging to see that the 2016 estimates of CJH programs were similar to nearby programs. In the future, with 4-5 years of smolt migration data the program should develop a statistical framework for evaluating smolt-to-smolt survival and establish targets that could be used to help adaptively manage the release strategies, if it is determined that survival or travel time are not adequate to meet program goals. Similar to 2015, it appeared that all hatchery fish migrated out of the system relatively quickly in 2016, with no detections of yearling migrants in July and very few detections of sub-yearlings in August. Unfortunately it is not possible to evaluate juvenile outmigration (or movement within the Columbia River) in the winter months because juvenile bypass facilities do not operate year round.

The vast majority (82-95%) of PIT tagged hatchery smolts released from Omak Pond and Riverside Pond migrated to the lower Okanogan River within one week of release. There was only one detection of a juvenile hatchery fish at OKL after May 26. This assessment suggests that the program was successful at releasing actively migrating smolts. This analysis did not attempt to account for detection probability at OKL. It is

likely that the detection rate was different throughout the time period when smolts were detected. However, detection rates at large river arrays generally increase with decreased flow, so late arriving fish would have a better chance of being detected at OKL than fish outmigrating during high flows from April to June. Therefore, it is not likely that a meaningful number of late migrating smolts or residual hatchery fish would have crossed OKL when compared to what was detected during peak migration. Although the OKL PIT detection site is 25 km from the confluence with the Columbia River, it is very close (~2km) to the inundated zone of Wells Pool. Therefore we can assume that smolts crossing OKL do represent fish leaving the Okanogan River system, or at least they are entering a more reservoir-like environment where interspecific competition for food and space is likely to be less than in the river.

SMOLT-TO-ADULT RETURN

SAR for the most recent full brood returns (2010) was slightly below the 5-year and long-term averages. It is likely that the SAR estimate is biased low because some recovery efforts were not expanded within RMIS, and also because some fish likely have yet to return. We had no way to obtain information necessary to do these expansions or to even speculate as the magnitude of the potential error introduced because of it. In the future, we suggest also using PIT tags as an independent, additional estimate of SAR.

Spring-Chinook Presence and Distribution

Environmental DNA (eDNA) surveys have been an important tool for monitoring the early stages of the spring Chinook reintroduction effort. CJHP has developed an annual eDNA survey strategy that allows for basin-wide spatiotemporal distribution assessments. eDNA surveys have confirmed a wide distribution of spring Chinook in the Okanogan River basin, including 11 tributaries in U.S. and Canada. This effort has been successful at identifying and prioritizing tributaries for future spawning ground surveys. Implementing eDNA sampling at a finer scale, within those tributaries that have indicated spring Chinook presence would help to locate spawning areas and/or reaches that would be most appropriate for more intensive survey efforts, such as visual redd surveys. Additionally, eDNA surveys conducted in winter or early spring could help to confirm successful spawning in a tributary, as a positive detection during this time of year would likely be the result of juvenile presence.

PIT tag have been another important tool for monitoring the progress of reintroduction efforts. Future analysis should include an estimate of run escapement to the Okanogan using fish PIT-tagged at Wells Dam as the mark group and those redetected in the Okanogan as the recapture group. Similar to previous years, a portion (19%) of the Spring Chinook detected in the Okanogan had a final destination in the Methow River basin, so it will be important to exclude those fish from escapement estimates.

ADAPTIVE MANAGEMENT AND LESSONS LEARNED

The Annual Program Review (APR)

Each year the CJHP hosts a workshop to review and present findings from the previous year and plan for the upcoming fish production and science monitoring cycle. The APR was convened in March 2017 with the purpose of reviewing data collection efforts and results from 2016 and developing the hatchery implementation and monitoring plan for 2017 (Figure 33). This effort is focused on using adaptive management to guide the program. After a series of presentations highlighting the data collection activities and results, the group (CJHP staff and invited guests from Federal, State, PUD, and other organizations) used the In-Season Implementation Tool (ISIT) during the “Analysis” step (Figure 34). The group reviewed the ISIT input parameters for key assumptions, status and trends and decision rules to be sure that the best available information was included in the model. ISIT then used the pre-season Upper Columbia summer/fall Chinook Salmon forecast to provide an estimate of how the program could be implemented with respect to broodstock collection, harvest, weir and hatchery ladder operations to achieve biological targets for 2017. APR materials with more details than what is provided within this report can be found at <https://www.cct-fnw.com/annual-program-review/>.

Key Management Questions

Answering key management questions is an essential function of the CJHP and is central to the analysis and reporting steps in both the APR and this annual report. Management questions inform the development of the RM&E activities, the CJHPs Key Management Questions (KMQs) are:

1. What is the current status and recent historical trend of the naturally-spawning population in terms of Viable Salmonid Population (VSP) parameters?⁸
2. What is the current status and recent historical trends for hatchery returns and harvest?
3. Is the hatchery program meeting target in-hatchery performance standards?
4. Are the hatchery post-release targets met for survival, catch contribution and straying?
5. Are targets for total catch contribution and selectivity for HORs met?
6. Are there negative effects of the hatchery on the natural population?
7. Are assumptions about natural production potential valid?

⁸ From McElhany, 2000 (NOAA), a viable salmonid population is an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame. The four VSP parameters are abundance, productivity, spatial structure and diversity.

8. How should the program be operated in the coming year?

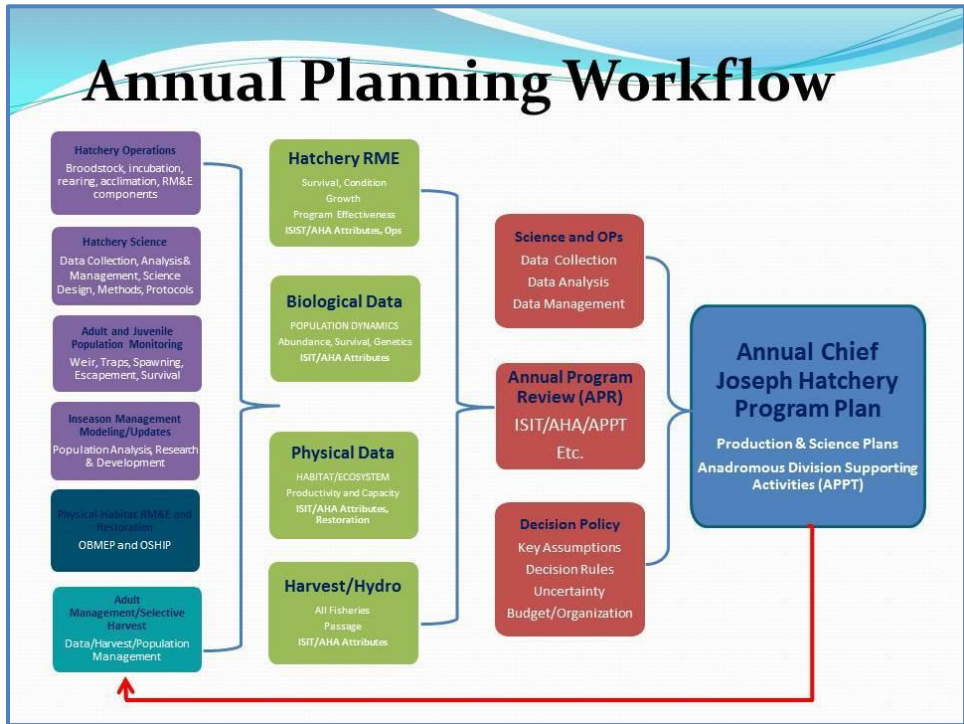


Figure 33. The Chief Joseph Hatchery's annual planning process and work flow.

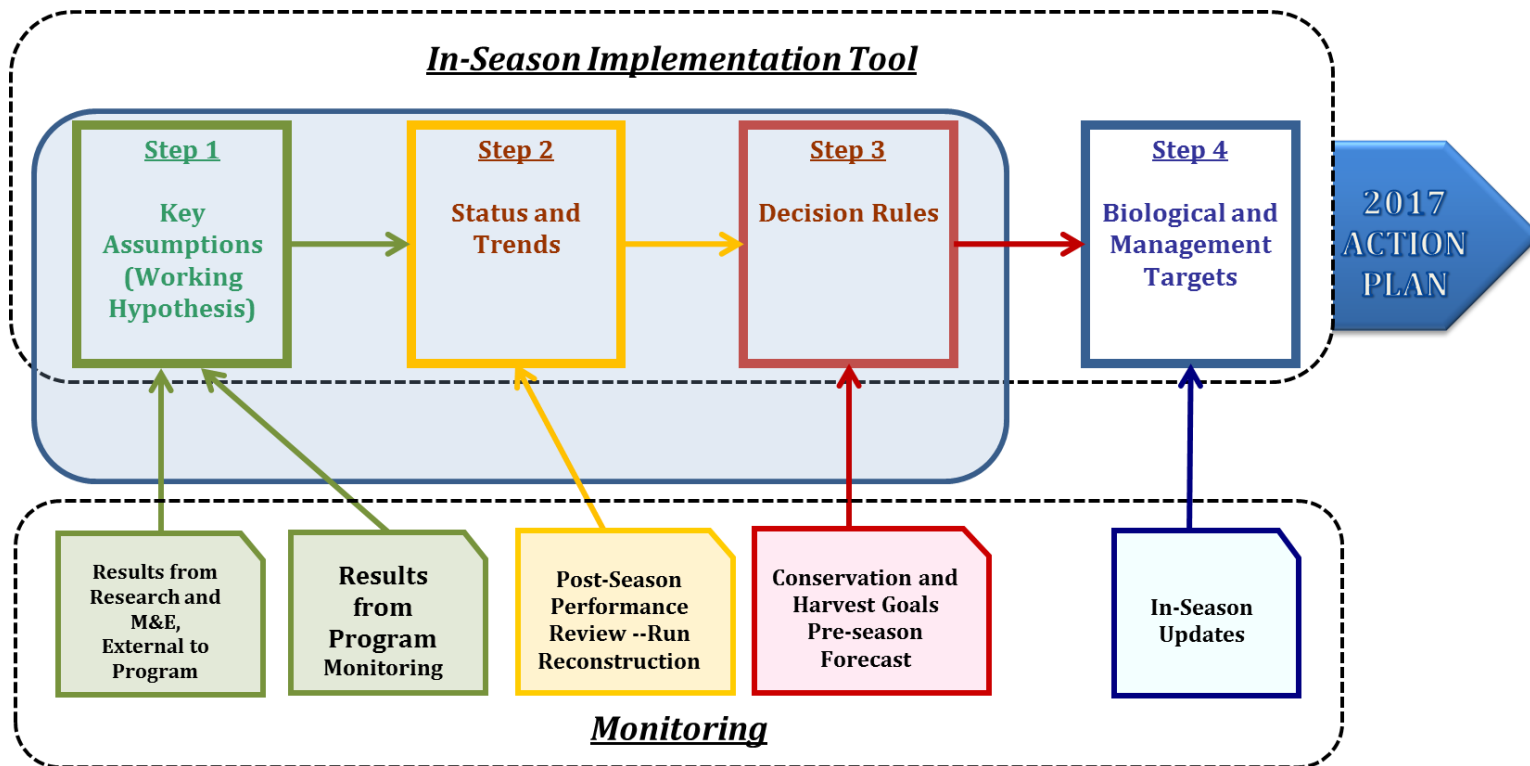


Figure 34. The Chief Joseph Hatchery's analytical work flow.

2017 Run Size Forecast and Biological Targets

Run-size forecasts and updates are an early indicator for the biological targets for the coming season, through the Decision Rules outlined in the ISIT. The preseason forecast is based on brood year escapement and juvenile survival indicators and is generated through the Technical Advisory Committee (TAC) to the *U.S. v. Oregon* fish management agreement. As the season nears, this information is supplemented with return data from downstream dam counts. The pre-season forecast for Upper Columbia summer Chinook Salmon was 74,100. The pre-season forecast, and subsequent run updates from early dam counts, were used to predict the NOR and HOR run size for the Okanogan population. Hatchery broodstock and selective harvest targets are determined based on these estimates and the objectives for pHOS (<0.30) and PNI (>0.67). A regression analysis conducted within ISIT in preparation for the APR predicted that the pre-season forecast of 74,100 upper Columbia would yield 7,627 NORs and 6,413 HORs (Figure 35). The harvest and broodstock collection goals were established from this prediction. With a NOR run size over 5,000 the broodstock collection recommendation for the integrated program was full production (616 NOB) with 100% pNOB (Figure 35). Likewise, the segregated program should achieve full production with 503 HOB. The model predicted that 1,889 HORs would be captured in the terminal (above Wells Dam) fisheries and that 116 HORs could be removed at the weir. These efforts could result in 6,345 NOS and 2,146 HOS for a pHOS of 21% and a PNI of 0.82. Under this modeling scenario the biological targets would be met in 2016. As run size updates become available (through TAC) the ISIT outputs will be double checked until the final in-season check point on July 15, 2017. At that time the run size at Wells Dam will be input into ISIT and the final plan for broodstock and harvest will be updated. If the July 15 update includes more hatchery and natural fish than predicted, then harvest and removal of surplus fish at the weir and the hatchery ladder will be implemented by CCT and WDFW (through their mark-selective sport fishery).

ANNUAL MANAGEMENT TARGETS

2016 <- Most recent return year

Use 5 -year running averages to calculate prior-cumulatives			
Recent History:		Management Targets	2017 Forecast
Average NOB	356	Harvest*	HORs retained in Fisheries 1,889
Average HOB	43		Incidental Loss of NORs 666
Average pNOB	89%		<i>*Partial source of broodstock</i>
Average NOS	7,543	Hatchery and Weir*	Return of HORs to Hatchery 2,262
Average HOS	1,806		HORs retained at Weir 116
Average pHOS	19%		<i>*Partial source of broodstock</i>
Average PNI	0.82	Integrated Hatchery Program	Natural Origin Brood (NOB)-Okan 616
			Hatch. Origin Brood (HOB)-Okan -
			Projected Annual pNOB-Okan 100%
			Cum pNOB 92%
			Smolt Release-Okanogon 1,100,029
Expected Returns to Wells Dam (most recent update):	2017 Forecast	2016 Final	
NOR Return (excludes jacks)	7,627	10,083	
HORs from Integrated Program (excludes jacks)	6,413	10,572	
HORs from Segregated Program (excludes jacks)	-	-	
			Segregated Hatchery Program
			Hatch. Origin Brood (HOB) -CJH 503
			Smolt Release-CJH 900,000
Resize Prediction for:	2017		
Preseason forecast (Columbia)	74,100		Natural Spawning Escapement
Applies until:	15-Jul		Nat. Origin Spawners (NOS) 6,345
Wells Dam Count thru 07/15	15,124		Hat. Origin Spawners (HOS) 2,146
Okanogan NOR Forecast (excludes jacks)	7,627		Total Number of Spawners 8,491
HOR Forecast (excludes jacks)	6,413		pHOS 21%
			PNI 0.82
			Projected Status of Biological Indicators*:
			Average NOS 7,970
			Average pHOS 17%
			Average PNI 0.84

*Expected values of Biological Targets if Management Targets are met.

Figure 35. The in-season updates management worksheet used to set biological targets for the upcoming year (2017) in the In-Season Implementation Tool.

2017 Key Assumptions

The CJHP reviews the key assumptions (working hypothesis) each year at the APR workshop. These assumptions directly affect the decision rules used to guide in-season management decisions. The program documents the changes and uses this information for future review and analysis (Figure 36).

KEY ASSUMPTIONS-AHA

	Baseline	Biological				Segregated Prog
		Targets	Transition 1	Transition 2	Long-term	
Natural Production						
Productivity (Smolts/Spawner)	1307		1307	1307	1307	
Capacity (Smolts)	3,672,603		3,672,603	3,672,603	3,672,603	
Juv Passage Survival	27%		27%	27%	27%	
Ocean Survival (BON to BON)	1.98%		1.98%	1.98%	1.98%	
Adult Passage Survival	83%		83%	83%	83%	
Fitness	0.93		0.89	0.91	0.92	
PNI	0.81	< 0.67	0.75	0.77	0.77	
Total pHOS	12%	> 30%	32%	28%	27%	
Segr. pHOS	2%	< 5%	1%	2%	2%	
Ocean Harvest Rate	30%		30%	30%	30%	
Lower Columbia Harvest Rate (Zones 1-6, Mouth to MCN)	7%		7%	7%	7%	
Upper Columbia Harvest Rate (MCN to Wells)	27%		27%	27%	27%	
Terminal Harvest Rate (Post Wells)	8%		8%	8%	8%	
Natural Origin Spawners	4,614	< 5,250	4,170	4,481	4,467	
Hatchery Production						
Local Brood	140		616	421	421	337
Yearling Release	250,000		800,000	750,000	750,000	500,000
Sub-yearling Release	1		300,000	1	1	400,000
SAR (yearling)	1.49%		1.49%	1.49%	1.49%	1.49%
SAR (sub-yearling)	0.30%		0.30%	0.30%	0.30%	0.30%
Return Rate to Okanogan	50%		50%	50%	50%	20%
pNOB	50%		100%	100%	100%	
NOB	70		616	421	421	
Relative Reproductive Success	80%		80%	80%	80%	80%
Ocean Harvest Rate	30%		30%	30%	30%	30%
Lower Columbia Harvest Rate (Zones 1-6, Mouth to MCN)	7%		7%	7%	7%	7%
Upper Columbia Harvest Rate (MCN to Wells)	27%		27%	27%	27%	27%
Pre-terminal Harvest Rate (Ocean to Wells)	53%		53%	53%	53%	53%
Terminal Harvest Rate (Post Wells)	29%		29%	29%	29%	90%
Hatchery Surplus	659		2,184	1,863	1,863	362
Average Terminal HOR Run	1,760		5,633	5,281	5,281	3,520
Expected HOS	589		1,885	1,767	1,767	488
Fisheries and Weirs						
Weir Factor	5%		5%	5%	5%	
NOR Harvest Release Mortality	4%		4%	4%	4%	

Figure 36. The key assumptions worksheet used in the 2016 In-Season Implementation Tool for the CJHP planning at the Annual Program Review

2016 Status and Trends

The recent performance of the population is a primary driver for determining how the hatchery program should be operated in the future. This was accomplished by updating and reviewing the status and trend information within five categories: (1) natural production, (2) hatchery production, (3) harvest, (4) migration, and (5) habitat (Figure 37).

Return year	FPC Reported Dam Count at Wells thru 7/15 (excludes jacks)	% of final count	PUD Counts at Wells Dam		Okanogan Origin Fish to Wells Dam		Terminal Harvest Above Wells								Broodstock						Okanogan Natural Spawning Escapement										
			NOR All Origins (excludes jacks)	HOR All Origins (excludes jacks)	Okan. NORs	Okan. HORs	Tribal Harvest				Recreational Harvest				Harvest Rates				Okanog./Similk Integrated Program					NOS	HOS	Census pHOS	Effective pHOS	PNI			
							Total NORs	Total HORs	Okan. NORs	Okan. HORs	Total Rec Harvest	Total NORs	Total HORs	Okan. NORs	Okan. HORs	NOR	HOR	Total NORs	Okan. NORs	Total HORs	Total Brood	Okanogan origin pNOB									
1998	3	1,060	0.25	970	5,519																										
1999	4	999	0.11	2,708	4,580	1,426	2,668																								
2000	5	2,266	0.26	2,726	7,398	1,111	2,257																								
2001	6	9,766	0.24	10,266	19,195	4,543	6,984																								
2002	7	23,221	0.34	24,138	42,035	5,060	11,757																								
2003	8	20,564	0.40	9,194	7,373	2,434	2,937																								
2004	9	14,762	0.40	23,227	13,989	7,716	2,598																								
2005	10	14,449	0.42	18,911	15,164	8,259	3,401																								
2006	11	12,563	0.43	20,262	8,730	8,348	4,113																								
2007	12	5,532	0.37	7,088	7,789	4,466	2,899																								
2008	13	8,838	0.35	11,244	13,779	4,311	6,368																								
2009	14	13,753	0.46	15,184	14,187	5,561	5,673																								
2010	15	12,264	0.41	5,671	7,167	4,541	5,394																								
2011	16	3,912	0.12	12,139	19,164	5,116	6,419																								
2012	17	10,082	0.24	14,424	27,716	6,271	7,168																								
2013	18	25,571	0.38	34,965	30,179	8,305	8,636																								
2014	19	26,010	0.39	36,060	21,015	12,797	7,555																								
2015	20	25,153	0.38	46,030	31,625	13,567	14,332																								
2016	21	21,479	0.32	28,467	21,542	10,083	10,572																								
2017	22	15,124	0.23																												

Figure 37. The status and trends worksheet in the In-Season Implementation Tool for CJHP planning at the Annual Program Review.

2016 Decision Rules

The decision rules determine the targeted size of the hatchery program and the management of natural escapement abundance and composition. The purpose of the Decision Rules is to assure that the CJHP manages the hatchery, terminal fisheries and weir to meet the guidelines for abundance, spawner composition, and distribution of the natural spawning escapement (Figure 38).

BIOLOGICAL TARGETS AND "PHASE TRIGGERS"		Population Designation: Primary				
		Current Phase: Transition 1 (from Decision Rules)				
		Applied Scenario	Phase 1 Recolonization	Phase 2 Local Adapt.	Phase 3 Recovered	
Biological Triggers for Phase Change Rules		Transition 1	Baseline	Transition 1	Transition 2	Long term
	Year	2020	2013	2020	2025	-
	Move up one phase if NORs greater than:	5,250	1,000	5,250	7,000	-
	Move down one phase if NORs less than:	800	-	800	3,000	6,000
	Based on N-Year Running Average, where N=	5	[Enter integer between 3 and 10, inclusive]			
Management Control Variables for "Sliding Scale" Rules		Transition 1	Baseline	Transition 1	Transition 2	Long term
Integrated Program	Minimum NOR escapement	800	800	800	800	800
	Smallest viable hatchery program	100,000	100,000	100,000	100,000	100,000
	Max % of NORs used for Broodstock	30%	30%	30%	30%	30%
	Maximum Yearling Releases	800,000	250,000	800,000	750,000	750,000
	Maximum Sub-yearling Releases	300,000	1	300,000	1	1
	Broodstock Required	616	140	616	421	421
	pNOB [Lo] Trigger (NOR run)	2,000	1,100	2,000	2,000	3,000
	pNOB above Trigger	100%	50%	100%	100%	100%
	pNOB below Trigger	30%	30%	30%	30%	100%
Segregated Program	Maximum Yearling Releases	500,000	-	500,000	600,000	600,000
	Maximum Sub-yearling Releases	400,000	-	400,000	-	-
	Backfill w/ HORs (Y, N)	N	N	N	N	N
Other Control Variables	Maximum Weir Efficiency	5%	5%	5%	5%	5%
	Term. Harvest Rate Integrated HORs	29%	29%	29%	29%	29%
	Term. Harvest Rate Segregated HORs	90%	90%	90%	90%	90%
	pNOB Trigger Range (NOR run)	1,000	sets range for "sliding scale pNOB" --applied to all phases			

Modeled outcomes versus Biological Targets

	Targets	Status in 2016	Projected Status in 2017	Projected Status 2017-2041	
				Median*	Range*
NOS	> 5250	7,543	7,970	3,844	2,298 - 6,964
pHOS	< 30%	19%	17%	33%	14% - 40%
PNI	> 0.67	0.82	0.84	0.75	0.72 - 0.88
Terminal Catch	> 3000	1,889	2,555	6,520	855 - 11,508

*Median, minimum and maximum values from 2017 to 2041 based on a single model run.

Figure 38. Screen shot of the decision rules in the In-Season Implementation Tool for CJHP planning at the Annual Program Review.

Data Gaps and Research Needs

In a partnership with USGS, WDFW and the ONA, the CJHP is working to identify data gaps and applied research needs within the Okanogan Basin that would better inform hatchery management, increase available data for resource management decision making, and benefit overall salmonid recovery in the greater Columbia River basin. If funded in the future, the tasks identified could directly inform CJHP and other natural resource managers and aid in the decision making process. Some of the data gaps and applied research needs that have been identified include:

1. Refined estimates (extent, fate, timing and location) of summer/fall Chinook using the mainstem Columbia River above Wells Dam for spawning (i.e. straying), rather than returning to their natal Okanogan River using radio or acoustic telemetry.
2. Extent, fate, timing and location of spawning Chinook in the Canadian portion of the Okanogan Basin.
3. Development and testing of a panel of microsatellites and/or single nucleotide polymorphisms (SNPs) for genotyping genetic stocks of Chinook salmon in the Okanogan Basin and upper-Columbia River, upstream of Wells dam, to identify and differentiate Okanogan summer- vs. fall- vs. spring-Chinook, as well as hatchery × hatchery, hatchery × wild, and wild × wild crosses of these various life-history types.
4. Utilization of advancements in thermal imaging/LiDAR or other remote sensing technologies combined with in-stream temperature loggers and ArcGIS/R Statistical Program (STARS & FLoWs toolsets & SSN package) to map current thermal refugia in the Okanogan basin and model potential changes resulting from climate change scenarios.
5. Development and/or adaptation of existing methods for better estimation of fine sediment loads per reach length in the Okanogan River to quantify effects on Chinook salmon spawning redds and productivity.
6. Design for testing fish tagging rate assumptions. PIT, radio and genetic tagging emphasis.
7. Post-release mortality for various capture techniques including the purse seine, hatchery ladder, sport fishing, the weir, etc.
8. Abundance of Priest Rapids Hatchery fish at the Okanogan weir and CJH ladder.
9. Use of otolith microchemistry to determine origin and rearing locations of sub-yearling Chinook captured at various beach seining locations.

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APPENDIX A

Hatchery operations and production

The CJH's central facility is a 15 acre facility located immediately below Chief Joseph Dam along the right bank of the Columbia River at rkm. 872 near Bridgeport, WA. There are two CJH acclimation facilities on the Okanogan River, Omak (rkm 51) and Riverside (rkm 64) acclimation ponds. There is an additional acclimation facility on the Similkameen River (rkm 6.4) that is part of the CJH program but is operated by WDFW and funded by the CPUD.

Construction of the hatchery was completed in 2013 and broodstock were brought on station for the first time. The goal of the CJHP is to contribute to the increased abundance, productivity, temporal-spatial diversity, re-colonization of Chinook in the Okanogan Basin, and provide increased harvest for all fishers.

Production Objectives

Full program production totals 2.9 million Chinook Salmon, including 2 million summer/fall Chinook and 900,000 spring Chinook. The summer/fall Chinook program incorporates both an integrated program (1.1 million smolts) supported by Okanogan River natural-origin broodstock and a segregated program (900,000 smolts) supported by hatchery-origin adults returning from the integrated program. The spring Chinook program includes a segregated program (700,000 smolts) supported by Leavenworth National Fish Hatchery (LNFH) broodstock and a re-introduction program (200,000 smolts) supported by WNFH broodstock (Met Comp stock) to reintroduce spring Chinook to the Okanogan under section 10(j) of the ESA.

In 2016, the summer/fall Chinook program production level did not meet full production as planned, due to higher than expected pre-spawn mortality on both the integrated and segregated summer/fall brood. The segregated spring Chinook program also did not meet full production goals due to an infrastructural automatic power transfer switch failure resulting in egg loss, which has since been corrected. The 10(j) spring Chinook reintroduction program was full program..

Spring Chinook Salmon

BY 2015 LEAVENWORTH SPRING CHINOOK REARING AND RELEASE

Pre-spawn mortality was average and BKD prevalence was low, resulting in the program meeting its goal for fry ponded. A total of 784,165 fish were ad-clipped, with a total of 200,000 also receiving a CWT. This group also received 5,000 PIT tags, with a total

of 4,815 released (4,283 detected at release). During the month of April, reservoir water temperatures increased steadily, triggering a good smolt response. Feeding rates were increased for final grow out. A forced, nocturnal release strategy was implemented beginning on April 17th with the last of the fish being pushed out April 18th.

Cumulative egg to smolt survival

The cumulative egg to smolt survival for the 2015 brood Leavenworth-stock Spring Chinook was 96.7% (Table A 1). This includes ponding loss, rearing loss, and subtracting the shortage realized at marking. This overall survival metric will be a critical assessment of the hatchery’s performance each brood year. The target egg to smolt survival identified in the original spring Chinook HGMP was 77% (CCT 2008a).

Table A 1. Chief Joseph Hatchery BY 2015 Spring Chinook rearing summary, April 2017.

	<u>Total on hand</u>	<u>Mortality</u>	<u>Feed Fed</u>	<u>Fish per pound</u>	<u>Cumulative Survival (%)</u>
Month	Total	Total	Total	Total	Total
Feb. 29	767,279	13,762	497	1,300	98.2%
Mar. 31	763,160	4,119	1,874	750	97.7%
Apr 30	761,868	1,292	1,561	150	97.5%
May 31	761,239	629	1,920	100	97.4%
June 30	784,563	372	1,311	70	97.4%
July 31	747,086**	1,597	2,693	50	97.1%
Aug. 31	746,780	306	2,024	40	97.1%
Sept. 30	746,419	361	3,666	35	97.0%
Oct. 31	746,066	353	5,500	20	97.0%
Nov. 30	745,362	704	2,464	20	96.9%
Dec. 31	744,871	491	2,904	18	96.9%
Jan. 31	744,560	311	2,508	16	96.8%
Feb. 28	744,324	236	4,840	16	96.8%
Mar. 31	744,199	125	2,816	15	96.8%
Apr. 18	743,996*	203	3,872	15	96.7%
Cumulative	743,996	24,861	40,450	15	96.7%

*Planted **Shortage of 35,880 in remaining raceways – total shortage overall of 12,184

BY 2015 10J MET COMP SPRING CHINOOK REARING AND RELEASE

On October 26th, 2015, CCT staff transported 209,956 MetComp Spring Chinook eyed eggs from the USFWS Winthrop National Fish Hatchery for rearing at CJH. On October

25th, 2015 fish were transferred to the Riverside Acclimation Pond. Under Permit No. 18928, issued by the National Marine Fisheries Service, this group is designated as an (10j) experimental population, for the reintroduction of Spring Chinook into the Okanogan Basin.

Temperatures at both Omak and Riverside dropped dramatically during December, and both ponds iced over. Over the course of the spring, temperatures rose steadily, and the fish growth stayed on target for release. These fish were forced released on April 15th, 2017. Table A 2 illustrates feed fed, feeding rate, and mortality to date. After subtracting mortality and shed tags, a total of 5,036 PIT tags were released (661 were detected at release.)

Table A 2. Riverside Acclimation Pond BY 2015 integrated Spring Chinook rearing summary, April 2017.

^aReleased

	<u>Total on hand</u>	<u>Rearing Mortality</u>	<u>Feed Fed</u>	<u>Fish per pound</u>	<u>Cumulative Survival (%)</u>
Month	Total	Total	Total	Total	Total
Nov 30	202,859	141	1,980	30	96.6%
Dec. 31	202,326	533	132	24	96.5%
Jan. 31	202,225	101	0	24	96.5%
Feb. 28	201,952	273	88	25	96.4%
Mar. 31	201,836	116	1,496	20	96.4%
Apr. 15	201,821 ^a	15	572	15.9	96.4%
Cumulative	201,821	5,662^b	10,234^c	15.9	96.4%

^bIncludes ponding and rearing mortality that occurred at CJH prior to transfer and rearing at the acclimation pond

^cIncludes feed fed that occurred at CJH prior to transfer to the acclimation pond

BY 2016 LEAVENWORTH SPRING CHINOOK

2016 Brood Collection

The segregated spring Chinook production goal for the 2016 brood is a release of 700,000 yearlings in April of 2018. The calculated number of brood needed to meet this production was 640 adults, based on a 50/50 ratio of males and females. This includes 10% pre-spawn mortality, up to 20% culling for Bacterial Kidney Disease (BKD) management, 10% egg loss, and rearing mortality of 15%. The mortality per life stage benchmarks were based on historical performance at LNFH. As with any new facility, baseline data collected

during initial production years will be the basis for adjusting broodstock requirements in future years.

A total of 639 spring Chinook broodstock were transferred from LNFH to CJH June 1st through 2nd, 2016; including 319 females, 320 males (Table A 3). The 639 spring Chinook transferred represents 99.8% of the collection objective.

Transport water was obtained from LNFH to fill the transport trucks, at a temperature of 51° F and the adult holding pond temperature, at LNFH, was 48° F. Transport densities on both days were 0.60 lbs. /gal. (Table A 3). All transport included Vita Life, a calming agent superior to salt, at a rate of 500 ml per 2,000 gal., and supplemental oxygen at 8 L/min. There were no mortalities associated with the transport.

Broodstock were off loaded, via water-to-water transfer, into adult ponds #5 and #6, at CJH. The receiving water was 55° F. The adult pond had a flow rate of 380 gpm. and an exchange rate of 60 minutes, representing a Flow Index (FI) of 0.42 and 0.20 for pond #5 and #6, respectively (Table A 4). The Density Index (DI) was 0.04 and 0.02 for ponds #5 and #6, respectively. Both adult ponds were 100% well water. Both ponds were treated two days per week with hydrogen peroxide at 1:10,000 for a copepod infection on the gills, three days per week with formalin at 1:6,000 to control fungus. All treatments were performed for one exchange.

On July 6th, 2016 and again on August 3rd, 2016 USFWS DVM Trista Welsh-Becker assisted hatchery staff with inoculations for all spring Chinook brood. Each female was inoculated with Draxxin at a rate of 10 mg/kg for reduction of BKD, and Vetricymycin – 200 (Oxytetracycline) IP at 20 mg/kg; for reduction of pre-spawn mortality due to furunculosis. Pre-spawn mortality was very low at 99.1% survival. (Table A 5)

Table A 3. Chief Joseph Hatchery spring Chinook broodstock transfer summary for 2016.

Date	Trap site	Receiving Facility	Males			Females	Total Brood	Holding Temp (°F)	Transport Temp. (°F)	Transport Density (lbs./gal)
			Adult	Jack	Total					
6/1/2016	LNFH	CJH	156	0	156	165	321	48	51	0.48
6/2/2016	LNFH	CJH	164	0	164	154	318	48	51	0.48
Total			320	0	320	319	639			

Table A 4. Spring Chinook broodstock adult holding conditions for 2016.

Transfer Date	Adult Pond	<u>Males</u>				Females	Total Brood	Transport Temp (°F)	Holding Temp. (°F)	Flow Index	Density Index
		Adult	Jack	Total							
6/1/2016	#5	156	0	156	165	321	51	56	0.26	0.05	
6/2/2016	#6	164	0	164	154	318	51	56	0.26	0.05	

Table A 5. Chief Joseph Hatchery spring Chinook broodstock holding and survival summary for 2016. (M= adult males, J = jacks, and F = adult females). The survival standard for this life stage was 90%.

<u>Beginning</u>			<u>Ending</u>			<u>Mortality</u>			<u>Cumulative Survival (%)</u>		
M	J	F	M	J	F	M	J	F	M	J	F
320	0	319	316	0	317	4	0	2	98.8%	NA	99.4%

Spawning

Spring Chinook spawning started August 17th and concluded on August 31st (**Error! eference source not found.**). The spawn consisted of 279 females and 279 males, with nine non-viable (green) females killed resulting in a green egg take of approximately 1,060,200 (**Error! Reference source not found.**).

Spawning occurred inside the spawning shed adjacent to the adult holding raceways, and gametes were then transported to the main facilities egg entry room for processing. Each individually numbered female was fertilized with a primary male initially, and then a backup male was added to ensure fertilization. Each female’s eggs were then placed in the corresponding numbered tray. The eggs from one female was culled due to high or moderate ELISA results (culled eggs from ELISA results are not included in **Error! eference source not found.**). This was approximately 0.4% of the females spawned and was far less than planned for (up to 20%).

Incubation

Each female’s eggs were initially incubated separately to facilitate culling based on ELISA results. Once eyed, egg mortality was removed and eggs were combined for hatching. All spring Chinook eggs were placed on varying degrees of chilled water. The water temperature was gradually dropped, on the first egg take, to 37° F degrees. This process was done over a several hour period four days after spawning. The second egg take was left on well water (60° F) until such time as the total numbers of temperature units

(TUs) were earned to equal the first egg take, then the same procedure was used to lower water temperature to 37° F. This process provided the ability to control when, and how many, fish are brought out of the incubators and placed into early rearing.

Green egg to eyed egg survival was 51.1% (**Error! Reference source not found.**). his survival was far lower than the key assumption (90%) due to a flaw in power monitoring switches that provide electricity to the well pumps, resulting in mortality associated with oxygen deprivation.

Rearing

Due to the manipulation of TUs, the first group of spring Chinook was brought out of incubation and transferred into early rearing troughs on April 28th, 2017, and the second group on May 12th, 2017. During the month, the first group was introduced to feed in the early rearing troughs, and reared for a period of two weeks. After the initial rearing period inside, this group was transferred outside to the standard raceways via the fry transfer line. The second group, however, were transferred immediately after ponding to outdoor raceways via transfer line, due to a major water pipeline crisis two hours after ponding from incubator into early-rearing trough. Although a higher than normal level of early rearing mortality did occur due the stress from this premature transfer, <1.6% of population was lost (as opposed to 0.5% for the first ponding group). No inventory was taken at ponding to prevent excess handling stress. Survival from incubation to ponding was 94.5% which was on par with the standard (95%) for this life stage (**Error! Reference source not found.**).

Table A 6. Chief Joseph Hatchery spring Chinook spawning and survival summary for 2016 (M = adult males, J = jacks and F = adult females). The target survival standard for this life stage was 90%.

Spawn Date	Total Adults Spawned			Green Egg Take	Eyed Egg	Mortality (Pick off)	Cumulative Survival (%)
	M	J	F	Total	Total	Total	Total
August 17	94	0	89	338,200	310,332	47,210	86.80%
August 24	136	0	134	509,200	287,879	210,162	57.80%
August 31	57	0	56	212,800	17,320	185,067	8.56%
Total	287	0	279	1,060,200	615,532	442,439	51.05%

Table A 7. Chief Joseph Hatchery spring Chinook ponding summary for BY 2016 as of May 2017.

Production Group	<u>Total Fry Poned</u>	<u>Ponding Mortality</u>	<u>Monthly Feed</u>	<u>Monthly Mortality</u>	<u>Ponding Loss (%)</u>	<u>Cumulative Survival (%)</u>
	Total	Total	Total	Total	Total	Total
LVNH	299,944	10,388	0	3,694	3.35%	95.3%
LVNH	281,584	23,616	486	4,623	8.38%	90.0%
Total	581,528	34,004	486	8,317	5.84%	92.8%

The key assumption survival for this life stage is 95%.

Spring Chinook were fed Bio-Oregon’s BioPro 2 diet, and converted at an average of 0.88:1 for their first six weeks of rearing. Post ponding rearing is on schedule, with no fish health issues and minimal mortality to date (Table A 8). Survival for this life stage will be reported in subsequent annual reports once all release information is available.

Table A 8. Chief Joseph Hatchery BY 2016 segregated spring Chinook rearing summary as of May 2017.

Month	<u>Total on hand</u>	<u>Mortality</u>	<u>Feed Fed</u>	<u>Fish per pound</u>	<u>Cumulative Survival (%)</u>
	Total	Total	Total	Total	Total
LVN					
May 31	581,528	8,317	486	620	98.6%

Summer/Fall Chinook Salmon

BY 2015 SUMMER/FALL CHINOOK SALMON REARING AND RELEASE

A total of 423,658 sub-yearling summer/fall Chinook were brought out of incubation from December 23rd, 2015 through January 21st, 2016. An addition 603,421 yearling summer/fall Chinook were also brought out of incubation from March 31st, 2016 through April 26th, 2016.

Rearing proceeded on schedule, with the marking and releasing of both the integrated and segregated sub-yearlings in April. On May 3rd, a total of 175,872 integrated sub-yearlings were transferred to the Omak Acclimation Pond, at 58 fpp. This group was released on May 23rd, 2016, with a post transfer survival of 88.0%, and a cumulative survival from ponding of 87.9% (Table A 9). Approximately 5,000 PIT tags were added to each group and after subtracting shed tags and mortality, a total of 4,979 PIT tags were released (1,237 were detected at release).

Table A 9. Chief Joseph Hatchery brood year 2015 integrated summer/fall Chinook sub-yearling rearing summary.

Month	<u>Total Planted</u>	<u>Mortality</u>	<u>Feed Fed</u>	<u>Fish per pound</u>	<u>Cumulative Survival (%)</u>
	Total	Total	Total	Total	Total
May 23	175,771	22,040	2,650	44	87.9
Cumulative	175,771	22,040	2,650	44	87.9

A total of 218,459 segregated summer/fall sub-yearlings were marked and transferred into rearing Pond B, for final rearing and release. This group was released on May 16th, 2016, at 56.7 fpp. Cumulative rearing survival was 90.3% (Table A 10). Approximately 5,000 PIT tags were added to each group and after subtracting shed tags and mortality, a total of 3,936 PIT tags were detected at release

Table A 10. Chief Joseph Hatchery brood year 2015 segregated summer/fall Chinook sub-yearling rearing summary.

Month	<u>Total Planted</u>	<u>Mortality</u>	<u>Feed Fed</u>	<u>Fish per pound</u>	<u>Cumulative Survival (%)</u>
	Total	Total	Total	Total	Total
May 16	218,383	24,386	2,951	56.7	90.3
Cumulative	218,383	24,386	2,951	56.7	90.3

The yearling summer/fall Chinook rearing proceeded on schedule, with both the integrated and segregated groups being marked in July and August. Marking was completed, for both the integrated and the segregated programs, on August 4th, 2016. The segregated Summer Chinook were 100% ad-clipped, with a 100k CWT group tagged. The integrated Summer Chinook were 100% AD/CWT. As shown in **Error! Reference source not found.**, ponding and rearing mortality for the segregated program has been lower than anticipated, although both stocks were short of book numbers, at marking. The segregated production was marked into rearing Pond B, while the integrated program was marked into the lower raceways, and reared until transfer to the acclimation ponds in late October. Both groups were released the evening of April 18th, 2017. Approximately 5,000 PIT tags were added to each group in October 2016. After subtracting shed tags and mortality, a total of 5,024 PIT tags were released from the segregated group (4,194 were detected at release). Final feed conversion from rearing stage to release was 1.09:1.

The integrated Summer Chinook were shipped to the Omak Acclimation Pond, and the Similkameen Acclimation Pond, on October 24th, 2016. Reporting for the Similkameen Pond will reside with WDFW through release. A nocturnal forced release took place on April 20th, 2017 at the Omak Pond.

Table A 11. Chief Joseph Hatchery BY 2015 segregated Summer/Fall Chinook rearing summary.

*Overage at marking – 20,473

HORs	<u>Total on hand</u>	<u>Mortality</u>	<u>Feed Fed</u>	<u>Fish per pound</u>	<u>Cumulative Survival (%)</u>
Month	Total	Total	Total	Total	Total
Apr. 30	216,291	1,333	120	650	99.4%
May 31	214,660	1,631	495	270	98.6%
June 30	213,815	845	673	150	98.2%
July 31	233,985*	303	1,239	100	98.2%
Aug. 31	233,718	267	1,056	60	98.1%
Sept. 30	233,642	76	1,247	40	98.1%
Oct. 31	233,472	170	1,936	30	98.0%
Nov. 30	232,960	512	968	20	97.9%
Dec. 31	232,638	322	1,320	20	97.9%
Jan. 31	232,459	179	1,320	16	97.8%
Feb. 28	232,379	80	1,936	15	97.8%
Mar. 31	232,280	99	4,180	14	97.7%
Apr. 18	232,103^	177	4,620	12	97.7%
Sub Total	232,103	5,994	21,110	12	97.7%

Omak Acclimation Pond

On October 24th, 2016 Chief Joseph Hatchery staff transferred 213,830 Integrated BY 15 Summer Chinook from Chief Joseph Hatchery to the Omak Acclimation Pond. At the time of transfer, the fish were approximately 30 fpp, and were programmed to be reared over winter, with a target size at release of 10 fpp. An additional 167,291 BY 15 Summer Chinook were transferred to WDFW’s Similkameen Pond, as part of the cost share agreement. These fish were forced released April 20th, 2017. Table A 12 illustrates feed fed, feeding rate, and mortality to date for the integrated summer/fall Chinook transferred to the Omak Acclimation pond. After subtracting mortality and shed tags, a total of 4,830 PIT tags were released (1,578 were detected at release).

Table A 12. Omak Acclimation Pond BY 15 integrated summer/fall Chinook rearing summary.

Month	<u>Total on hand</u>	<u>Mortality</u>	<u>Feed Fed</u>	<u>Fish per pound</u>	<u>Cumulative Survival (%)</u>
	Total	Total	Total	Total	Total
Nov. 30	213,621	209	1,980	20	98.0%
Dec. 31	213,543	78	176	20	98.0%
Jan. 31	213,259	284	0	20	97.9%
Feb. 28	212,898	361	88	21	97.8%
Mar. 31	212,790	108	1,884	17	97.8%
Apr. 20	212,726	64	1,279	13.8	97.7%
Cumulative	212,726	8,398	15,612	13.8	97.7%

Riverside Acclimation Pond

Riverside Acclimation Pond was not used to rear BY 2015 summer/fall Chinook, but was utilized to rear BY 15 10j Spring Chinook, as noted above.

Similkameen Acclimation Pond

Similkameen Pond was used to rear yearling summer Chinook per the WDFW program funded by CPUD. Adult broodstock used to generate the juveniles for BY 2015 were collected via the CCT purse seine as part of the transition to the collaborative CJH program. On October 24th, 2016, Chief Joseph Hatchery staff transferred 167,291 summer/fall Chinook to the Similkameen Pond, with the assistance of WDFW’s Eastbank Hatchery staff. At the time of transfer, the fish were approximately 30 fpp, and were programmed for over winter acclimation, with a target size at release of 10 fpp. These fish began volitional release on April 12th, with an end release date of April 15nd, 2017. Cumulative survival, at the date of transfer, was 98.1%. Survival from transfer to release was 78.4%.

Cumulative egg to smolt survival

The target egg to smolt survival identified in the original summer/fall Chinook HGMP was 77.5% for sub-yearlings and 73.5% for yearlings (CCT 2008b). The cumulative egg to smolt survival, for the BY 2015 sub-yearlings, was 89.1%. The cumulative egg to smolt survival, for the BY 2015 yearlings, was 97.7%.

2016 Broodstock collection

Collection of summer/fall Chinook for BY 2016 occurred between July 5th, 2016 and August 28th, 2016 via the CCT purse seine operation at the mouth of the Okanogan River. Both hatchery- and natural-origin brood were collected to supply the integrated and segregated production programs at CJH. As the seine was being pursed, 9-meter transport barges approached the seine vessel and tied off on the opposite side. The broodstock transport barges have two transport tanks, a 300 gallon for HORs and a 600 gallon for NORs. Brood fish were removed from the seine and placed headfirst in a rubber tube, or boot, containing some water and handed to the staff on the barges for placement in the holding tanks. A maximum of 14 HOR and 28 NOR brood could be loaded per barge. Once full, or at the commencement of the purse seine haul, the barges returned to the offload area at Mosquito Park approximately 2 km away. The brood was then removed from the tanks by hand, placed into a boot, then delivered to one of two 2,500 gallon tanker trucks and transported 16 km to the hatchery.

Water temperatures were of major concern during these operations and monitored to minimize trauma to the adult brood. Okanogan River temperatures during July ranged from 66° F (19° C) to 78° F (25.5° C). In order to limit the effects of the temperature changes we monitored the temperature of all transport vessels and strived to not expose brood to changes greater than 8° F. We accomplish this by utilizing both well water and surface water when filling the barges and transport tankers, and monitoring our raceway temperatures.

A weekly quota was developed to ensure that brood collections occurred across as much of the summer run timing as possible (Table A 13). If brood collection failed to meet the weekly quota it was adjusted the following week. The purse seine is only effective when there is a thermal barrier at the mouth of the Okanogan, therefore broodstock can only be collected there until late August or early September. Broodstock were offloaded, via water-to-water transfer, into adult ponds at CJH. The receiving water was approximately 57° F. The adult ponds had a flow rate of 380 gpm., and an exchange rate of 60 minutes, representing a Flow Index (FI) of 0.15 and a Density Index (DI) of 0.02. Upon arrival, adult ponds were put on well water. All adult ponds were treated a minimum of four days per week with formalin to control fungus at a rate of 1:6000, for one exchange. Additionally, brood fish were treated two days per week with Chloramine-T at 12 ppm for one exchange to control Columnaris bacteria.

On August 10th, 2016 USFWS DVM Trista Welsh-Becker assisted hatchery staff with inoculations for all summer/fall Chinook brood. Each female was inoculated with Draxxin

at a rate of 10 mg/kg IP, for reduction of BKD, and Vetrinycin – 200 (Oxytetracycline) IP, at the 20 mg/kg for reduction of pre-spawn mortality due to furunculosis.

A total of 552 HOB were collected including 281 females, 271 adult males and 0 jacks (**Error! Reference source not found.**). A total of 572 NOB was collected including 87 females, 285 adult males, and 0 jacks (**Error! Reference source not found.**). No steelhead or Bull trout were encountered during broodstock collection efforts.

The brood collection objective for the weir was 84 NOB. Fourteen NOB Chinook were collected from the weir trap between September 5 and September 14, 2016. The adults were transported to shore via a fish boot (rubber tire inner tube) and placed into an 800-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 spawn date the first week in October. The broodstock shortfall (n=72) for late-arriving fish was filled by beach seining the Kline site on the Similkameen River. We recognize that fish collected late may have arrived at any point in their run timing; however, the efforts to collect fish in September at least offer the opportunity to include fish that arrive later in the run timing. These adults were 100% otolith sampled at spawning. The goal was to ensure that, prior to being included in the integrated production; there would be no unmarked Priest Rapids Hatchery fish in this group. Based on results from the WDFW Otolith Lab, there were no unmarked Priest Rapids Hatchery fish collected in September for the integrated program; therefore, it was not necessary to place any of these fish into the segregated program.

Table A 13. Chief Joseph Hatchery summer/fall Chinook weekly broodstock collection objectives and results for brood year 2016.

Week	Weekly Quota		<u>Cumulative Proportion</u>	<u>Cumulative Collection</u>	
	<u>Natural Origin</u> ²	<u>Hatchery Origin</u> ³		<u>Natural Origin</u>	<u>Hatchery Origin</u>
July 4 - July 10	22	22	0.04	22	22
July 11 - July 17	22	22	0.08	44	44
July 18 - July 24	108	104	0.27	152	148
July 25 - July 31	108	104	0.46	260	252
Aug. 1 - Aug.7	132	126	0.69	392	378
Aug. 8 - Aug. 14	132	126	0.92	524	504
Aug. 15 - Aug. 21	36	36	0.98	560	540
Aug. 22 - Aug. 28	12	12	1.00	572	552
*Sept. 15 - Oct. 15 *NOR weir collection	84			656	
¹ Weekly collection short-fall to be added to following week's collection ² Combined collection strategies in priority order (purse seine, tangle-net, Okanogan weir beach seine and CJH ladder) ³ Combined collection strategies in priority order: purse seine, tangle-net, CJH ladder, Okanogan weir and beach seine					

Table A 14. Chief Joseph Hatchery summer/fall Chinook Hatchery-Origin Broodstock (HOB) transfer summary for brood year 2016.

Date	Trapping site	Receiving Facility	Males	Females	Jacks	Total Broodstock	River Temp (f0)	Barge Temp (F0)	Transport Temp. (F0)	Adult Pond Temp (f0)
7/5/2016	SEINE	CJH	1	0	0	1	72	62	58	57
7/6/2016	SEINE	CJH	10	11	0	22	72	62	58	57
7/11/2016	SEINE	CJH	1	3	0	26	72	62	58	57
7/12/2016	SEINE	CJH	7	10	0	43	74	66	60	57
7/18/2016	SEINE	CJH	17	11	0	71	76	64	59	57
7/19/2016	SEINE	CJH	39	35	0	145	76	64	59	57
7/25/2016	SEINE	CJH	12	14	0	171	76	64	59	57
7/26/2016	SEINE	CJH	2	4	0	177	76	64	59	57
7/27/2016	SEINE	CJH	6	4	0	187	78	64	59	57
7/28/2016	SEINE	CJH	31	34	0	242	78	64	59	57
7/29/2016	SEINE	CJH	9	8	0	269	80	64	59	57
Total			135	134	0	269				

Table A 15. Chief Joseph Hatchery summer/fall Chinook Natural-Origin Broodstock (NOB) transfer summary for brood year 2016.

Date	Trapping site	Receiving Facility	Males	Females	Jacks	Total Broodstock	River Temp (f0)	Barge Temp (F0)	Transport Temp. (F0)	Adult Pond Temp (f0)
7/5/2016	SEINE	CJH	0	3	0	3	74	64	59	57
7/6/2016	SEINE	CJH	9	13	0	25	74	64	59	57
7/11/2016	SEINE	CJH	8	6	0	39	76	64	59	57
7/12/2016	SEINE	CJH	1	7	0	47	76	64	59	57
7/18/2016	SEINE	CJH	61	49	0	157	76	64	59	57
7/19/2016	SEINE	CJH	0	0	0	157	76	64	59	57
7/25/2016	SEINE	CJH	32	32	0	221	76	64	59	57
7/26/2016	SEINE	CJH	7	19	0	247	76	64	59	57
7/27/2016	SEINE	CJH	12	6	0	265	78	64	59	57
7/28/2016	SEINE	CJH	0	0	0	265	78	64	59	57
7/29/2016	SEINE	CJH	15	25	0	305	80	64	56	56
Total			145	160	0	305				

The cumulative pre spawn holding survival, for all Summer/Fall brood collected, was 95.9% for HOB and 93.4% for NOB (Table A 16). Both programs met the survival standard (90%).

Table A 16. Chief Joseph Hatchery summer/fall Chinook Hatchery (HOB) and Natural (NOB) origin broodstock holding survival summary for brood year 2016. (M = adult males, J = jacks and F = adult females). The survival standard for this life stage was 90%.

Month	Beginning Month			Ending Month			Mortality			Monthly Survival (%)			Cumulative Survival (%)		
	M	J	F	M	J	F	M	J	F	M	J	F	M	J	F
HOR															
Aug	271	0	281	269	0	275	2	0	6	99.2%	100%	97.8%	99.2%	100%	97.8%
Sept	269	0	275	269	0	276*	0	0	5	100%	100%	98.3%	99.2%	100%	96.1%
Oct	269	0	276	265	0	270	4	0	6	98.5%	100%	97.8%	97.7%	100%	94.0%
NOR															
Aug	285	0	287	283	0	282	2	0	5	99.2%	100%	98.2%	99.2%	100%	98.2%
Sept	283	0	282	323^	0	324^	2	0	2	99.4%	100%	99.4%	98.8%	100%	97.9%
Oct	323	0	324	314	0	307	9	0	17	97.2%	100%	94.7%	96.0%	100%	92.7%
Nov.	314	0	307	314	0	298	0	0	9	100%	100%	97.0%	96.0%	100%	90.5%

* Weir Brood added ^Added 44 NOR Females and 42 NOR males

Spawning

Spawning of Summer Chinook began on October 5th, 2016, and continued through November 2nd, 2016. As with the Spring Chinook, the Summer Chinook program is also 100% ELISA sampled. For the 2016 brood, we experienced a much lower than normal disease profile, and as a result no females were culled.

Total NOB spawned included 287 males, zero jacks, and 297 females. (Table A 17) None of the 16 NOB taken from the weir and spawned had an otolith mark; indicating that there were no ad-present Priest Rapids Hatchery adults included in the integrated brood. Total HOR spawn included 244 males, zero jacks, and 238 females. In addition, 13 non-viable NOR females and eight non-viable HOR females were spawned. Total eyed egg take for the season was 2,004,861. Egg survival from green egg to eyed egg for NOB averaged 75.13% (Table A 17). Egg survival for HOB averaged 81.25%. Survival was lower than the key assumption of (90%) for this life stage.

Table A 17. Chief Joseph Hatchery brood year 2016 summer/fall Chinook spawning results.

Month	<u>Total Adults Spawmed</u>			<u>Green Egg Take</u>	<u>Eyed Egg</u>	<u>Mortality (Pick Off)</u>	<u>Cumulative Survival (%)</u>
	M	J	F	Total	Total	Total	Total
<u>NOR</u>							
Oct. 5	20	0	19	95,000	67,670	9,323	87.9%
Oct. 12	67	0	66	330,000	264,719	25,264	91.2%
Oct. 19	101	0	99	495,000	388,042	45,276	89.6%
Oct. 26	96	0	96	480,000	342,017	61,363	84.7%
Nov 2	3	0	17	85,000	36,251	39,943	47.5%
<i>Sub-total</i>	287	0	297	1,485,000	1,098,699	181,169	85.8%
<u>HOR</u>							
Oct. 5	24	0	23	115,000	95,517	8,717	91.6%
Oct. 12	97	0	94	470,000	386,930	26,858	92.6%
Oct. 19	101	0	10	500,000	264,990	17,786	93.7%
Oct. 26	22	0	21	105,000	158,725	96,753	62.1%
<i>Sub-total</i>	244	0	238	1,190,000	906,162	150,114	85.7%
<i>Total</i>	528	0	511	2,675,000	2,004,861	331,283	85.8%

Broodstock Origin

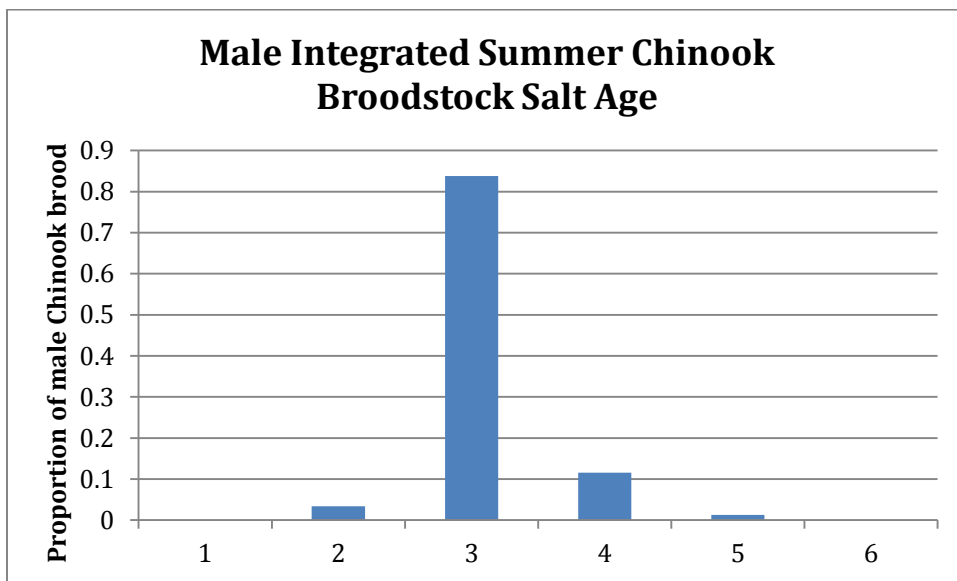
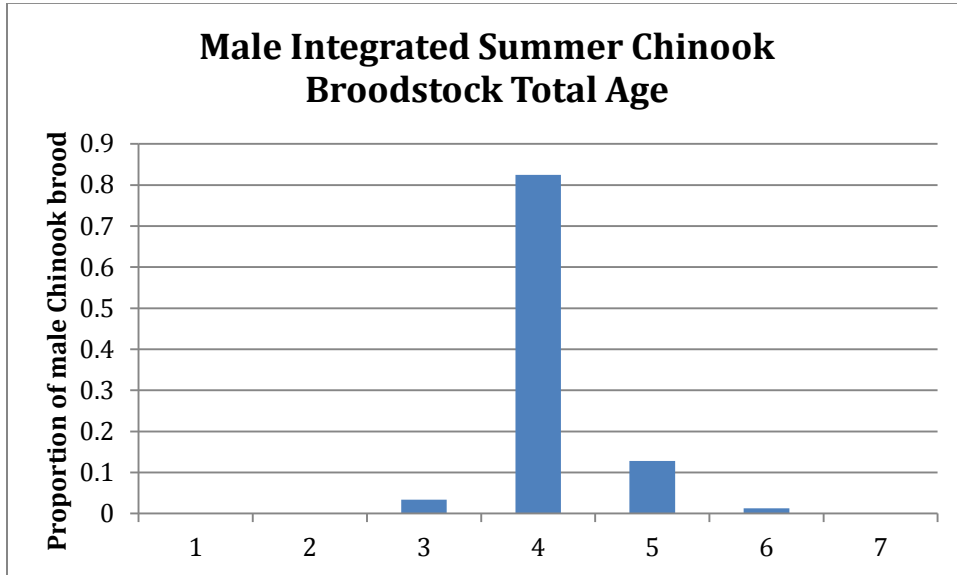
Broodstock were interrogated for coded-wire tags on four different spawning events during October: 10/5, 10/12, 10/19 and 10/26. When a wire was detected, the snout was collected for extraction and analysis that occurred in the laboratory at a later date. All of the brood stock collected for the summer Chinook segregated program came from an Upper Columbia River Hatchery program. The CJH integrated program was the largest contributor to segregated brood with (n=252) 53.6% of adults coming from either the Similkameen or Omak Pond. Other Upper Columbia River Hatcheries contributed (n=162) 34.4%, most of which were from Wells (20.0%) and Chelan Falls (9.2%) hatcheries. A large portion of snouts (n=47) indicated detection during spawning events but a coded-wire tag was not found during extraction. Reasons for this include but are not limited to rapidly shaking a Northwest Marine Technologies (NMT) T-Wand when scanning for a cwt (false positive in the field), failure to detect a tag in the lab (false negative), metals in the soil that transfer to a fish during handling or hooks or other metal debris in the fish's head. The unknown component represents 11.9% of the 2016 segregated brood (Table A 18). A relatively large percentage of the segregated CJH does not receive a CWT, however, in 2016 only jacks returned from the CJH segregated program and jacks were not collected for broodstock. A few 3 year old males may still have been included in the brood collection effort if they exceeded 66 cm fork length. The high rate of no CWT detection in the lab is concerning because all summer Chinook programs upstream of Priest Rapids Dam are supposed to have a 100% tag rate (except for CJH segregated). Most tag rates reported in RMIS are greater than 98%, indicating that there should be a relatively small percentage of adult summer Chinook that have an adipose clip and no CWT, particularly in 2016.

Table A 18. Composition of hatchery-origin brood, by program, collected for the CJH segregated summer/fall Chinook program in 2016.

Category	Hatchery Program	# tags	% of brood	
Okanogan Integrated	Similkameen	233	49.6%	53.6%
	Omak Pond	19	4.0%	
Other UCR summer/fall Chinook hatchery	Carlton	6	1.3%	34.4%
	Wells	94	20.0%	
	Chelan Falls	43	9.2%	
	Entiat	10	2.1%	
	Dryden	9	1.9%	
Unknown	Lost/scratched Tags	9	1.9%	11.9%
	No tag in snout	47	10.0%	
Total		470	100.0%	

Integrated Program Broodstock Age Structure

Scales are taken from summer Chinook integrated Program broodstock in order to capture the age of successfully spawned fish. In 2016, the integrated program was comprised of mostly four-year old male and female fish, whereas the segregated program skewed heavily to five-year old fish. (Figure A 1).



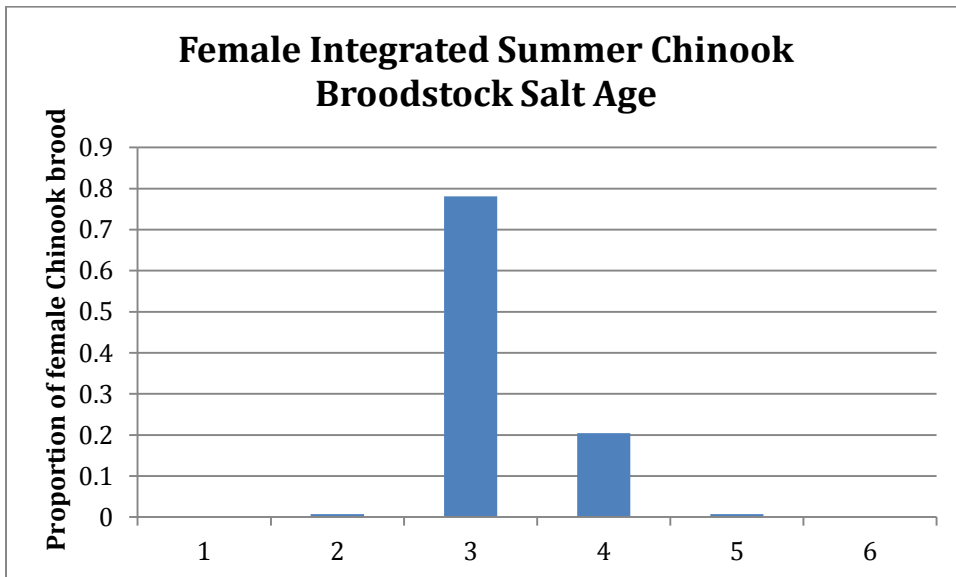
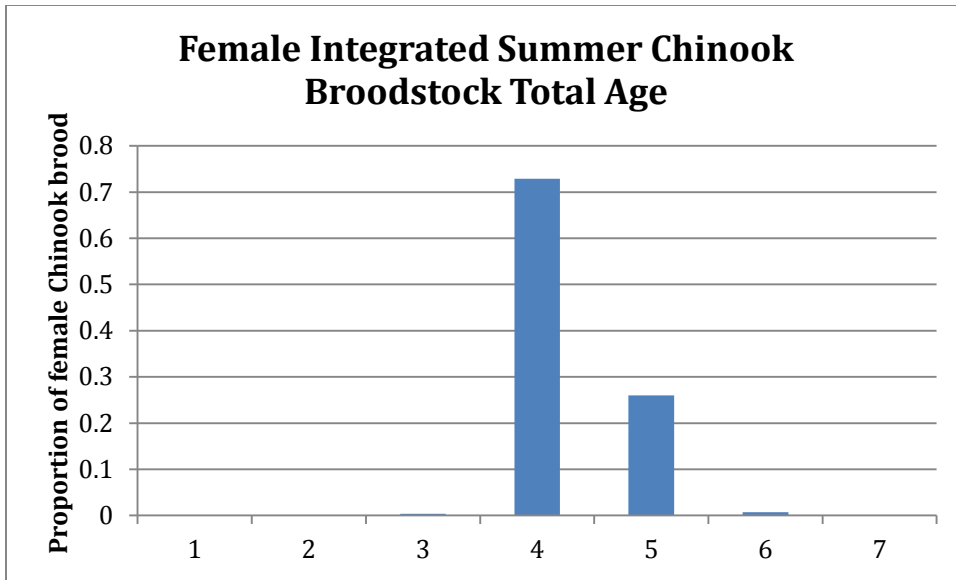
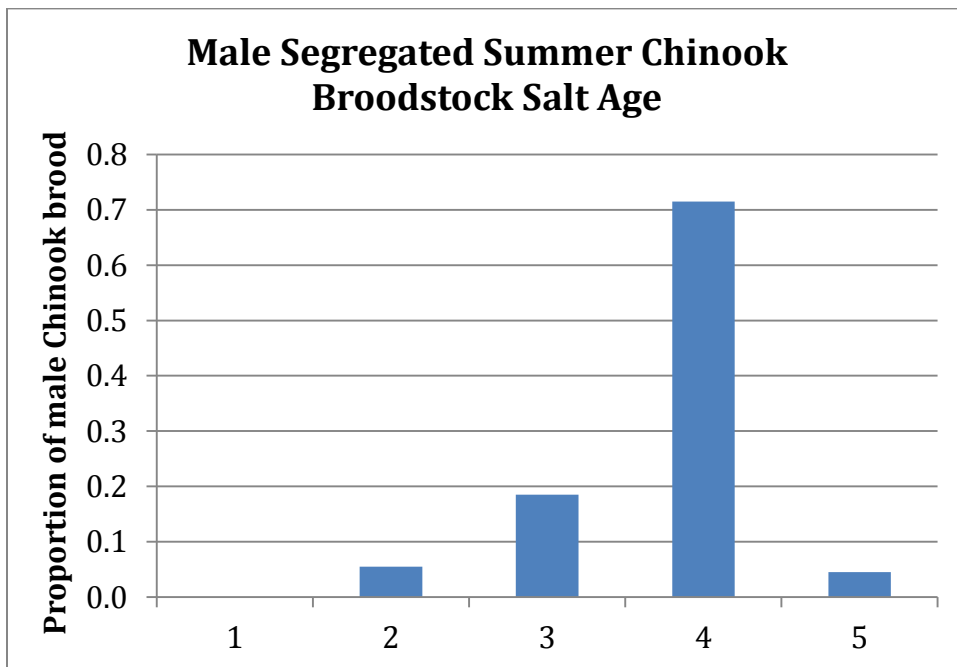
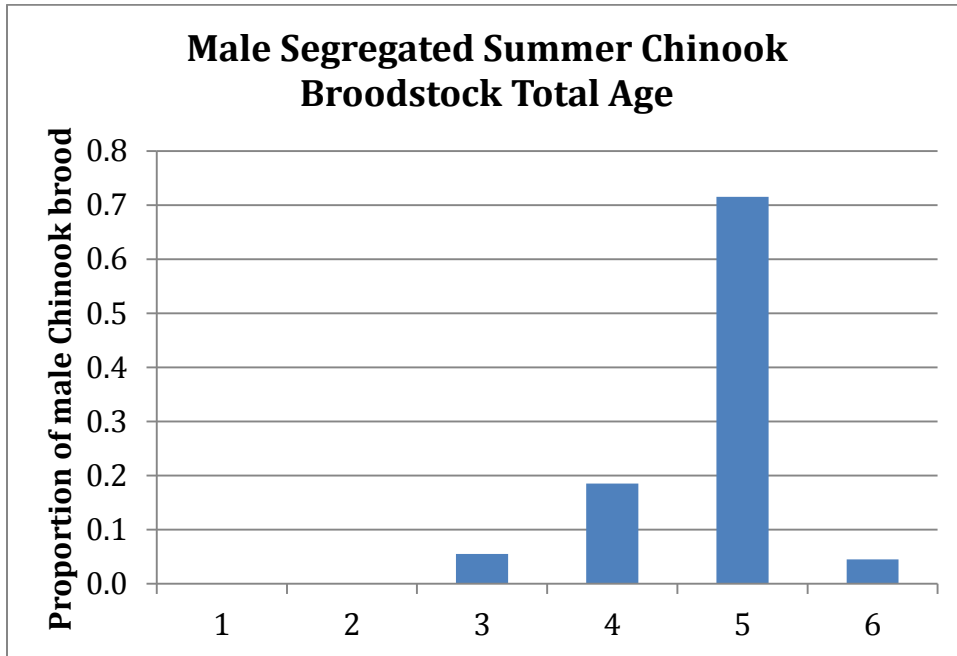


Figure A 1. The total and salt ages of the 2016 broodstock, males and females, collected for the Okanogan summer/fall Chinook integrated program.

Segregated Program Broodstock Age Structure

Coded wire tags are extracted from summer Chinook segregated program broodstock and later read in order to capture the age of successfully spawned fish.



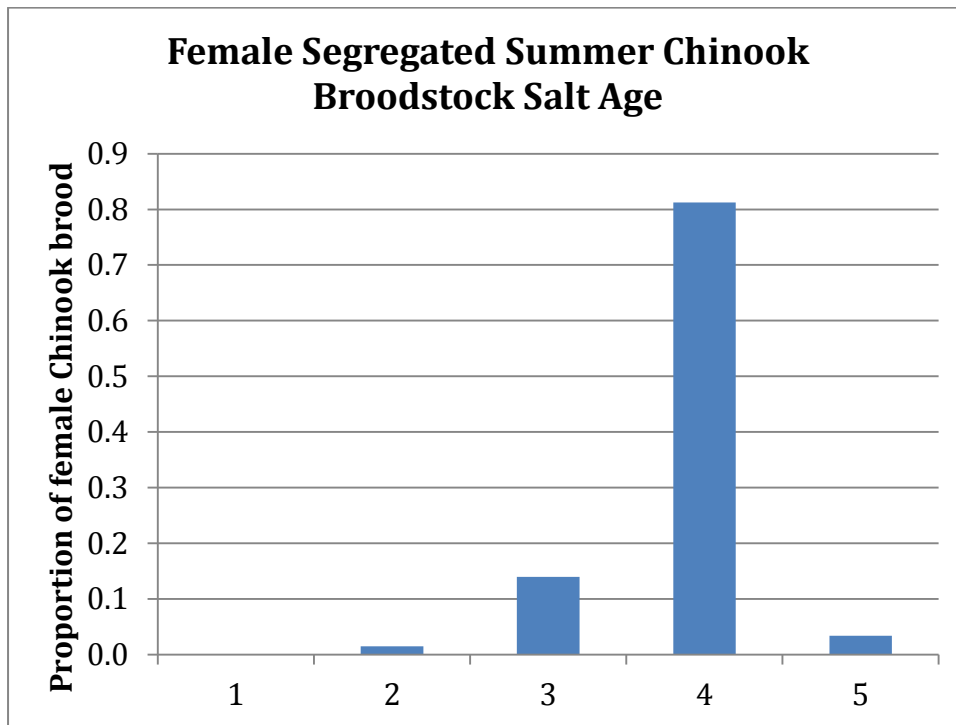
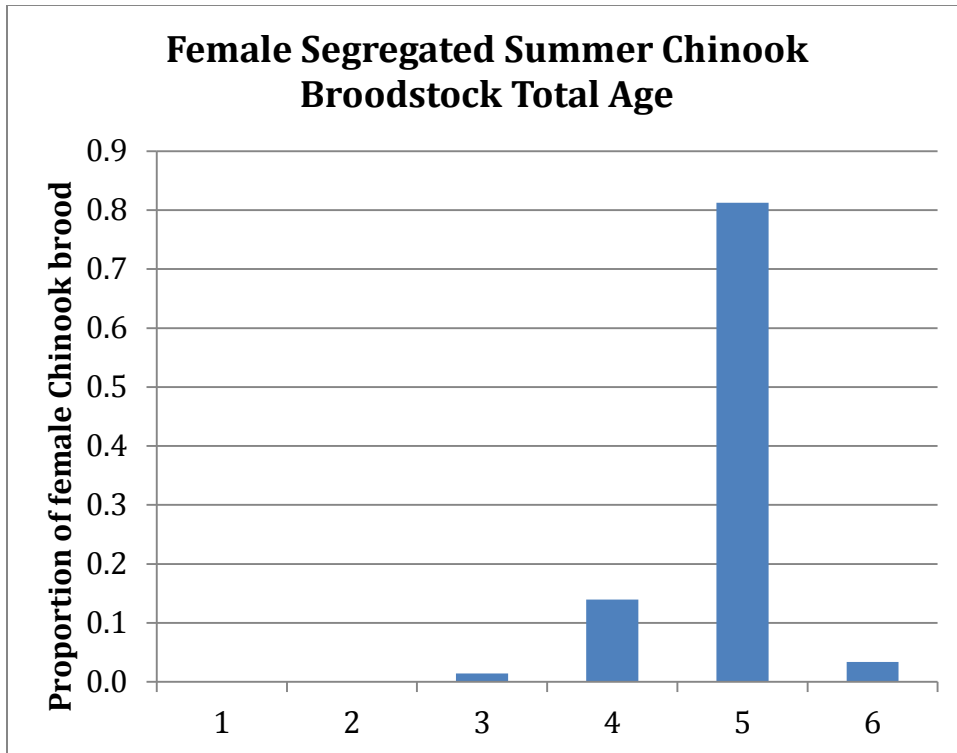


Figure A 2. The total and salt ages of the 2016 broodstock, males and females, collected for the Chief Joseph Hatchery segregated program.

Incubation

Eggs from each female summer/fall Chinook were placed in individual incubators (Heath Trays) and remained individually incubated until ELISA results were obtained. Once eye-up occurred, eggs from any moderate and high ELISA would be removed; no females were discarded from the 2016 brood. The cull rate for this production plan allows for a rate of 5% for segregated and 3% for integrated. After eye-up, egg mortality was removed and the eggs were inventoried and put into incubators at 5,000 eggs per tray for hatching. Incubation water temperatures were manipulated to the level necessary to synchronize the hatching and ponding of the spawn takes throughout October and November 2016 and to achieve the size-at-release target for both yearling and sub-yearling summer Chinook programs. Four days after spawning, the incubation water temperatures were gradually reduced on yearling egg-takes to a temperature of 37° F. Once each take achieved 100 TUs, incubation temperatures were, manipulated to either advance or delay maturation. Variable incubation water temperatures were required to synchronize hatching dates associated with variable spawn dates throughout the spawn period within yearling and sub-yearling production groups and to achieve target hatching date associated with size-at-release targets, based on projected growth rates and release dates for the respective production groups.

Rearing

The first groups of sub-yearlings were brought out of incubation and transferred into early rearing troughs on February 1st, 2017. During the month of February, this group was introduced to feed in the early rearing troughs, and reared for a period of two weeks. Ponding was completed on February 11th, 2017. After the initial rearing period inside, all groups were transferred outside to the standard raceways via the fry transfer line. No inventories were taken during transfers, to prevent excess handling stress. All sub-yearlings are released in the first spring of life, and after marking, both the integrated and segregated sub-yearlings were released in May of 2017. The integrated sub-yearlings were transferred to the Omak Acclimation pond after marking. In addition, both groups included a 5,000 PIT tag component. PIT tagging was contracted to USFWS, and was completed on April 20th, 2017.

Table A 19. Chief Joseph Hatchery brood year 2016 summer/fall Chinook sub-yearling ponding summary. The survival standard for this life stage was 95%.

Production Group	<u>Total Fry Poned</u>	<u>Ponding Mortality</u>	<u>Monthly Feed</u>	<u>Monthly Mortality</u>	<u>Ponding Loss (%)</u>	<u>Cumulative Survival (%)</u>
	Total	Total	Total	Total	Total	Total
<u>NOR</u>						
Subs	239,646	6,012	190	1,848	2.5%	96.7%
<i>Sub-total</i>	239,646	6,012	190	1,848	2.5%	96.7%
<u>HOR</u>						
Subs	187,237	1,624	138	1,355	0.9%	98.4%
<i>Sub-total</i>	187,237	1,624	138	1,355	0.9%	98.4%
<i>Total</i>	426,883	7,636	328	3,203	3.4%	97.5%

Table A 20. Chief Joseph Hatchery brood year 2016 summer/fall Chinook sub-yearling rearing summary., May 2017.

	<u>Total on hand</u>	<u>Mortality</u>	<u>Feed Fed</u>	<u>Fish per pound</u>	<u>Cumulative Survival (%)</u>
<u>Month</u>	<u>Total</u>	<u>Total</u>	<u>Total</u>	<u>Total</u>	<u>Total</u>
HORs					
Mar. 31	183,751	507	714	120	98.1%
Apr. 30	185,844**	183	1,595	75	98.0%
May 16	185,821^^	23	792	50	98.0%
<i>sub-total</i>	185,821	713	3,101	50	98.0%
NORs					
Mar. 31	225,481	550	896	120	94.9%
Apr. 30	217,909*	614	1,382	75	94.5%
May 22	216,804^	1,105	1,056	44	94.0%
<i>sub-total</i>	216,804	2,269	3,334	44	94.0%
Cumulative	402,625	2,982	6,435	47	96.0%

*Shortage of 9,123 at marking

** Overage at marking – 2,276

^Released

^^Released

The first group of integrated yearlings was brought out of incubation and transferred into early rearing troughs in late May, and continued into June. Once ponded, all groups were introduced to feed in the early rearing troughs, and remained in early rearing for a period of two weeks. After the initial rearing period inside, groups will be transferred outside to the standard raceways via the fry transfer line. Ponding survival ranged from 96% to 99% and averaged 98% across all groups which exceeded the survival standard (95%) for this life stage (Table A 21).

Table A 21. Chief Joseph Hatchery brood year 2016 summer/fall Chinook yearling ponding summary. The survival standard for this life stage was 95%.

	<u>Total Fry Ponded</u>	<u>Ponding Mortality</u>	<u>Monthly Feed</u>	<u>Monthly Mortality</u>	<u>Ponding Loss (%)</u>	<u>Cumulative Survival (%)</u>
Production Group	Total	Total	Total	Total	Total	Total
<u>NORs</u>						
May	384,480	11,200	17	2,283	2.91%	96.5%
Sub-total	384,480	11,200	17	2,283	2.91%	96.5%
<u>HORs</u>						
May	262,018	3,458	15	1,042	1.31%	98.3%
Sub-total	262,018	3,458	15	1,042	1.31%	98.3%
Total	646,498	14,658	32	3,325	2.11%	97.4%

Chief Joseph Hatchery Ladder

The CJH ladder is operated with the primary purpose of adult management (reducing pHOS) but can also be utilized to collect brood for the segregated program in years of low abundance or if the purse seine is not effective due to environmental conditions. In 2016, a small portion (3%) of hatchery fish collected from the CJH ladder were used for brood in the segregated program (Table A 22). The CJH fish ladder began operation on June 27th, 2016, with the first adult management activities occurring on June 29th. In 2016, only 3 year old fish were returning from the CJH program so adult returns were stray fish (or wandering⁹) from the Similkameen Pond program (pre-CJH) and other downstream facilities. All hatchery Chinook and Sockeye were removed from the ladder and utilized for Tribal subsistence and ceremonial food purposes. All steelhead and NOR Chinook were returned to the river via a water to water transfer.

From June 27th thru October 6th, 2016, 6,354 hatchery-origin summer/fall Chinook and five Sockeye were removed at the CJH ladder. 6,206 of the Chinook were utilized for Tribal subsistence purposes and 148 were shipped to the landfill as they were not deemed

⁹ A wandering fish is one that has bypassed its facility (or river) of origin and been intercepted by another facility. These fish are often categorized as a stray, but had the intercepting facility not retained the fish it may have fallen back and returned to its place of origin.

suitable for human consumption. 556 natural-origin Summer/Fall Chinook, and 56 steelhead were trapped, handled and released back to the Columbia River. (Table, A 22, Table A 23). Of the AD-present steelhead handled and released, 67% were determined to be of hatchery origin, based on the stock composition developed by WDFW at Wells Dam.

The encounter/handling and release of four NOR steelhead represents 35% of the allowable incidental take provided in the Biological Opinion (BiOp) for Chief Joseph Hatchery collection facilities (NMFS 2008). There were no observed immediate steelhead mortalities during the ladder operations in 2016.

Table A 22. Chief Joseph Hatchery adult summer/fall Chinook ladder operations from June to October 2016.

Date	# of Ladder Trap Checks	HOR Males surplus	HOR Females surplus	HOR Jacks (1) surplus	HOR Brood Males	HOR Brood Females	NOR Males RTS	NOR Females RTS	NOR Jacks RTS
June	1	79	89	88	0	0	7	8	2
July	8	1,566	1,530	400	70	70	144	106	42
Aug	5	816	677	329	27	28	72	54	27
Sept	3	261	195	176	0	0	39	32	20
Oct	2	74	72	2	0	0	2	1	0
Total	19	2,796	2,563	995	97	98	264	201	91

RTS= Return to stream

Table A 23. Chief Joseph Hatchery adult spring Chinook, sockeye and steelhead ladder operations from June to October 2016.

Date	# of Ladder Trap Checks	HOR Spring Chinook	HOR Spring Chinook Jacks	NOR Spring Chinook RTS	NOR Spring Chinook Jacks RTS	Sockeye	AD Present Steelhead RTS	AD Absent Steelhead RTS	Coho RTS
June	1	21	82	0	0	0	0	0	0
July	8	22	11	0	0	3	1	2	0
Aug	5	0	0	0	0	2	1	13	0
Sept	3	0	0	0	0	0	8	28	0
Oct	2	0	0	0	0	0	1	2	0
Total	19	43	93	0	0	5	11	45	0

RTS= Return to stream

Table A 24. Chief Joseph Hatchery annual summer/fall Chinook, sockeye, and steelhead collected during ladder operations.

Date	HOR Chinook surplussed	HOR jacks ⁽¹⁾ surplussed	NOR Chinook RTS	NOR jack RTS	HOR Chinook Brood	Sockeye	AD Present Steelhead RTS	AD Absent Steelhead RTS	Coho RTS
Aug- Nov. 2013	1,263	523	247	69	9	10	38	0	0
July- Nov. 2014	2,835	1,778	861	245	87	31	69	122	181 ⁶
July- Oct. 2015	6,773	1,651	1,671	369	217 ⁴	180	119 ²	401	2
June- Oct. 2016	5,359	995	465	91	196 ⁵	5	11 ³	45	0
Total	14,967	4,424	2,997	705	509	216	199	568	183

⁽¹⁾ Includes mini-jacks

⁽²⁾ 24% AD Present Steelhead were HORs

⁽³⁾ 67% AD Present Steelhead were HORs

⁽⁴⁾ 147 adults (80 males, 67 females) taken for transfer to Eastbank Hatchery

⁽⁵⁾ 98 males and 98 females taken in July and August,

⁽⁶⁾ Surplussed fish

RTS= Return to stream

Table A 25. Chief Joseph Hatchery spring Chinook collected during ladder operations in 2016.

Date	HOR Chinook surplussed	HOR Chinook Jacks surprussed	NOR Chinook RTS	NOR Chinook Jacks RTS	HOR Brood
6/29	21	82	0	0	0
7/7	5	0	0	0	0
7/13	1	3	0	0	0
7/19	8	1	0	0	0
7/21	1	1	0	0	0
7/22	5	3	0	0	0
7/26	1	1	0	0	0
7/28	1	2	0	0	0
Total	43	93	0	0	0

RTS= Return to stream

The ladder was closed and dewatered on October 6th, 2016, for the season. The protocol was to sample 20% (one of five) of the adipose-clipped summer/fall Chinook for code-wire tags (CWT). Snouts with positive CWT detection were held frozen until December 2016 when CWT extraction and reading took place in the Chief Joseph Hatchery lab. Coded wire tags were extracted and read from snouts collected from 2013-2016 (we had to catch up on 3 years of backlogged snouts after WDFW decided they could not process them without additional funding). Recovery data were expanded by the tag rate at the hatchery of origin and the sample rate at the ladder. Please refer to the Methods section for details on the expansion process for recovered tags. Beginning with jacks in 2016, snouts without a tag were assumed to be from the CJH segregated program.

Eight summer/fall Chinook hatchery programs were encountered during ladder operations at CJH in 2013, most of which came from upstream of Priest Rapids (Table A 26). The Chelan (33%) and Wells (22%) hatcheries as well as the Dryden Pond (26%) were the most common. Similkameen Pond was a small proportion (10%) of the composition (Table A 26). The Omak Pond and CJH segregated programs were not encountered in the ladder surplus, primarily because the first CJH releases didn't occur until 2014.

Table A 26. Summary of summer/fall Chinook coded-wire tags encountered and expansions for the CJH ladder in 2013.

Category	Hatchery Program	# Tags	Expanded Abundance	% of Ladder Surplus
Okanogan Integrated	Omak Yearlings	0	0	0%
	Omak Subyearlings	0	0	0%
	Similkameen	38	86	10%
CJH Segregated	Segregated yearlings	0	0	0%
	Segregated subyearlings	0	0	0%
	No CWT, assumed Seg.	0	0	0%
Other UCR summer/fall Chinook hatchery	Wells	87	201	22%
	Chelan	128	300	33%
	Carlton	34	77	8%
	Entiat	0	0	0%
	Dryden	99	237	26%
	Priest Rapids	2	4	0.5%
Out of ESU hatchery	Lyons Ferry	2	4	0.5%
Total		390	909	100%

In 2014 eleven summer/fall Chinook hatchery programs were encountered at the CJH ladder, most of which still came from upstream of Priest Rapids (Table A 27). Similar to 2013, Wells (28%), and Chelan (26%) hatcheries were the most common. Dryden (11%), Carlton (8%) and Similkameen (10%) were a smaller proportion of the composition (Table A 27). The Omak Pond and CJH segregated programs were not represented in the ladder surplus because there were no adult returns from those programs in 2014 (the first releases occurred in 2014).

Table A 27. Summary of summer/fall Chinook coded-wire tags encountered and expansions for the CJH ladder in 2014.

Category	Hatchery Program	# Tags	Expanded Abundance	% of Ladder Surplus
Okanogan Integrated	Omak Yearlings	0	0	0%
	Omak Subyearlings	0	0	0%
	Similkameen	111	197	10%
CJH Segregated	Segregated yearlings	0	0	0%
	Segregated subyearlings	0	0	0%
	No CWT, assumed Seg.	190	300	15%
Other UCR summer/fall Chinook hatchery	Wells	312	569	28%
	Chelan	290	526	26%
	Carlton	84	152	8%
	Entiat	18	32	2%
	Dryden	123	220	11%
	Priest Rapids	1	2	0.1%
Out of ESU hatchery	Irrigon	1	2	0.1%
	Lyons Ferry	2	4	0.2%
	Nez Perce Tribal	1	2	0.1%
	Oxbow	1	2	0.1%
Total		1,134	2,008	100%

In 2015 twelve summer/fall Chinook hatchery programs were encountered at the CJH ladder, most of which still came from upstream of Priest Rapids (Table A 28). Again, similar to previous years, Wells (34%) and Chelan (29%) hatcheries were the most common and Dryden (12%) and Similkameen (13%) remained a small proportion of the composition (Table A 28). The Omak Pond and CJH segregated programs were represented at less than 3% of the overall ladder surplus.

Table A 28. Summary of summer/fall Chinook coded-wire tags encountered and expansions for the CJH ladder in 2015.

Category	Hatchery Program	# Tags	Expanded Abundance	% of Ladder Surplus
Okanogan Integrated	Omak Yearlings	2	7	0.1%
	Omak Subyearlings	2	8	0.1%
	Similkameen	224	815	13%
CJH Segregated	Segregated yearlings	0	0	0%
	Segregated subyearlings	0	0	0%
	No CWT, presumed Seg	30	86	1%
Other UCR summer/fall Chinook hatchery	Wells	610	2212	34%
	Chelan	518	1898	29%
	Carlton	102	378	6%
	Dryden	218	795	12%
	Entiat	72	261	4%
	Priest Rapids	4	15	0.2%
Out of ESU hatchery	Irrigon	1	4	0.1%
	Nez Perce Tribal	3	11	0.2%
	Oxbow	1	4	0.1%
	Lyons Ferry	4	15	0.2%
	McCall	1	4	0.1%
Total		1,792	6,513	100%

Eleven summer/fall Chinook hatchery programs were encountered at the CJH ladder in 2016, most of which still came from upstream of Priest Rapids (Table A 29). Wells (50%) and Chelan (26%) hatcheries were the most common and Dryden (8%) and Similkameen (3%) still remained a small proportion of the composition (Table A 29). The Omak Pond (2%) program made up a small percentage of the overall ladder surplus while the CJH segregated program made up 5% of the composition. Most of these recoveries were from ad-clipped, non-coded wire tagged (CWT) fish and are presumed to be from the CJH segregated program since this is the only hatchery above Priest Rapids that releases ad-clipped, non-CWT fish.

Table A 29. Summary of summer/fall Chinook coded-wire tags encountered and expansions for the CJH ladder in 2016.

Category	Hatchery Program	# Tags	Expanded Abundance	% of Ladder Surplus
Okanogan Integrated	Omak Yearlings	14	64	1%
	Omak Subyearlings	12	57	1%
	Similkameen	37	170	3%
CJH Segregated	Segregated yearlings	0	0	0%
	Segregated subyearlings	24	110	2%
	No CWT, presumed Segr.	76	321	5%
Other UCR summer/fall Chinook hatchery	Wells	626	2864	50%
	Chelan	323	1486	26%
	Carlton	21	110	2%
	Entiat	28	128	2%
	Dryden	95	440	8%
Out of ESU hatchery	Irrigon	2	9	0.2%
	Nez Perce Tribal	1	5	0.1%
	Lyons Ferry	1	5	0.1%
	Umatilla	1	5	0.1%
Total		1,261	5,774	100%

Table A 30. Percent of CJH ladder surplus summer/fall Chinook each year estimated to be from various facilities based on CWT assessment. Similkameen includes some returns from Bonaparte Pond releases (2010 and 2011). Chelan includes returns from the Turtle Rock program (2010 and 2011). 2016 was the first year of jack returns (3 year old males) to CJH. 2018 will be the first return year with a full complement of brood years in the return (through age 5).

	# Surplus Fish	Facility/Program									
		CJH Seg. ^a	Omak	Similk ^b	Wells	Chelan ^c	Carlton	Entiat	Dryden ^d	Priest	Other ^e
2013	1,061	0%	0%	10%	22%	33%	8%	0%	26%	1%	1%
2014	2,008	0%	0%	10%	28%	26%	8%	2%	11%	0%	0%
2015	6,802	1%	0%	13%	34%	29%	6%	4%	12%	0%	0%
2016	5,788	5%	2%	3%	50%	26%	2%	2%	8%	0%	0%
Average	3,915	2%	1%	9%	26%	29%	6%	2%	14%	0%	0%

^aIncludes recoveries with 'no coded wire tags' under 62 cm. in fork length, 2015 and 2016

^bIncludes Bonaparte pond releases, all years

^cIncludes releases from Chelan Falls (all years), PUD (2013), Net Pens (2013-2015) and Turtle Rock (all years)

^dIncludes releases by the Eastbank Hatchery into the Wenatchee R. (2013)

^eIncludes releases by Lyons Ferry and Snake River basin hatcheries

The spring Chinook CWT recovery data from the CJH ladder represents spring Chinook encountered during summer Chinook ladder operations (June 29-October 6). In 2016, the majority (43%) of spring Chinook encountered at the CJH ladder were from the CJH segregated program, although only jacks were returning from that program (Table A 31). Thirteen percent of the Spring Chinook encountered at the ladder were from the Okanogan 10(j) program at Riverside Pond. and the contribution from LNFH dropped dramatically to 13% compared to previous years. Interestingly, the percent of 'Other' out-of-ESU contributors increased in 2016 and came from 2 different hatcheries (Table A 31). However, conclusions should not be made without sampling during the earlier run timing of spring Chinook and considering that a full set of brood years was not returning from the releases at CJH.

Table A 31. Percent of CJH ladder surplus spring Chinook each year estimated to be from various facilities based on CWT assessment of spring Chinook. Estimated number of annual spring Chinook coded wire tag recoveries, by release hatchery, from Chief Joseph Hatchery ladder operations in June to October.

	# Surplus Fish	Facility/Program						
		Riverside Pond	CJH	Winthrop	Leavenworth	Chiwawa Pond	Methow Hatchery	Other ^a
2013	3	0%	0%	0%	0%	100%	0%	0%
2014	46	0%	0%	0%	91%	7%	2%	0%
2015	24	0%	0%	4%	75%	17%	0%	4%
2016	17	13%	43%	6%	13%	13%	6%	6%
Average	23	3%	11%	3%	44%	34%	2%	3%

^a Releases from Out of ESU hatcheries include:, Parkdale and Nez Perce hatcheries

APPENDIX B

2017 Production Plan

Table B 1. Summer Chinook Early - Integrated Program (Similkameen Release)

Chief Joseph Hatchery Production Plan										
Brood Year:	2017							Planting Goal:	267,000	
Species:	Summer Chinook - Early							Pounds:	26,700	
Stock:	Okanogan									
Origin:	Wild									
Program:	Integrated									
Egg Take Goal:	360,000							Adult Goal:	158	
Estimated Release Data:										
Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
04/15/19	04/30/19	267,000	10	45	26,700	12,015	yearlings	Similkameen	Ad Clipped	CWT
Notes:	Egg take goal includes 3% for culling. Adult Goal includes 10% pre-spawn mortality 10% Green to Eyed egg mortality Rearing mortality is 16.7%									
Rearing Summary:										
Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed Fry	Released	Location		
EA SU Chinook YR	Okanogan	April	349,200	314,280	298,566	283,638	267,000	Similkameen		

Table B 2. Summer Chinook Late - Integrated Program (Omak Acclimation Pond Release)

<i>Chief Joseph Hatchery Production Plan</i>										
Brood Year:	2017					Planting Goal:	566,000			
Species:	Summer Chinook - Late					Pounds:	32,600			
Stock:	Okanogan									
Origin:	Wild									
Program:	Integrated									
Egg Take Goal:	765,000					Adult Goal:	340			
Estimated Release Data:										
Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
04/15/19	04/30/19	266,000	10	45	26,600	11,970	yearlings	Omak	Ad Clipped	CWT
05/15/18	06/01/18	300,000	50	11	6,000	3,300	sub-yearling	Omak	Ad Clipped	CWT
Notes:	Egg take goal includes 3% for culling. Adult Goal includes 10% pre-spawn mortality 10% Green to Eyed egg mortality Rearing mortality is 15.7% for yearlings, 16.2% for subs.									
Rearing Summary:										
Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed Fry	Released	Location		
EA SU Chinook YR	Okanogan	April	348,764	313,887	298,193	283,283	266,000	Omak		
EA SU Chinook Sub	Okanogan	June	393,287	353,958	336,260	319,447	300,000	Omak		

Table B 3. Summer Chinook Late – Segregated Program (CJH Site Release)

<i>Chief Joseph Hatchery Production Plan</i>										
Brood Year:	2017					Planting Goal:	450,000			
Species:	Summer Chinook - Late					Pounds:	29,000			
Stock:	Okanogan									
Origin:	Hatchery									
Program:	Segregated									
Egg Take Goal:	620,000					Adult Goal:	276			
Estimated Release Data:										
Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
04/15/19	04/30/19	250,000	10	45	25,000	11,250	yearlings	CJ hatchery	Ad Clipped	
05/15/18	06/01/18	200,000	50	11	4,000	2,200	sub-yearling	CJ hatchery	Ad Clipped	
Notes:	Egg take goal includes 5% for culling. Adult Goal includes 10% pre-spawn mortality 10% Green to Eyed egg mortality Rearing mortality is 14.4% for yearlings, 16.5% for subs.									
Rearing Summary:										
Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed Fry	Released	Location		
EA SU Chinook YR	Okanogan	April	323,950	291,555	276,977	263,128	250,000	CJ Hatchery		
EA SU Chinook Sub	Okanogan	June	265,050	238,545	226,618	215,287	200,000	CJ Hatchery		

Table B 4. Summer Chinook Early – Integrated Program (Riverside Acclimation Pond Release)

<i>Chief Joseph Hatchery Production Plan</i>										
Brood Year:	2017							Planting Goal:	266,000	
Species:	Summer Chinook - Early							Pounds:	26,600	
Stock:	Okanogan									
Origin:	Wild									
Program:	Integrated									
Egg Take Goal:	360,000							Adult Goal:	158	
Estimated Release Data:										
Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
04/15/19	04/30/19	266,000	10	45	26,600	11,970	yearlings	Riverside	Ad Clipped	CWT
Notes:	Egg take goal includes 3% for culling. Adult Goal includes 10% pre-spawn mortality 10% Green to Eyed egg mortality Rearing mortality is 16.7%									
Rearing Summary:										
Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed Fry	Released	Location		
EA SU Chinook YR	Okanogan	April	349,200	314,280	298,566	283,638	266,000	Riverside		

Table B 5. Summer Chinook Early – Segregated Program (CJH Release Site)

<i>Chief Joseph Hatchery Production Plan</i>										
Brood Year:	2017							Planting Goal:	450,000	
Species:	Summer Chinook - Early							Pounds:	29,000	
Stock:	Okanogan									
Origin:	Hatchery									
Program:	Segregated									
Egg Take Goal:	620,000							Adult Goal:	276	
Estimated Release Data:										
Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
04/15/19	04/30/19	250,000	10	45	25,000	11,250	yearlings	CJ hatchery	Ad Clipped	
05/15/18	06/01/18	200,000	50	9	4,000	1,800	sub-yearling	CJ hatchery	Ad Clipped	
Notes:	Egg take goal includes 5% for culling. Adult Goal includes 10% pre-spawn mortality 10% Green to Eyed egg mortality Rearing mortality is 14.4% for yearlings, 16.5% for subs.									
Rearing Summary:										
Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed fry	Released	Location		
EA SU Chinook YR	Okanogan	April	323,950	291,555	276,977	263,128	250,000	CJ Hatchery		
EA SU Chinook Sub	Okanogan	June	265,050	238,545	226,618	215,287	200,000	CJ Hatchery		

Table B 6. Spring Chinook - Leavenworth (CJH Release)

<i>Chief Joseph Hatchery Production Plan</i>										
Brood Year:	2017							Planting Goal:	700,000	
Species:	Spring Chinook							Pounds:	46,667	
Stock:	Leavenworth									
Origin:	Hatchery									
Egg Take Goal:	1,094,400							Adult Goal:	640	
Estimated Release Data:										
Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
04/15/19	04/30/19	700,000	15	30	46,667	21,000	yearlings	CJ hatchery	Ad Clipped	
Notes:	Egg take goal includes 20% for culling. Adult Goal includes 10% pre-spawn mortality 10% Green to Eyed egg mortality Rearing mortality is 15.5%									
Rearing Summary:										
Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed Fry	Released	Location		
Spring Chinook	Leavenworth	April	875,520	787,968	748,570	711,141	700,000	CJ Hatchery		

Table B 7. Spring Chinook - Met Comp (Riverside Acclimation Pond Release)

<i>Chief Joseph Hatchery Production Plan</i>										
Brood Year:	2017							Planting Goal:	200,000	
Species:	Spring Chinook							Pounds:	13,333	
Stock:	Met Comp									
Origin:	Hatchery/Wild									
Egg Take Goal:	326,800							Adult Goal:	190	
Estimated Release Data:										
Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
04/15/19	04/30/19	200,000	15	30	13,333	6,000	yearlings	Tonasket Pond	Ad Clipped	CWT
Notes:	Egg take goal includes 20% for culling. Adult Goal includes 10% pre-spawn mortality 10% Green to Eyed egg mortality Rearing mortality is 15.8%									
Rearing Summary:										
Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed Fry	Released	Location		
Spring Chinook	Met Comp	April	261,440	235,296	223,531	212,355	200,000	Tonasket		

APPENDIX C

Reach Weighted Effective pHOS

Table C 1. pHOS information for adjustments based on hatchery fish effectiveness (relative reproductive success assumption) and the reach weighting based on the proportion of redds in each reach in the Okanogan River from 2006 to 2016.

Brood Year		Number of Summer Chinook Carcasses								Total	Effective Reach Weighted pHOS ¹
		Okanogan						Similkameen			
		O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2		
2006	NOS	2	2	22	10	105	247	370	73	831	18.0%
	HOS	2	1	9	6	15	44	138	33	248	
	Effective pHOS ²	44.4%	28.6%	24.7%	32.4%	10.3%	12.5%	23.0%	26.6%		
	% Redds	0.2%	1.3%	4.1%	3.4%	19.7%	32.0%	29.9%	9.5%	100%	
2007	NOS	1	0	30	1	284	322	405	20	1063	31.7%
	HOS	1	0	25	0	169	197	253	9	654	
	Effective pHOS ²	44.4%	0.0%	40.0%	0.0%	32.3%	32.9%	33.3%	26.5%		
	% Redds	0.2%	0.8%	5.8%	3.1%	27.3%	27.6%	31.0%	4.3%	100%	
2008	NOS	2	1	14	11	107	324	347	41	847	54.3%
	HOS	2	9	26	25	141	341	512	116	1172	
	Effective pHOS ²	44.4%	87.8%	59.8%	64.5%	51.3%	45.7%	54.1%	69.4%		
	% Redds	0.2%	2.4%	2.8%	4.5%	17.4%	26.2%	37.3%	9.3%	100%	
2009	NOS	2	3	13	14	189	347	330	75	973	40.4%

	HOS	0	4	18	18	159	153	373	75	800	
	Effective pHOS ²	0.0%	51.6%	52.6%	50.7%	40.2%	26.1%	47.5%	44.4%		
	% Redds	0.1%	1.1%	3.1%	4.7%	20.9%	26.5%	36.8%	7.0%	100%	
2010	NOS	1	5	19	18	154	180	329	69	775	41.2%
	HOS	2	5	11	24	87	172	296	79	676	
	Effective pHOS ²	61.5%	44.4%	31.7%	51.6%	31.1%	43.3%	41.9%	47.8%		
	% Redds	0.4%	2.7%	3.2%	4.2%	16.9%	20.3%	42.3%	10.0%	100%	
2011	NOS	0	0	21	4	201	362	216	19	823	47.4%
	HOS	0	0	34	10	160	116	537	95	952	
	Effective pHOS ²	0.0%	0.0%	56.4%	66.7%	38.9%	20.4%	66.5%	80.0%		
	% Redds	0.1%	0.6%	3.2%	1.8%	19.0%	30.2%	39.0%	6.1%	100%	
2012	NOS	0	0	18	9	133	427	206	23	816	39.7%
	HOS	1	0	38	6	123	110	288	31	597	
	Effective pHOS ²	100.0%	0.0%	62.8%	34.8%	42.5%	17.1%	52.8%	51.9%		
	% Redds	0.4%	2.0%	5.9%	2.5%	20.7%	28.6%	34.1%	5.7%	100%	
2013	NOS	0	0	22	7	37	352	191	4	613	27.1%
	HOS	0	0	8	2	15	80	188	4	297	
	Effective pHOS ²	0.0%	0.0%	21.6%	21.6%	24.5%	15.4%	44.1%	44.1%		
	% Redds	0.1%	0.1%	4.5%	1.3%	11.2%	46.8%	35.4%	0.7%	100%	
2014	NOS	0	1	60	47	233	716	641	425	2123	12.0%
	HOS	1	0	19	7	42	67	129	64	329	

	Effective pHOS ²	100.0%	0.0%	20.2%	10.6%	12.6%	7.0%	13.9%	10.8%		
	% Redds	0.3%	1.3%	4.5%	2.6%	20.0%	23.7%	40.8%	6.7%	100%	
2015	NOS	0	5	39	9	209	931	1186	176	2555	21.0%
	HOS	0	5	22	2	74	63	516	56	738	
	Effective pHOS ²	20.8%	44.4%	31.1%	15.1%	22.1%	5.1%	25.8%	20.3%		
	% Redds	0.8%	2.6%	6.6%	1.8%	23.6%	20.1%	37.7%	6.7%	100%	
2016	NOS	0	6	13	7	186	1019	819	121	2171	15.5%
	HOS	0	6	1	4	44	56	395	78	584	
	Effective pHOS ²	15.5%	44.4%	5.8%	31.4%	15.9%	4.2%	27.8%	34.0%		
	% Redds	0.0%	1.1%	1.0%	2.5%	17.2%	44.3%	31.2%	2.7%	100%	
Average % Redds		0.3%	1.5%	4.1%	2.9%	19.4%	29.7%	35.9%	6.2%		
Average Effective pHOS		44.4%	52.2%	42.0%	46.5%	33.0%	19.1%	38.9%	42.6%		
Average Reach Weighted Effective pHOS =										29.4%	

Table C 2 Number of hatchery- and natural-origin (wild) summer Chinook carcasses collected in each reach of the Okanogan (O1-06) and Similkameen rivers from 1993 to 2016.

Survey year	Origin	Survey reach								Total
		O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
1993 ^a	Wild	0	0	3	0	13	4	48	1	69
	Hatchery	0	2	0	0	10	9	25	0	46
1994 ^b	Wild	0	0	1	0	7	1	113	22	144
	Hatchery	0	4	3	0	20	4	205	38	274
1995	Wild	0	0	1	0	10	0	66	4	81
	Hatchery	0	0	1	0	20	0	173	11	205
1996	Wild	0	0	0	1	3	1	53	0	58
	Hatchery	0	0	0	1	2	1	173	0	177
1997	Wild	0	0	1	0	0	3	83	0	87
	Hatchery	0	0	1	0	9	0	142	1	153
1998	Wild	0	1	3	1	6	5	162	4	182
	Hatchery	0	0	5	0	1	2	178	0	186
1999	Wild	0	0	0	0	9	23	293	9	334
	Hatchery	0	0	3	2	14	30	473	39	561
2000	Wild	0	0	8	8	24	11	189	4	244
	Hatchery	0	2	12	7	23	5	538	37	624
2001	Wild	0	10	23	5	67	42	390	54	591
	Hatchery	0	16	52	5	60	70	751	51	1,005
2002	Wild	6	14	20	10	81	212	340	72	755
	Hatchery	4	18	63	25	123	360	925	187	1,705
2003 ^c	Wild	0	0	13	0	12	152	231	124	532
	Hatchery	0	0	15	0	5	91	365	257	733
2004	Wild	0	2	19	19	108	225	1,125	260	1,758
	Hatchery	0	2	12	5	38	58	267	38	420
2005	Wild	0	5	51	21	256	364	531	176	1,404
	Hatchery	0	3	42	16	115	70	200	100	546
2006	Wild	2	2	22	10	105	247	370	73	831
	Hatchery	2	1	9	6	15	44	138	33	248

2007	Wild	1	0	30	1	284	322	405	20	1,063
	Hatchery	1	0	25	0	169	197	253	9	654
2008	Wild	2	1	14	11	107	324	347	41	847
	Hatchery	2	9	26	25	141	341	512	116	1,172
2009	Wild	2	3	13	14	189	347	330	75	973
	Hatchery	0	4	18	18	159	153	373	75	800
2010	Wild	1	5	19	18	154	180	329	69	775
	Hatchery	2	5	11	24	87	172	296	79	676
2011	Wild	0	0	21	4	201	362	216	19	823
	Hatchery	0	0	34	10	160	116	537	95	952
2012	Wild	0	0	18	9	133	427	206	23	816
	Hatchery	1	0	38	6	123	110	288	31	597
2013 ^{d,e}	Wild	0	0	22	7	37	352	191	4	613
	Hatchery	0	0	8	2	15	80	188	4	297
2014	Wild	0	1	60	47	233	716	641	425	2123
	Hatchery	1	0	19	7	42	67	129	64	329
2015	Wild	0	5	39	9	209	931	1186	176	2555
	Hatchery	0	5	22	2	74	63	516	56	738
2016	Wild	0	6	13	7	186	1019	819	121	2171
	Hatchery	0	6	1	4	44	56	395	78	584
Average	Wild	1	2	18	9	105	273	374	77	859
	Hatchery	1	3	18	7	63	91	342	60	586

^a 25 additional carcasses were sampled on the Similkameen and 46 on the Okanogan without any reach designation.

^b One additional carcass was sampled on the Similkameen without any reach designation.

^c 793 carcasses were sampled on the Similkameen before initiation of spawning (pre-spawn mortality) and an additional 40 carcasses were sampled on the Okanogan. The cause of the high mortality (*Ichthyophthirius multifiliis* and *Flavobacterium columnarae*) was exacerbated by high river temperatures.

^d In 2013, carcass recoveries were combined in reaches O-3 and O-4, and S-1 and S-2. Then re-apportioned based on redd counts within each reach.

^e 2013 data have been updated to reflect age and origin data acquired from scale reading since the publication of the 2013 annual report

Age at Maturity

Table C 3 Salt age of recovered carcasses in the Okanogan and Similkameen Rivers.

Hatchery-Origin Male Salt Age Carcasses Recovered							
Survey Year	0	1	2	3	4	5	Total
1993	0	0	33	0	0	0	33
1994	0	5	23	92	0	0	120
1995	0	2	23	27	17	0	69
1996	0	3	17	24	5	0	49
1997	0	0	1	25	2	0	28
1998	0	9	64	12	9	0	94
1999	2	0	35	74	2	0	113
2000	7	65	6	104	8	0	190
2001	0	47	625	3	11	0	686
2002	0	10	267	419	0	1	697
2003	0	18	30	146	27	0	221
2004	0	2	100	67	18	0	187
2005	0	12	19	104	15	0	150
2006	0	7	15	11	27	0	60
2007	0	122	116	56	5	3	302
2008	0	18	460	137	3	0	618
2009	0	43	33	158	2	0	236
2010	4	20	293	29	7	0	353
2011	0	144	47	118	0	0	309
2012	1	31	168	63	7	0	270
2013	0	7	27	22	2	1	59
2014	0	55	58	39	0	0	152
2015	0	17	234	49	0	0	300
2016	0	6	15	74	4	0	99
<i>Average</i>	<i>1</i>	<i>27</i>	<i>113</i>	<i>77</i>	<i>7</i>	<i>0</i>	<i>225</i>

Hatchery-Origin Female Salt Age Carcasses Recovered							
Survey Year	0	1	2	3	4	5	Total
1993	0	0	10	1	0	0	11
1994	0	0	3	141	1	0	145
1995	0	0	9	44	82	0	135
1996	0	0	21	74	31	1	127
1997	0	0	2	107	16	0	125
1998	0	1	28	30	32	0	91
1999	1	0	31	393	13	2	440
2000	0	1	4	307	49	0	361
2001	0	1	256	19	42	0	318
2002	0	0	54	921	9	0	984
2003	0	1	9	368	54	0	432
2004	0	0	22	103	69	0	194
2005	0	0	11	303	64	2	380
2006	0	0	10	21	48	0	79
2007	0	0	53	178	22	4	257
2008	0	0	197	267	25	1	490
2009	0	0	9	516	22	0	547
2010	0	0	155	120	42	1	318
2011	0	1	22	602	6	0	631
2012	0	1	153	140	25	0	319
2013	1	0	34	188	7	0	230
2014	0	0	23	127	5	0	155
2015	0	1	138	102	5	0	246
2016	0	0	6	283	13	0	302
<i>Average</i>	<i>0</i>	<i>0</i>	<i>53</i>	<i>223</i>	<i>28</i>	<i>0</i>	<i>305</i>

Natural-Origin Male Salt Age Carcasses Recovered							
Survey Year	0	1	2	3	4	5	Total
1993	0	0	8	19	3	0	30
1994	0	3	13	22	10	0	48
1995	0	0	6	11	4	0	21
1996	0	1	7	4	1	0	13
1997	0	3	8	8	1	0	20
1998	0	3	32	27	5	0	67
1999	0	0	22	39	8	1	70
2000	0	6	24	27	12	0	69
2001	0	13	82	168	8	0	271
2002	0	15	85	232	52	1	385
2003	0	12	55	171	34	0	272
2004	0	19	226	166	303	3	717
2005	0	1	129	447	28	4	609
2006	0	1	14	189	116	0	320
2007	0	17	67	53	226	5	368
2008	0	8	258	263	13	2	544
2009	0	10	21	276	31	0	338
2010	0	3	90	123	50	0	266
2011	0	10	46	228	17	0	301
2012	1	14	160	112	58	0	345
2013	0	6	83	140	12	0	241
2014	0	43	135	633	76	0	887
2015	0	8	809	402	113	0	1332
2016	0	1	53	548	109	1	712
Average	0	8	101	180	54	1	344

Natural-Origin Female Salt Age Carcasses Recovered							
Survey Year	0	1	2	3	4	5	Total
1993	0	0	5	25	3	0	33
1994	0	0	2	36	29	0	67
1995	0	0	7	27	11	0	45
1996	0	0	3	18	2	0	23
1997	0	0	12	31	10	0	53
1998	0	0	21	51	12	0	84
1999	0	0	32	132	34	0	198
2000	0	0	9	106	32	0	147
2001	0	0	11	237	12	0	260
2002	0	0	18	199	90	0	307
2003	2	2	29	130	45	0	208
2004	0	0	37	233	539	2	811
2005	0	0	28	566	71	7	672
2006	0	0	2	250	256	2	510
2007	0	0	8	72	601	12	693
2008	0	0	12	269	19	3	303
2009	0	0	3	473	112	0	588
2010	0	0	20	195	226	1	442
2011	0	0	12	416	58	0	486
2012	0	0	15	195	196	0	406
2013	0	0	5	254	27	0	286
2014	0	3	24	809	189	0	1025
2015	0	0	66	342	426	1	835
2016	0	0	4	927	288	4	1223
<i>Average</i>	<i>0</i>	<i>0</i>	<i>16</i>	<i>250</i>	<i>137</i>	<i>1</i>	<i>404</i>

Table C 4 Salt age structure (percent of recovered carcasses) for sex-origin classes.

Hatchery-Origin Male							
Salt Age - Percent of carcasses recovered within origin/sex class							
Survey Year	0	1	2	3	4	5	Total
1993	0%	0%	100%	0%	0%	0%	1
1994	0%	4%	19%	77%	0%	0%	1
1995	0%	3%	33%	39%	25%	0%	1
1996	0%	6%	35%	49%	10%	0%	1
1997	0%	0%	4%	89%	7%	0%	1
1998	0%	10%	68%	13%	10%	0%	1
1999	2%	0%	31%	65%	2%	0%	1
2000	4%	34%	3%	55%	4%	0%	1
2001	0%	7%	91%	0%	2%	0%	1
2002	0%	1%	38%	60%	0%	0%	1
2003	0%	8%	14%	66%	12%	0%	1
2004	0%	1%	53%	36%	10%	0%	1
2005	0%	8%	13%	69%	10%	0%	1
2006	0%	12%	25%	18%	45%	0%	1
2007	0%	40%	38%	19%	2%	1%	1
2008	0%	3%	74%	22%	0%	0%	1
2009	0%	18%	14%	67%	1%	0%	1
2010	1%	6%	83%	8%	2%	0%	1
2011	0%	47%	15%	38%	0%	0%	1
2012	0%	11%	62%	23%	3%	0%	1
2013	0%	12%	46%	37%	3%	2%	1
2014	0%	36%	38%	26%	0%	0%	1
2015	0%	6%	78%	16%	0%	0%	1
2016	0%	6%	15%	75%	4%	0%	1
Average	0%	12%	41%	40%	6%	0%	1

Hatchery-Origin Female							
Salt Age - Percent of carcasses recovered within origin/sex class							
Survey Year	0	1	2	3	4	5	Total
1993	0%	0%	91%	9%	0%	0%	1
1994	0%	0%	2%	97%	1%	0%	1
1995	0%	0%	7%	33%	61%	0%	1
1996	0%	0%	17%	58%	24%	1%	1
1997	0%	0%	2%	86%	13%	0%	1
1998	0%	1%	31%	33%	35%	0%	1
1999	0%	0%	7%	89%	3%	0%	1
2000	0%	0%	1%	85%	14%	0%	1
2001	0%	0%	81%	6%	13%	0%	1
2002	0%	0%	5%	94%	1%	0%	1
2003	0%	0%	2%	85%	13%	0%	1
2004	0%	0%	11%	53%	36%	0%	1
2005	0%	0%	3%	80%	17%	1%	1
2006	0%	0%	13%	27%	61%	0%	1
2007	0%	0%	21%	69%	9%	2%	1
2008	0%	0%	40%	54%	5%	0%	1
2009	0%	0%	2%	94%	4%	0%	1
2010	0%	0%	49%	38%	13%	0%	1
2011	0%	0%	3%	95%	1%	0%	1
2012	0%	0%	48%	44%	8%	0%	1
2013	0%	0%	15%	82%	3%	0%	1
2014	0%	0%	15%	82%	3%	0%	1
2015	0%	0%	56%	41%	2%	0%	1
2016	0%	0%	2%	94%	4%	0%	1
Average	0%	0%	22%	64%	14%	0%	1

Natural-Origin Male							
Salt Age - Percent of carcasses recovered within origin/sex class							
Survey Year	0	1	2	3	4	5	Total
1993	0%	0%	27%	63%	10%	0%	1
1994	0%	6%	27%	46%	21%	0%	1
1995	0%	0%	29%	52%	19%	0%	1
1996	0%	8%	54%	31%	8%	0%	1
1997	0%	15%	40%	40%	5%	0%	1
1998	0%	4%	48%	40%	7%	0%	1
1999	0%	0%	31%	56%	11%	1%	1
2000	0%	9%	35%	39%	17%	0%	1
2001	0%	5%	30%	62%	3%	0%	1
2002	0%	4%	22%	60%	14%	0%	1
2003	0%	4%	20%	63%	13%	0%	1
2004	0%	3%	32%	23%	42%	0%	1
2005	0%	0%	21%	73%	5%	1%	1
2006	0%	0%	4%	59%	36%	0%	1
2007	0%	5%	18%	14%	61%	1%	1
2008	0%	1%	47%	48%	2%	0%	1
2009	0%	3%	6%	82%	9%	0%	1
2010	0%	1%	34%	46%	19%	0%	1
2011	0%	3%	15%	76%	6%	0%	1
2012	0%	4%	46%	32%	17%	0%	1
2013	0%	2%	34%	58%	5%	0%	1
2014	0%	5%	15%	71%	9%	0%	1
2015	0%	1%	61%	30%	8%	0%	1
2016	0%	7%	77%	15%	0%	0%	1
Average	0%	4%	32%	49%	14%	0%	1

Natural-Origin Female							
Salt Age - Percent of carcasses recovered within origin/sex class							
Sample Year	0	1	2	3	4	5	Total
1993	0%	0%	15%	76%	9%	0%	1
1994	0%	0%	3%	54%	43%	0%	1
1995	0%	0%	16%	60%	24%	0%	1
1996	0%	0%	13%	78%	9%	0%	1
1997	0%	0%	23%	58%	19%	0%	1
1998	0%	0%	25%	61%	14%	0%	1
1999	0%	0%	16%	67%	17%	0%	1
2000	0%	0%	6%	72%	22%	0%	1
2001	0%	0%	4%	91%	5%	0%	1
2002	0%	0%	6%	65%	29%	0%	1
2003	1%	1%	14%	63%	22%	0%	1
2004	0%	0%	5%	29%	66%	0%	1
2005	0%	0%	4%	84%	11%	1%	1
2006	0%	0%	0%	49%	50%	0%	1
2007	0%	0%	1%	10%	87%	2%	1
2008	0%	0%	4%	89%	6%	1%	1
2009	0%	0%	1%	80%	19%	0%	1
2010	0%	0%	5%	44%	51%	0%	1
2011	0%	0%	2%	86%	12%	0%	1
2012	0%	0%	4%	48%	48%	0%	1
2013	0%	0%	2%	89%	9%	0%	1
2014	0%	0%	2%	79%	18%	0%	1
2015	0%	0%	8%	41%	51%	0%	1
2016	0%	0%	0%	76%	24%	0%	1
Average	0%	0%	7%	65%	28%	0%	1

Contribution to Fisheries

Table C 5. Estimated number and percent of hatchery-origin Okanogan/Similkameen summer Chinook captured in different fisheries, brood years 1989-2010.

Brood year	Ocean fisheries	Columbia River Fisheries			Total	Percent of brood year escapement harvested ^a
		Tribal	Commercial (Zones 1-5)	Recreational (sport)		
1989	2,360 (80)	553 (19)	0 (0)	53 (2)	2,966	39.8
1990	355 (89)	34 (8)	0 (0)	12 (3)	401	28.2
1991	220 (86)	37 (14)	0 (0)	0 (0)	257	14.0
1992	422 (91)	28 (6)	2 (0)	10 (2)	462	20.0
1993	24 (80)	6 (20)	0 (0)	0 (0)	30	25.6
1994	372 (92)	23 (6)	2 (0)	7 (2)	404	26.1
1995	643 (93)	9 (1)	12 (2)	25 (4)	689	23.8
1996	6 (100)	0 (0)	0 (0)	0 (0)	6	18.2
1997	6,483 (92)	136 (2)	36 (1)	424 (6)	7,079	37.1
1998	4,414 (89)	251 (5)	45 (1)	223 (5)	4,933	62.8
1999	1,359 (68)	224 (11)	31 (2)	384 (19)	1,998	70.0
2000	3,139 (69)	533 (12)	222 (5)	675 (15)	4,559	67.1
2001	184 (58)	81 (25)	31 (10)	23 (7)	319	74.9
2002	706 (56)	200 (16)	90 (7)	258 (21)	1,254	63.2
2003	711 (38)	568 (30)	130 (7)	466 (25)	1,875	53.3
2004	3,153 (39)	2,162 (26)	694 (8)	2,168 (27)	8,177	60.9
2005	470 (46)	306 (30)	79 (8)	167 (16)	1,022	61.1
2006	3,136 (37)	3,352 (40)	469 (6)	1,419 (17)	8,376	61.0
2007	1,549 (44)	992 (28)	67 (2)	905 (26)	3,513	70.8
2008	4,226 (38)	2,576 (23)	218 (2)	3,969 (36)	10,989	73.5
2009	2,005 (36)	2,155 (39)	207 (4)	1,138 (21)	5,505	77.2
2010	3,193 (38)	3,933 (46)	247 (3)	1,110 (13)	8,483	79.0
2011	5,801 (40)	5,812 (40)	456 (3)	2,598 (18)	14,667	78.0
Average	1,953 (51)	1,042 (27)	132 (3)	697 (18)	3,825	51.5
Median	1,359 (68)	251 (19)	45 (2)	258 (13)	1,998	61.0

^a Percent of brood year escapement harvested = Total brood year harvest / (Total brood year harvest + Σ Hatchery collection + Σ escapement) * 100. In other words, this indicates the percentage of all detected CWTs that ended up in harvest.

APPENDIX D

Glossary of Terms, Acronyms, and Abbreviations

The following is a list of key terms and variables used in the Chief Joseph Hatchery Program and in this Annual Report. This is not a complete list, but provides many of the main terms used in this report or that will likely be used in future CJHP Annual Report.

Accord/MOA = A ten-year agreement (2008 – 2018) between BPA and the CCT whereas BPA agreed to fund pre-determined fish and wildlife projects and CCT agreed not to sue the Action Agencies regarding the BiOp for the FCRPS.

CJHP Master Plan = A three-step development and review process required for all new hatcheries funded by BPA in the Columbia Basin.

eDNA = environmental DNA; dissolved or cell-bound DNA that persists in the environment.

Escapement Target = Number of fish of all origins targeted to pass upstream of the Okanogan Adult Fish weir

HOB = the number of hatchery-origin fish used as hatchery broodstock.

HOR = hatchery-origin recruit. The number of HORs equals the sum of HOS + HOB + hatchery-origin fish intercepted in fisheries.

HOR Terminal Run Size = Number of Chief Joseph Hatchery HORs returning to Wells Dam

HOS = the number of hatchery-origin fish spawning naturally.

Juvenile Abundance = annual abundance of out-migrant juveniles estimated by expanding data from juveniles captured at the rotary screw trap.

Met Comp = Methow composite Spring Chinook. These fish are part of the Winthrop NFH program and are intended to be used for the Okanogan reintroduction pending approval under section 10(j) of the ESA.

NOB = the number of natural-origin fish used as hatchery broodstock.

NOR = natural-origin recruit. The number of NOR's equals the sum of NOB, + NOS + natural-origin fish intercepted in fisheries.

NOR Terminal Run Size = Number of Okanogan (and Similkameen, combined) NOR's returning to Wells Dam.

NOS = the number of natural-origin fish spawning naturally.

pHOS = proportion of natural spawners composed of HORs. Equals $HOS / (NOS + HOS)$.

PNI = proportion of natural influence on a composite hatchery-/natural-origin population. Can also be thought of as the percentage of time the genes of a composite population spend in the natural environment. Equals $1 - \text{pNOB} / (\text{pNOB} + \text{pHOS})$.

pNOB = proportion of hatchery broodstock composed of NORs. Equals $\text{NOB} / (\text{HOB} + \text{NOB})$.

SAR = smolt to adult return.

Recovery Plans = Federally-required plans under the Endangered Species Act that describe species status, recovery criteria and expected restoration actions.

Relative Reproductive Success = The probability that an HOR produce adult offspring and summer/fall expressed as a fraction of the same probability for a NOR

Spatial Distribution = Geographic spawning distribution of adult salmon.

Spawner Abundance = Total number of adult spawners each year.

Subbasin Plans = Plans developed in the early 2000s for the NPCC project funding process describing “limiting factors” used for development of regional recovery and protection strategies.

Total NOR Recruitment = Annual number of adult recruits (catch plus escapement)

AHA = All H Analyzer

APPT = Annual Program Planning Tool

APR = Annual Program Review

BiOp = Biological Opinion

BKD = Bacterial Kidney Disease

BPA = Bonneville Power Administration

CA = Coordinated Assessments

CBFWA = Columbia Basin Fish and Wildlife Authority

CCT = Confederated Tribes of the Colville Indian Reservation

cfs = Cubic feet per second

CJH = Chief Joseph Hatchery

CJHP = Chief Joseph Hatchery Program

Colville Tribes = Confederated Tribes of the Colville Reservation

CTFWP = Colville Tribes Fish & Wildlife Program

CRITFC = Columbia River Inter-Tribal Fish Commission

CWT = Coded Wire Tag

DI = Density Index

DPS = Distinct Population Segment
EDT = Ecosystem Diagnostic & Treatment
ELISA = Enzyme-Linked Immunosorbent Assay
ESA = Endangered Species Act
ESU = Evolutionarily Significant Unit
FCRPS = Federal Columbia River Power System
FI = Flow Index
FPP = Fish per pound
FWS = U.S. Fish and Wildlife Service
GIS = Geographic Information System
gpm = gallons per minute
GPS = Global Positioning System
HCP = Habitat Conservation Plan(s)
HGMP = Hatchery Genetic Management Plan(s)
HSRG = Hatchery Science Review Group
ISIT = In-season Implementation Tool
ISRP = Independent Scientific Review Panel
KMQ = Key Management Questions
LNFH = Leavenworth National Fish Hatchery
NEPA = National Environmental Policy Act
NMFS = National Marine Fisheries Service
NOAA = National Oceanic and Atmospheric Administration
NPCC = Northwest Power and Conservation Council
OBMEP = Okanogan Basin Monitoring and Evaluation Program
ODFW = Oregon Department of Fish and Wildlife
ONA = Okanogan Nation Alliance
PBT = Parental Based Tagging
PIT = Passive Integrated Transponder
PNAMP = Pacific Northwest Aquatic Monitoring Partnership
PSMFC = Pacific States Marine Fisheries Commission
PTAGIS = PIT Tag Information System
PUD = Public Utility District

RKM= River Kilometer

RM = River Mile

RMIS = Regional Mark Information System

RM&E = Research, Monitoring, and Evaluation

RST = Rotary Screw Trap

SNP = Single Nucleotide Polymorphism

TAC = Technical Advisory Committee

TRMP = Tribal Resources Management Plan

TU = Temperature Unit

UCSRB = Upper Columbia Salmon Recovery Board

USGS = U.S. Geological Survey

WDFW = Washington Department of Fish and Wildlife

WNFH = Winthrop National Fish Hatchery