THE CHIEF JOSEPH HATCHERY PROGRAM 2015 ANNUAL REPORT

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This report includes both hatchery production/operations and the corresponding monitoring activities completed through April of 2016. 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: www.colvilletribes/cjhp.

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The list of people responsible for planning, designing, building, funding and implementing the brand-new Chief Joseph Hatchery (CJH) is too long to mention here. None of the authors of this report were involved in the initial efforts to convince the Federal government to fund this endeavor, but we are grateful for the efforts. As are the Colville Tribal fishermen and other fishermen from Alaska, British Columbia, the Washington Coast, and all through the Columbia River who will benefit from the fish production for many generations to come. We wish to acknowledge Randall Friedlander, CCT Fish & Wildlife Program Director, Kirk Truscott, CCT Anadromous Division Manager, the Colville Business Council and the Natural Resource Committee for their policy direction and program guidance. This hatchery program would not exist today if not for the vision and dedicated efforts of a variety of current and former employees of CCT and BPA, particularly the former CCT Fish and Wildlife Program Manager, Joe Peone and the former CCT Anadromous Division Manager, Jerry Marco. Additionally, expert contributions, counsel, and examples came from a variety of staff from management agencies (WDFW, USFWS), groups (Mid-C HCP hatchery committees), and contractors to the Colville Tribes. Some of the tables, formatting, and table header text were copied from the CPUD/GPUD 2013 annual report to provide continuity with reporting for other populations in the Upper Columbia River and past reporting in the Okanogan River.

We want to thank our skilled and dedicated CJHP staff who cared for the fish, collected the data, maintained the equipment and generally did whatever was necessary for the project to be successful. We appreciate their willingness to work long hours under adverse conditions to get the job done.

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Table of Contents

Figures

Tables

EXECUTIVE SUMMARY

The 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 2015 during the third year of operation for the Spring and Summer/Fall Chinook programs. Leavenworth National Fish Hatchery (LNFH) provided 648 Spring Chinook broodstock in May 2015. The Leavenworth Spring Chinook program broodstock survival was 96.8% for females, 99.4% for males with a combined survival of 98.1%. The total green egg take for the Leavenworth Spring Chinook program was 1,159,000 (100% of full program). Green egg to eyed egg survival was 91.4%. This survival was slightly higher than the standard (90%). With lower than expected pre-spawn mortality, a low culling rate, and a less than 10% pick off, our final inventory was higher than needed to make program. After ensuring there was no need for eyed eggs within the region, a decision was made to cull an additional 88,000 eyed eggs, to meet our target. Survival from incubation to ponding for the Leavenworth groups was 98.5% which exceeded the standard (95%). With the higher than anticipated hatchery survival of eggs and juveniles the segregated spring Chinook program was 98% of full program. The 10(j) spring Chinook reintroduction program received its full component of 209,956 eyed eggs from the Winthrop NFH in October.

In July and August the CCT used a purse seine vessel to collect 1,122 summer/fall Chinook for broodstock for both the integrated and segregated programs (including Similkameen). Additionally, 19 summer/fall Chinook were collected at the Okanogan adult weir in September. The summer/fall and spring Chinook programs collected enough brood to meet full production levels. The cumulative pre spawn holding survival, for all Summer/Fall brood collected, was 65.9% for hatchery-origin broodstock (HOB) and 45.8% for natural-origin broodstock (NOB). Neither brood met the survival standard (90%) except Jacks, which are not included in the stated cumulative survival. Broodstock mortality increased in October when Columnaris was present in the holding ponds, despite the use of 100% well water. Total green egg take for the season was 1,845,000 (91% of full program). Egg survival from green egg to eyed egg averaged 75.1% for NOB and 77.5% for

HOB, both under the survival standard (90%) for this life stage. Ponding survival for the integrated program ranged from 88% to 92% and averaged 90% across all subyearlings and yearlings groups. Ponding survival for the segregated program ranged from 89% to 97% and averaged 92% across all subyearling and yearling groups. The cumulative survival for the integrated and segregated programs was 89% for the subyearlings, which was under the survival standard (95%) and 97% for the yearlings, which met the survival standard. After in-hatchery mortalities from pre-spawn holding through ponding there were 603,421 fish on hand at the end of April for the yearling releases in 2017 and 386,917 fish on hand for the sub-yearling releases in 2016 (50% of full program).

2015 was the second year for Summer/Fall Chinook sub-yearling hatchery releases from the CJH programs and the first year for yearlings released from Similkameen and Omak acclimation ponds that had been reared at the CJH central facility. In April, 290,665 integrated yearling summer/fall Chinook were released from the Omak acclimation pond and 205,892 were released by WDFW from the Similkameen Pond. Subsequently, sub-yearlings from BY2014 were transferred to Omak Pond for short term acclimation and 300,546 were released in May (100% of full program). Additionally, 930,885 yearling and 375,315 sub-yearling segregated Chinook were released directly from Chief Joseph Hatchery (100% of full program). For Spring Chinook, 197,917 smolts (100% of full production) were released in the spring of 2015 and mark the beginning of implementation of the non-essential experimental population under section 10(j) of the Endangered Species Act.

2015 was the first year of PIT tagged releases from the CJH and was the first time the program could evaluate post release survival of hatchery smolts. Yearling hatchery Chinook survival was 71-79% to Rocky Reach Juvenile bypass and 43-68% to McNary Dam and was similar to other nearby programs in the Methow. Summer Chinook sub-yearling survival was 28-37% to Rocky Reach Dam and 20-23% to McNary Dam. The vast majority (>95%) of PIT tagged hatchery smolts released from Omak Pond (sub-yearling Summer Chinook) and Riverside Pond (Spring Chinook yearlings) migrated to the lower Okanogan River within one week of release. There were zero detections of juvenile hatchery fish at the lower Okanogan River PIT tag array (OKL) after June 12th. This assessment suggests that the program was successful at releasing actively migrating smolts.

The CJH monitoring project collected field data to determine Chinook population status, trend, and hatchery effectiveness centered on five 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).

Rotary screw trap operations began on March 25 and continued through July 2, capturing 37,444 natural-origin Chinook and 13,894 hatchery-origin Chinook. After conducting 9 mark-recapture events, the efficiency of the trapping configuration was calculated to be approximately 0.78%. This translated to an overall juvenile natural-origin Chinook outmigration estimate of 4,675,213 with 95% confidence intervals of 3,195,439 to 6,154,988. 2,904 steelhead (*O. mykiss*) were also captured in the rotary screw trap including 485 natural-origin (adipose fin present and no CWT) and 2,419 hatchery-origin (adipose fin clipped and/or CWT present). Other species commonly caught in the rotary screw traps included sockeye (*O. nerka*) (6,992), and mountain whitefish (*Prosopium williamsoni*)(307).

7,648 juvenile Chinook salmonids were collected with the beach seine, and 5,823 (76%) were PIT tagged and released. Pre- and post-tag mortality was 9% and 6% respectively. In 2015, wild summer Chinook tagged at the mouth of the Okanogan had a minimum apparent survival to RRJ of 0.26. Unfortunately, an estimate of survival to MCN could not be generated due to insufficient recaptures below MCN.

The Okanogan Adult Fish Weir was deployed on July 15th when discharge was 1,250 cfs. The thermal barrier was present in the lower Okanogan after installation until July 25th when the Okanogan River temperature began dropping below 22.5 °C. The temperature generally varied between 20.5 °C and 24.7 °C until August 20th. On August 21 the thermal barrier began to break down, allowing Chinook to migrate up the Okanogan. At that time, trapping operations were suspended for one week due to the hazardous working conditions created by the Okanogan Complex wildfires. 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 the mode of fish passage occurred during this trapping suspension, within a week after the mean daily temperature dropped below 22.0 °C. After trapping resumed, the majority of Chinook (94%) were trapped between August 28 and September 14. Fifty four adult Chinook were trapped in 2015. Nineteen natural-origin Chinook were transported to the hatchery and held as broodstock for the integrated program. 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 0.4% 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. There was also not an increase in the number of Chinook mortalities after trapping operations began. 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 24.

Spawning ground surveys estimated 4,276 Summer/Fall Chinook redds and 3,293 carcasses were recovered (2,555 natural-origin and 738 hatchery-origin). Adult summer/fall Chinook spawning escapement in 2015 was estimated to be 13,769, with 10,350 natural-origin spawners, which exceeded the recent five-year and long-term averages. The values for pHOS (0.21) and proportion of natural influence (PNI) (0.82) in 2015 exceeded the program objectives (<0.30 and >0.67). The five-year average for pHOS fell just short of the long-term goal (0.30), but the five-year average for PNI (0.77) exceeded the long-term goal (0.67). Selective harvest activities by CCT and WDFW contributed to the reduced pHOS and increased PNI in 2015, along with removals of more than 8,000 surplus hatchery fish at the CJH ladder and trap.

Monitoring of spring Chinook spatial distribution was conducted in the Okanogan basin from 2012 to 2014 to assess the status and progress of the reintroduction which began in 2015. Results revealed that the basin likely does have a limited distribution of spring Chinook. Several tributaries have produced consistent annual detections of Chinook eDNA, including Shingle Creek, Vaseux Creek, Salmon Creek and Omak Creek. No sampling was conducted in 2015.

An Annual Program Review (APR) was held in March 2016 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 73,000 Upper Columbia summer/fall Chinook, the plan for 2016 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 principles[1]:

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

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
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 Okanagan 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.

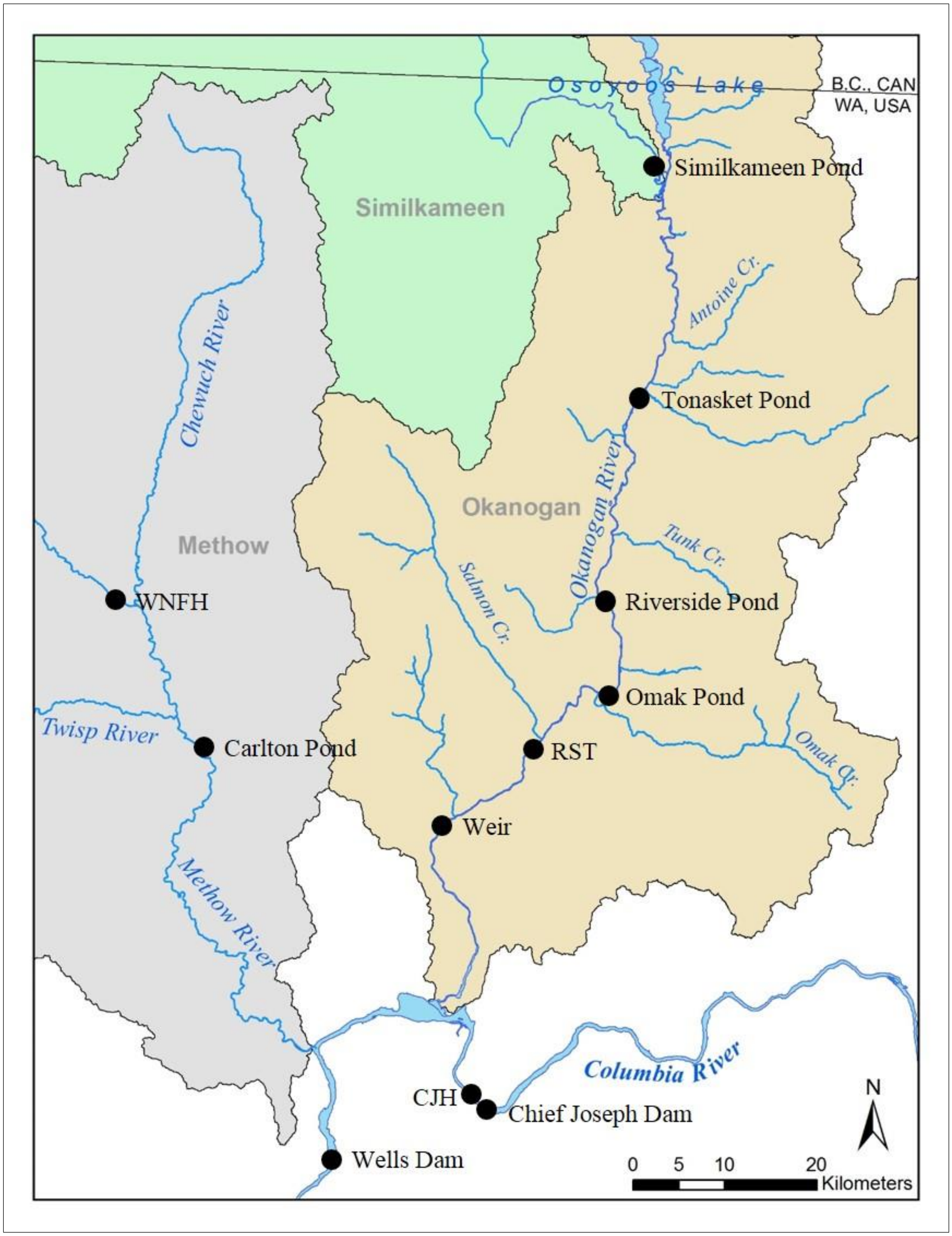


Figure 1. Map of the U.S. portion of the Okanogan River Basin, the Chief Joseph Hatchery (CJH), Winthrop National Fish Hatchery (WNFH), Okanogan adult weir (Weir), Rotary screw trap (RST), and Chinook Salmon acclimation sites. Horizontal coordinate information is referenced to the North American Datum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

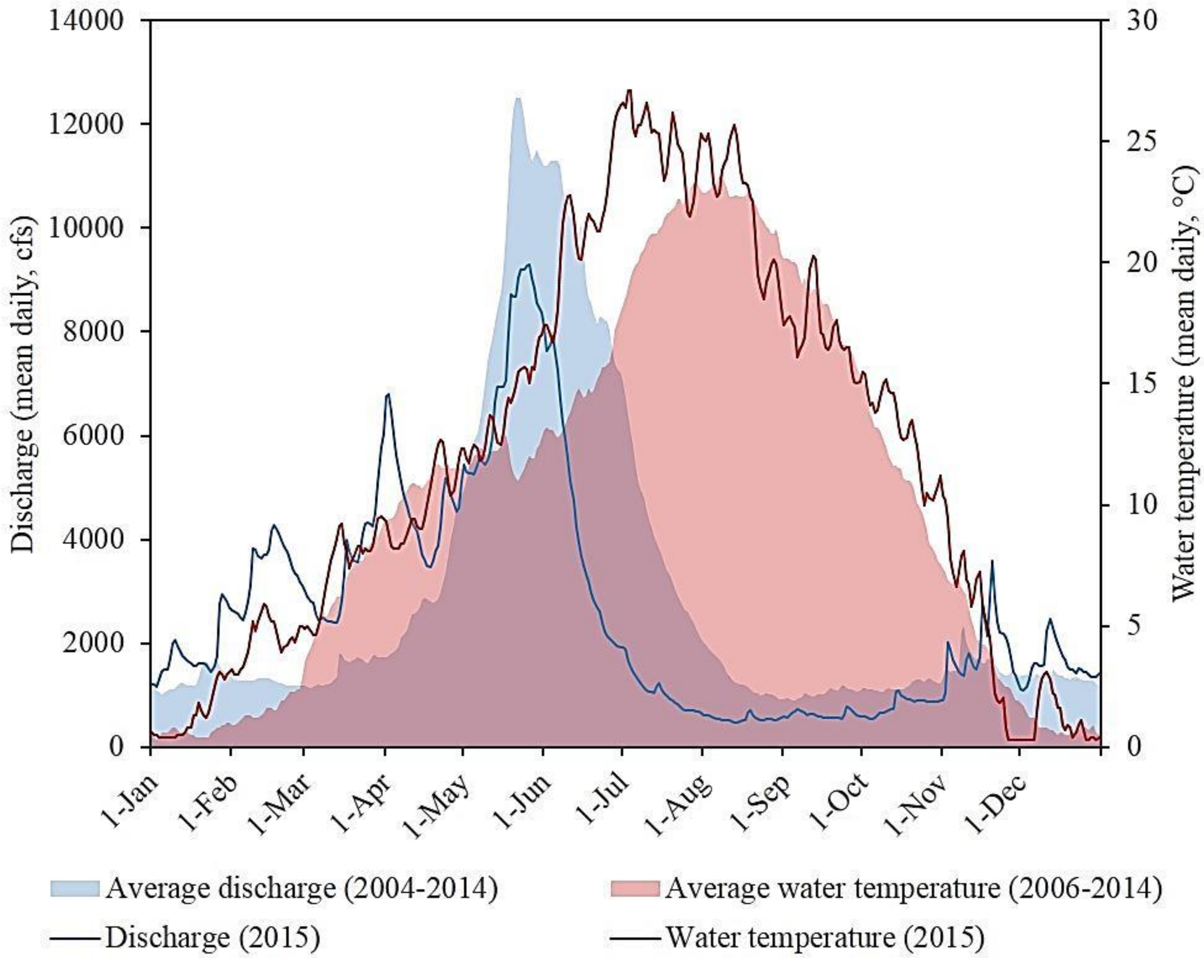


Figure 2. Okanogan River mean daily discharge (blue lines) and water temperature (red lines) at Malott, WA (USGS Stream Gage 12447200).

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	250,000	Yearling	100%	100%	
Riverside Pond	275,000	Yearling	100%	100%	
Omak Pond	275,000	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

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%	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 2015. 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 (200 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 March 25 to July 2, 2015. Trapping typically occurred continuously from Monday through Friday, and for 12 hours, from 2000-0800 Saturday and Sunday. Trapping operations were suspended on April 24, May 24, and May 28 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, $\sum Rti$ 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 May 19, and so catch for that day was estimated to be the average of total catch on May 18 and May 20.

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 (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 June 15 to July 6 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 2015, 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.

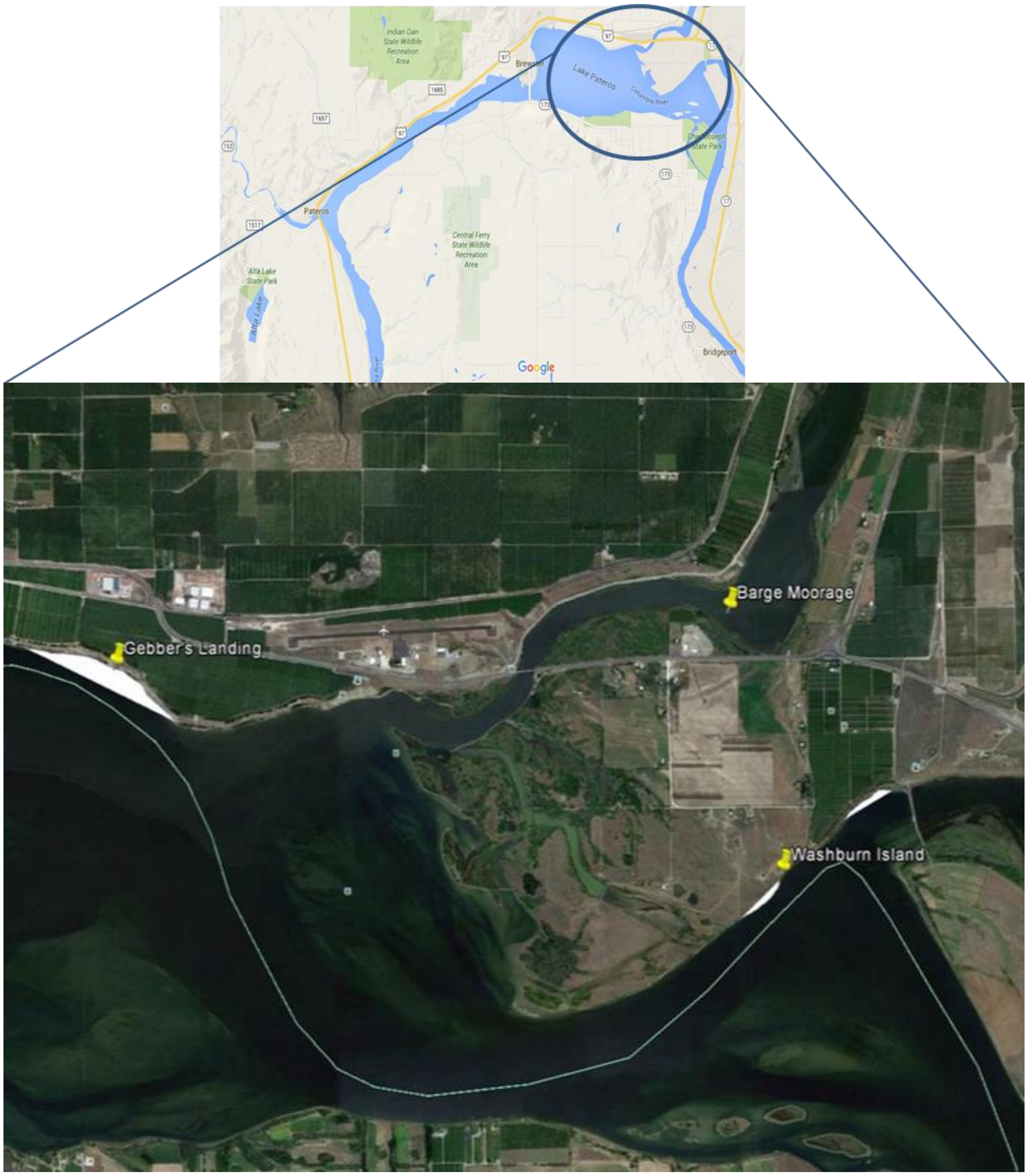


Figure 4. Seining locations downstream (Gebbers Landing) and upstream (Washburn Island) of the confluence.

A single beach seine (30.49 m × 3.05 m with a 28.32 m^3 '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 m^3 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).

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 ≥ 65mm were tagged with a full duplex 12 mm PIT tag and 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 m^2 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 >19 °C, ice was added to the anesthetic solution to decrease the temperature. A solution of 40 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.pitagis.org), and submitted to 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 volitionally 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 fourth year of design modifications and testing in 2015. 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 2015 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 July 15th at a river flow of 1,250 cfs and was complete with the underwater video system on July 23rd. An aluminum trap was installed near the center of the channel at the upstream end of the deep pool in the thalweg of the channel. The trap was 3 m wide, 6 m long and 3 m high (Figure 1). The wings of the weir stretched out from either side of the trap towards the river banks, 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 7.6 cm (1 to 3 inch) in 1.2 cm (half-inch) increments (Figure 2). Pickets were manually forced into the river substrate upon deployment and then as needed to prevent fish passage under the weir.

Figure 6. Lower Okanogan adult fish pilot weir, 2015. Photo taken in late August, one week after start of the Okanogan Complex wildfire.

The river-right wing consisted entirely of 2.5 cm picket spacing. A 3 m gap between the last panel and the right shoreline remained to allow for portage of small vessels around the weir. This was a very shallow gravelly area and under most flow conditions it did not appear to be a viable path for adult salmon passage. However, a block net was set up from the last panel to the river-right shore to limit escapement via this route. The river left wing had variable picket spacing to accommodate non-Chinook fish passage through the pickets. The primary objective of the wider picket spacing was to allow Sockeye (*O. nerka*) to pass through the weir and reduce the number of Sockeye that would enter the trap. River left was selected for this spacing to better accommodate observation/data collection regarding successful passage of smaller fish through the panels. In past years CCT has observed jack and even adult Chinook passing through the 7.6 cm picket spacing panels. To reduce the escapement of smaller hatchery Chinook, CCT wanted to partially block the 7.6 cm panels once the majority of sockeye had passed the weir. After consultation with the Technical Oversight Group (TOG), aluminum grating was placed on the 7.6 cm picket spacings on August 28th.

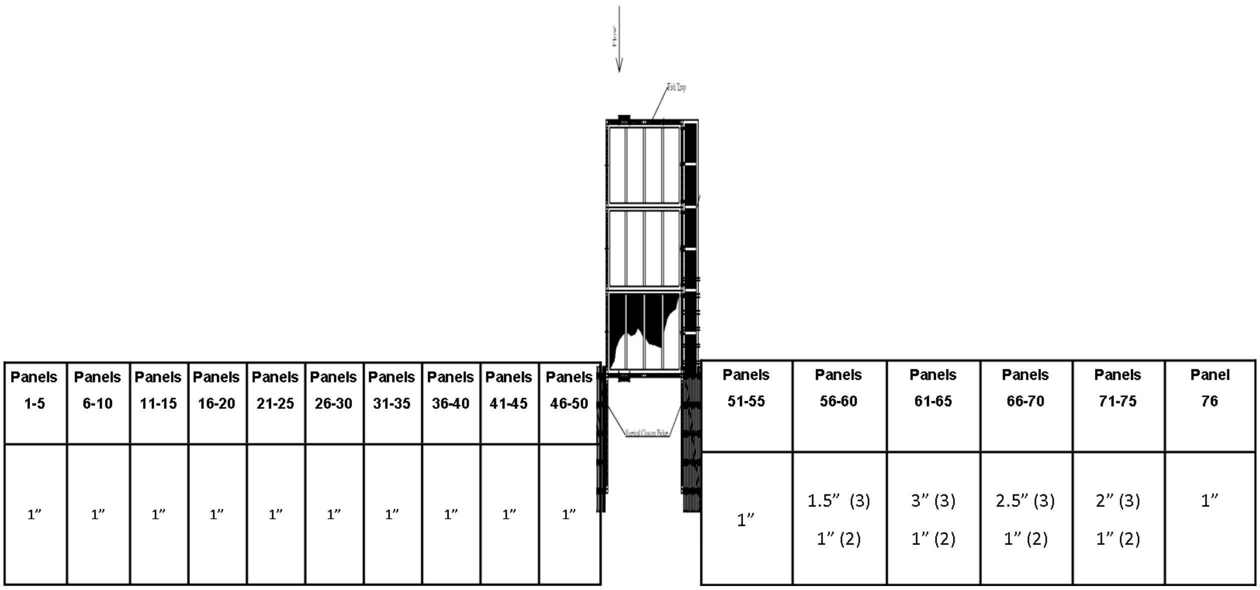


Figure 7. Conceptual diagram of picket (ABS pipe) spacing within each panel (or set of 5 panels) at the Lower Okanogan adult fish pilot weir in 2015.

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 (July 27-August 26) 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 (July 22-August 20, August 25-September 24), 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 boat 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 0600-2000, under allowable temperature conditions (≤22.5° C) from July 27 to September 24. Trapping operations were ceased from August 20 to 26 due to a ban on fieldwork and safety concerns related to the forest fires. 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. Nineteen natural origin Chinook were collected from the weir trap from September 11 to September 20, transported to shore via a fish boot (rubber tire inner tube) and immediately taken to a 2,500 gallon hatchery truck. The fish were then transported approximately 32 km to Chief Joseph Hatchery where they were held in the broodstock raceways until spawning in mid-October.

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	C*x*	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 (3.22 for 2015). The expansion factor = 1 + the number of males per female as randomly collected for broodstock at Wells Dam (2.22:1.00 in 2015). 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 Okanagan 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. In 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. A fallback/reascension rate was applied to the total Zosel estimate for the season. A fallback adjustment (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 ascents:

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

where,

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

a_i = number of ascents made by the ith PIT-tagged fish (i= 1, …, = 1, …, N_{PIT}).

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

$$N = C \cdot AFA$$

Fallback/reascension is likely an underestimate of actual fallback since not all fallback re-ascend. Actual fallback is unknown.

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.

Escapement into Canada was reported as part of the Similkameen Pond Hatchery monitoring program. 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. distribution of CJ hatchery fish among spawning reaches
2) Length
3) Sex
4) Age
5) Egg retention

The target annual carcass recovery sample size was 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 beach site was reached 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-origin[3]. Biological data collected from carcasses included sex, fork length (FL) and post-orbital hypural length (POH) to the nearest cm, and estimated egg retention for all females (0 to 5,000 max; visually estimated). All eggs that were not detected 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

[3]There 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.

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 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 generation[4] 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:

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

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

[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.

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 populations[5]. We made a correction for non-Okanogan NOB for all years when Wells Dam was used for brood collection using the formula:

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

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 Regional Mark Information System (RMIS; http://www.rmis.org/rmis) was queried in

[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).

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 were not adjusted for residuals, tag failure, tag loss (shedding), or other factors which could result in fish not surviving but not being detected at a downstream location. Due to these factors, actual survival would be higher than the apparent 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 sub-yearlings at Omak Pond and Spring Chinook yearlings at Riverside Pond. No PIT tags were released from Similkameen Pond and not enough yearlings were released with a PIT tag to evaluate those release groups. 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:

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

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 spring Chinook did not occur in the Okanogan until April 2015. Therefore, pre-reintroduction monitoring for spring Chinook currently consists only of eDNA sampling and analysis at tributary and mainstem Okanogan sites to determine the baseline distribution, prior to the reintroduction. 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 WDFW monitoring program at Wells Dam tags returning adult spring Chinook, which greatly increases the probability of encountering a spring Chinook with a PIT tag in the Okanogan. For 2015, the presence and distribution of spring Chinook were evaluated by querying 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. The Lower Okanogan River array (OKL) was installed in the fall of 2013, therefore 2014 was the first year when this site was available throughout the calendar year.

RESULTS

Rotary Screw Traps

The rotary screw traps captured 51,338 Chinook juvenile out migrants, including 13,894 hatchery- and 37,444 natural-origin. Pulses of high catch rates coincided with periods of increased streamflow in mid-May and June (Figure 8). 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=561) (Figure 10). Four fish recovered on or before 15 April 2015 were greater than 100 mm and 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 were Sockeye and steelhead (Table 4). 485 adipose fin present[6] steelhead and 2,419 adipose fin absent (hatchery-origin) steelhead were removed from the trap and released immediately into the river. There were five juvenile steelhead mortalities (3 adipose fin present and 2 adipose clipped) at the trap resulting in a 0.17% handling mortality rate. The encounter of 2,419 adipose clipped and 485 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).

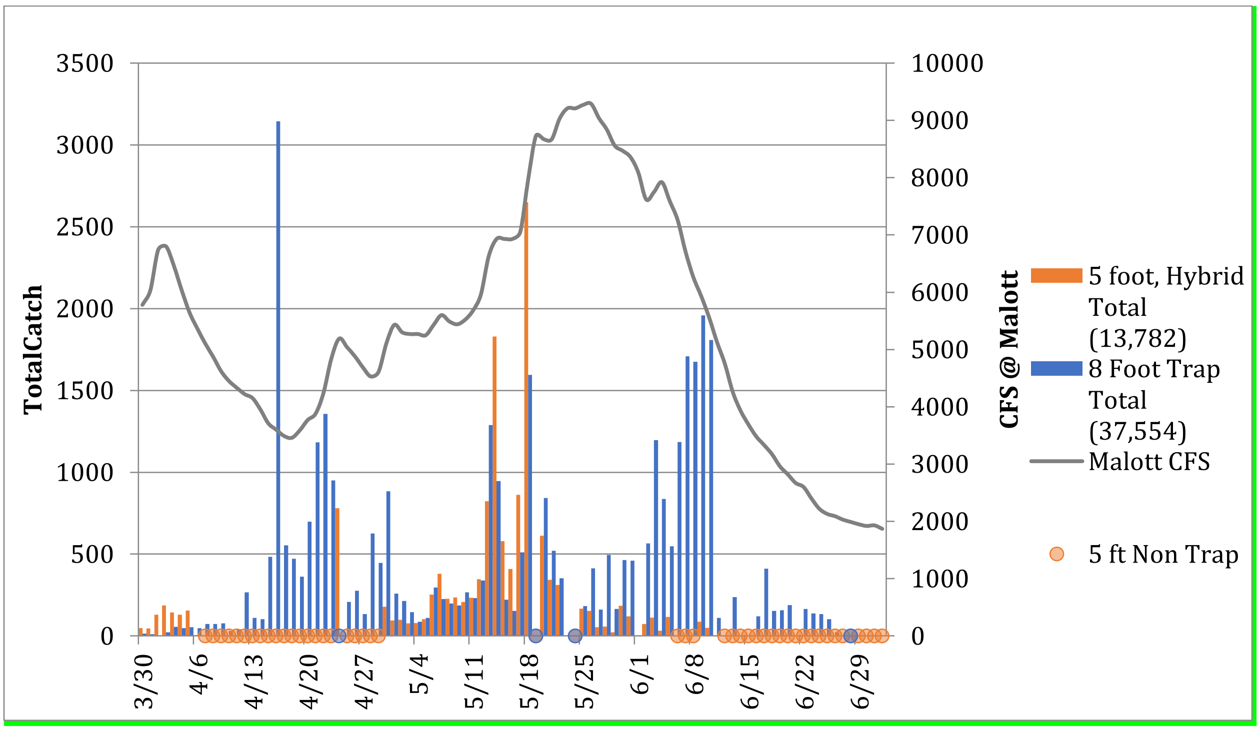


Figure 8. Daily natural-origin sub-yearling Chinook catch in the Okanogan River in 2015.

[6] Not all hatchery steelhead released in the Okanogan receive an adipose fin clip. In 2015, 51% of hatchery steelhead released into Omak Creek were adipose-present.

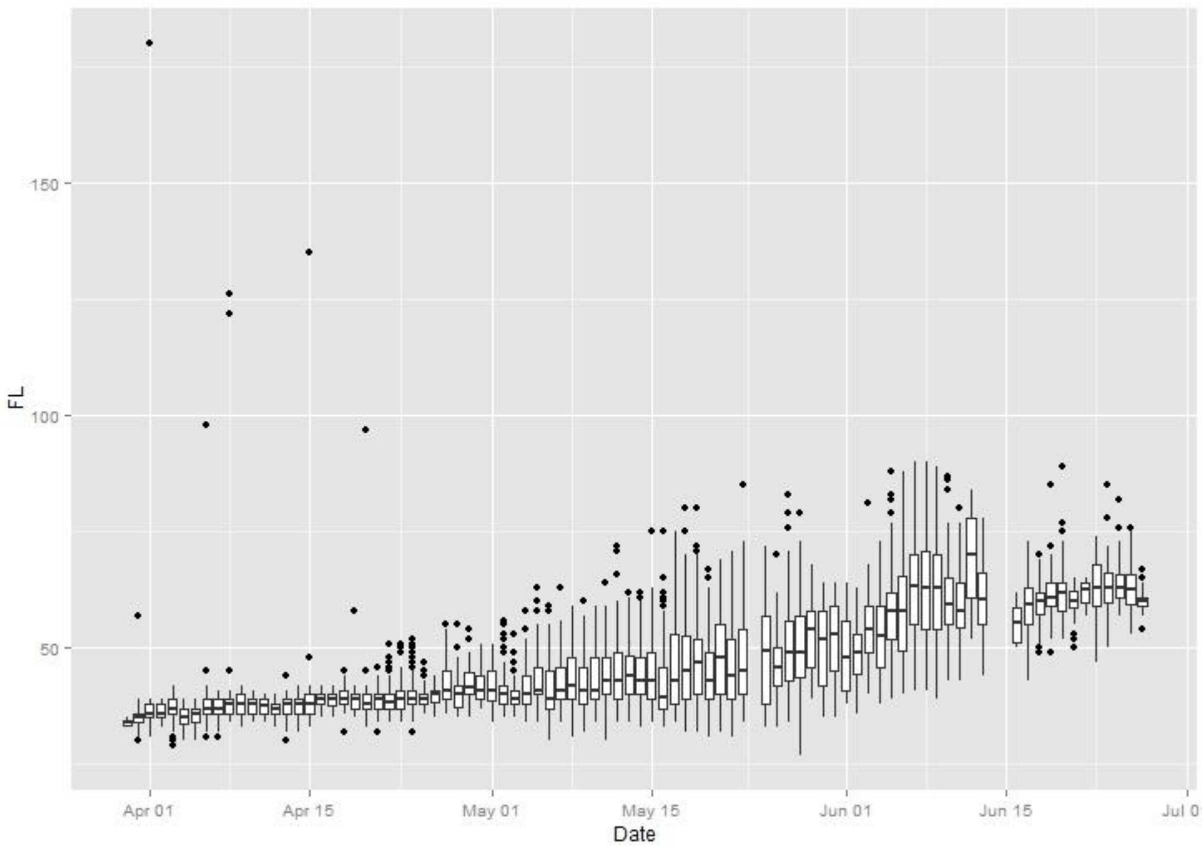


Figure 9. Natural-origin sub-yearling Chinook size distribution (n= 9,337) from the rotary screw traps on the Okanogan River in 2015.

Table 4. Number of juvenile fish trapped at the Okanogan River rotary screw traps in 2014.

Species	Total Trapped
Crappie (*Pomoxis* spp.)	1
Bluegill	30
Bridgelip Sucker	4
Common Carp	23
Longnose Dace	23
Mountain Whitefish	307
Northern Pikeminnow	37
Largemouth Bass	121
Sculpin (*Cottus* spp.)	5
Smallmouth Bass	96
Three Spine Stickleback	7
Chiselmouth	1
Unknown Sucker (*Catostomous* spp.)	1
White Crappie	1
Bullhead (*Ameiurus* spp.)	11
Yellow Perch	38
Non-salmonid	4,510
Adipose Clipped Steelhead	2419
Adipose Present Steelhead	485
Hatchery Chinook	13,894
Sockeye	6,992
Wild Chinook Subs	37,440
Wild Chinook Yearling	4
Salmonid	33,416

Seven efficiency trials were conducted with natural-origin sub-yearling Chinook between 3,530-8,620 cfs (Table 5.). The trial conducted on 18 May was, however, excluded from analysis because shortly after release, the RSTs ceased to operate because of high debris load. Because streamflow was not a significant variable in explaining variation of efficiency between trials, 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, 2015.

Trap Date	River Flow @ USGS Malott	Total Chinook Marked	Total Chinook Released	Total Chinook Recaptured	Trap Efficiency
4/16	3,530	169	169	0	0.00
4/22	4,460	256	256	0	0.00
4/29	4,800	94	94	0	0.00
5/4	5,240	256	256	1	0.004
5/7	5,560	573	573	5	0.009
5/11	4,460	904	904	4	0.004
5/18	8,620	1078	1078	0	0.00
Total		**1,733**	**1,733**	**10**	**0.01**

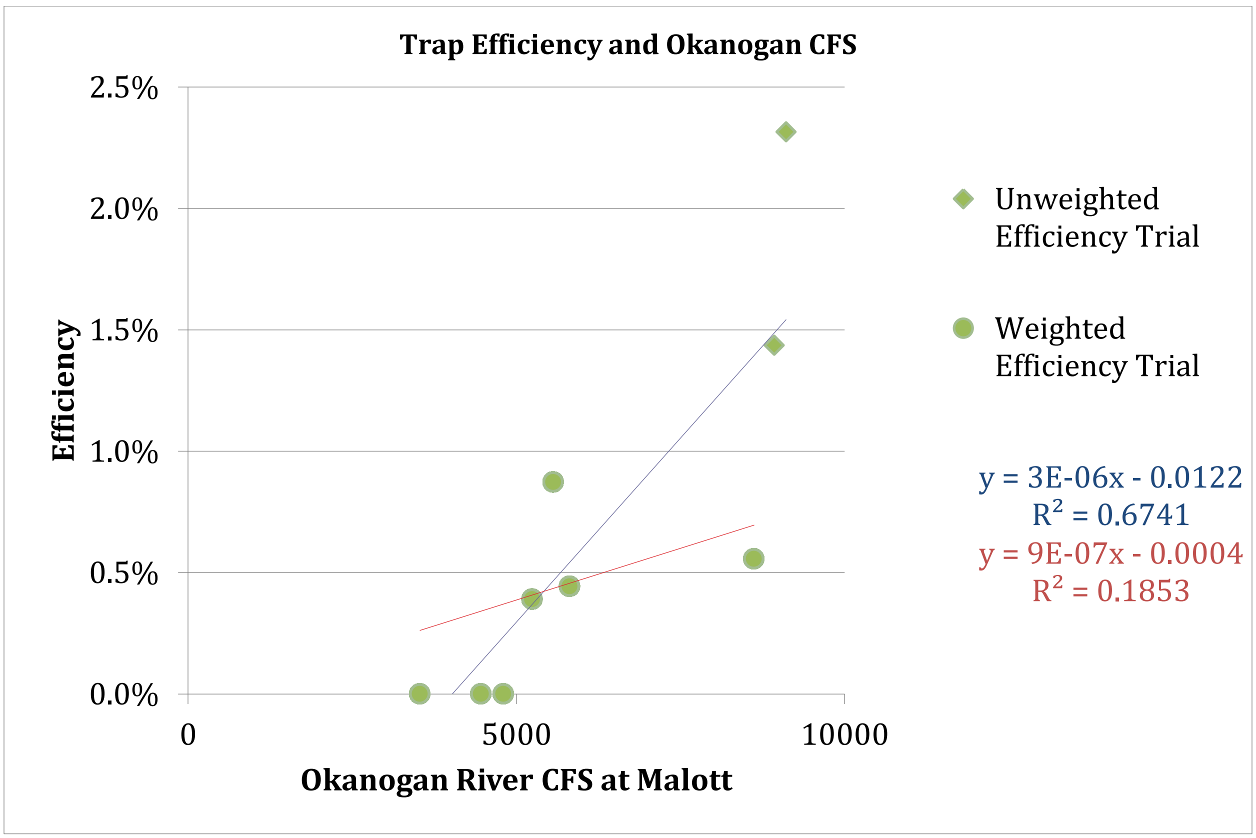


Figure 10. Okanogan River CFS was not predictive of RST efficiency, and so was excluded as a variable from juvenile production estimates.

To explore the possibility of using hatchery-released fish as a surrogate for wild fish, efficiency trials were conducted on April 8-and April 13 using hatchery yearlings and on May 27 using hatchery sub-yearlings from the Omak Pond (Table 6.). Twenty-five hatchery yearlings (out of 1,067 released in two trials) and 15 hatchery sub-yearlings (out of 1,045 released in one trial) were recaptured. Because of significant differences between the recapture rates for hatchery-origin and natural-origin fish within the 2.4m and 1.5m traps ($p<.001$), hatchery-origin fish were not used as a surrogate (Table 7).

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.). Hatchery-origin Chinook were more likely to be recaptured, especially in the 2.4m trap. Overall efficiency estimates for natural- and hatchery-origin fish were low, leading to a relatively imprecise estimate of total emigration (Table 8).

Table 6. Efficiency trials conducted on hatchery-origin Chinook smolts at the Okanogan rotary screw traps in April and May, 2015

Trap Date	River Flow @ USGS Malott	Total Chinook Marked	Total Chinook Released	Total Chinook Recaptured	Trap Efficiency
4/8	2,200	550	550	11	0.02
4/13	2,330	517	517	14	0.03
5/27	8,930	1,045	1,045	15	0.01
Total		**2,112**	**2,112**	**40**	**0.02**

Table 7. Pooled efficiency trail results for all trap configurations.

		Mark-Released	Recaptured	Efficiency
2.4 m Trap	Hatchery Chinook	5,658	46	0.81%
	Wild Chinook	3,546	5	0.14%
1.5 m Trap	Hatchery Chinook	5,658	7	0.12%
	Wild Chinook	3,027	17	0.56%
Combined Traps	Hatchery Chinook	5,658	53	0.94%
	Wild Chinook	3,027	22	0.73%

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*	1,456,144	1,073,890	1,838,397
Natural-origin Chinook	4,675,213	3,195,439	6,154,988

* A total of 985,813 hatchery-origin Chinook were released into the Okanogan River system upriver from the screw trap site in 2015. 195,145 were released from the Riverside acclimation pond from April 15-21; 202,907 were released from the Similkameen hatchery from April 15 – April 30; 285,838 were released from the Omak acclimation pond on April 15-May 5; and 301,923 were released from Omak Pond on May 28.

Juvenile Beach Seine and Pit Tagging

In 2014, 7,648 juvenile salmonids were collected in 199 sets for a total catch per unit effort of 44 salmonids per seine haul (Table 9.). Thousands of three-spined stickleback (*Gasterosteus aculeatus*) were also collected but not enumerated. Out of the 7,648 juvenile salmonids collected, 5,823 (76%) sub-yearling Chinook were PIT tagged and released (Figure 11). Pre- and post-tag mortality was 8.8% and 4.6% respectively. Ten shed tags were recovered from the net pens prior to release. All of the sheds were from post-tag mortalities. In addition to stickleback, bycatch consisted of three adult hatchery-origin Chinook. Fish size increased through the second and fourth week of tagging but the number of available fish to tag decreased (Figure 12). At that time temperatures in the Columbia River at Gebber's Landing were approximately 16.5°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. Overall size distribution for tagged fish was skewed towards smaller size ranging from 55-120 mm in length (Figure 13).

Table 9. Summary of juvenile Chinook beach seining effort at Gebber's Landing (Geb.) and Washburn Island (W.I.) in 2015. CPUE represents (target species and bycatch) per set.

Week start	Geb. sets	Geb. collected	Geb. CPUE (total/set)	W.I. sets	W.I. collected	W.I. CPUE (total/sets)
6/15/2015	29	2,052	71	3	1500	500
6/22/2015	39	1,208	31	27	2584	96
6/29/2015	0	0	-	54	1149	21
7/6/2015	40	218	5	7	55	8
Total	**108**	**3,478**	**107**	**91**	**5,288**	**58**
Mean	**36**	**1,159**	**36**	**23**	**1,322**	**156**

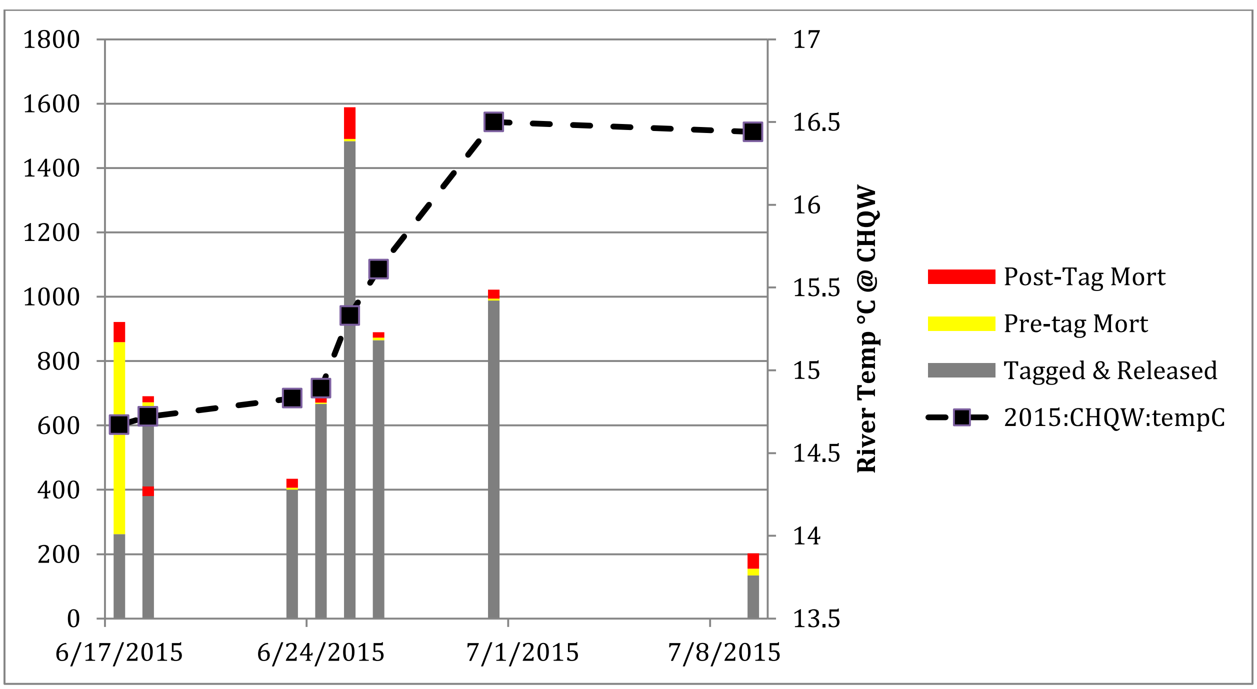


Figure 11. Total mortality and number of released natural-origin sub-yearling Chinook in 2015.

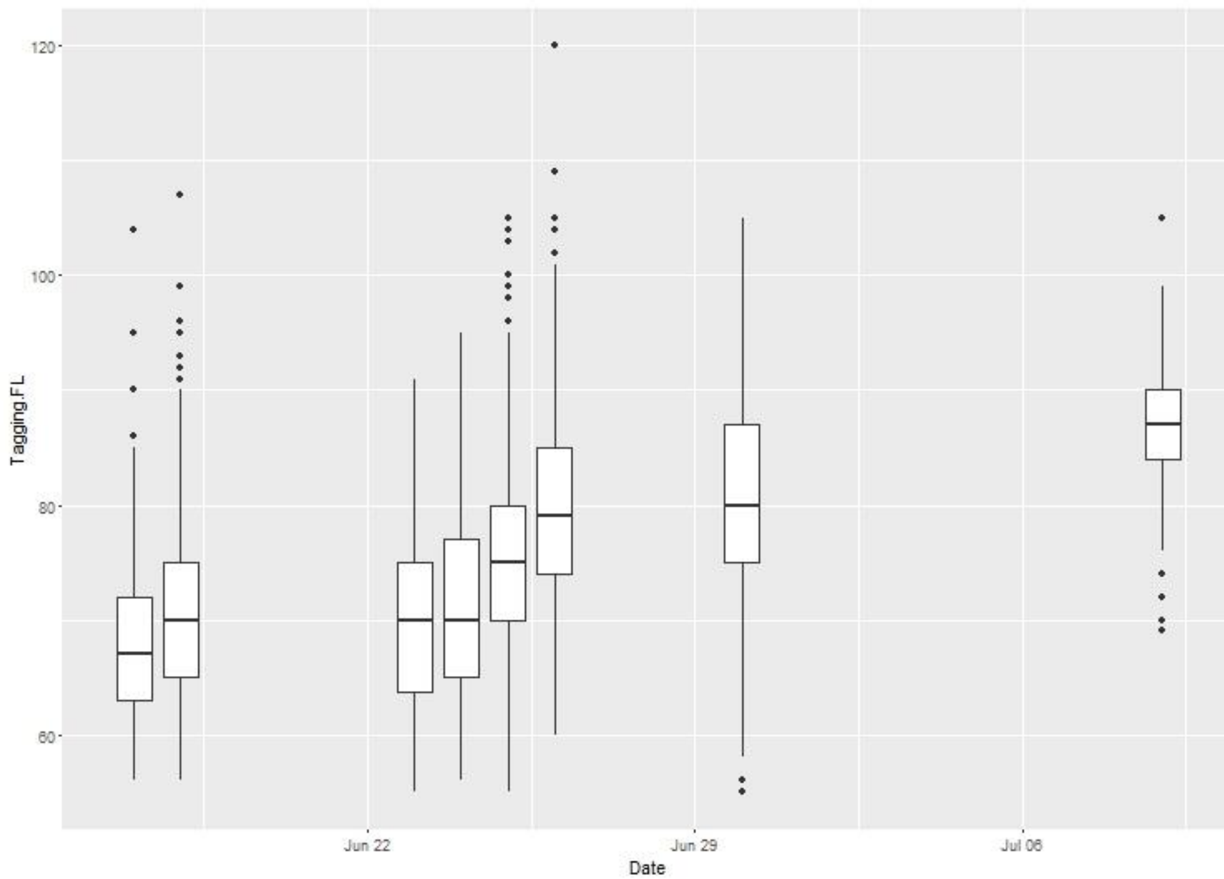


Figure 12. Size distribution of PIT tagged juvenile Chinook by release date from the beach seine effort in 2015.

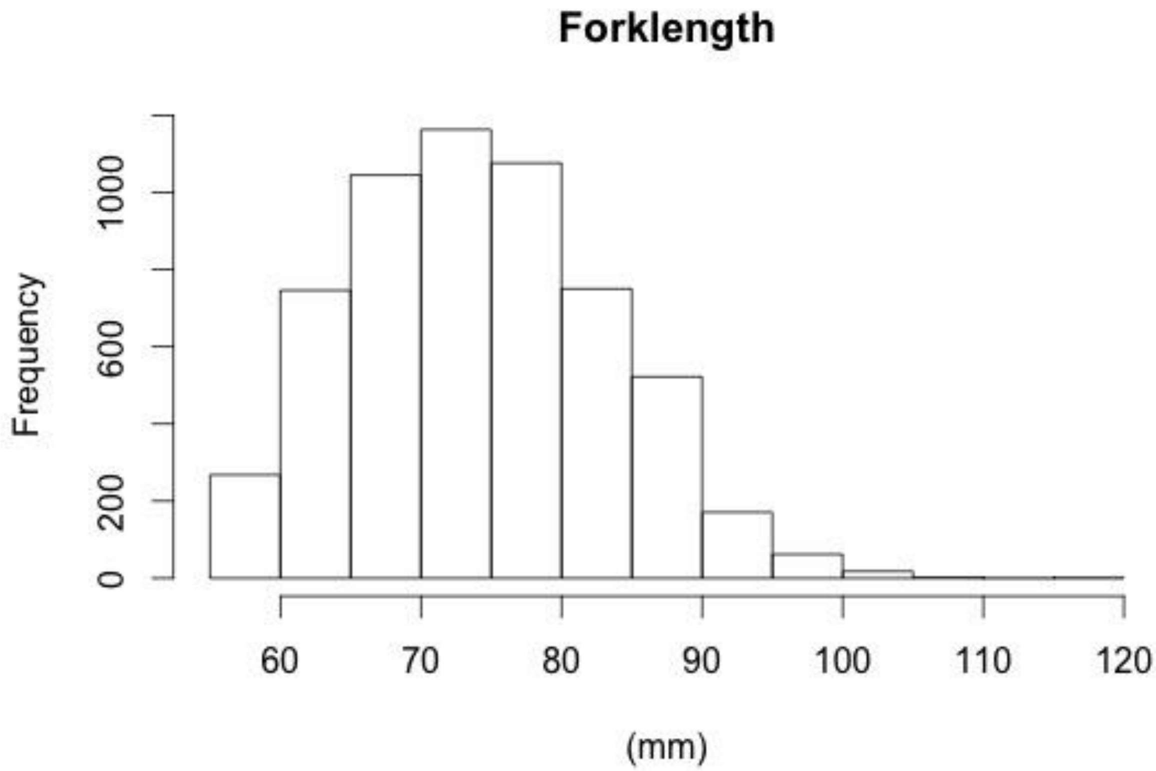
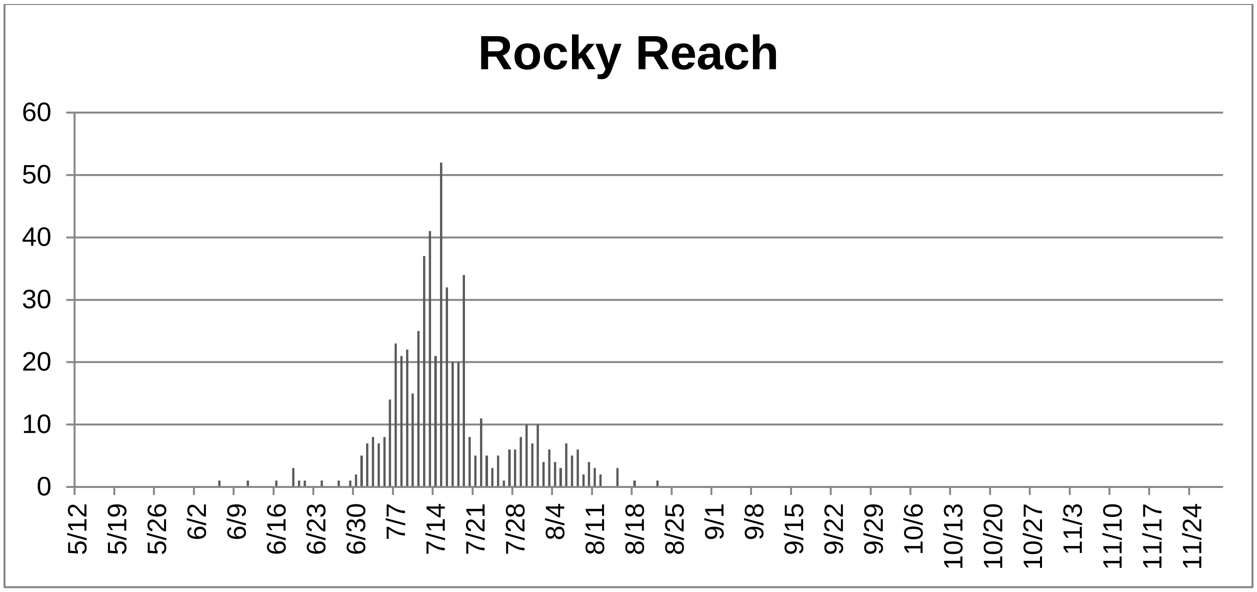
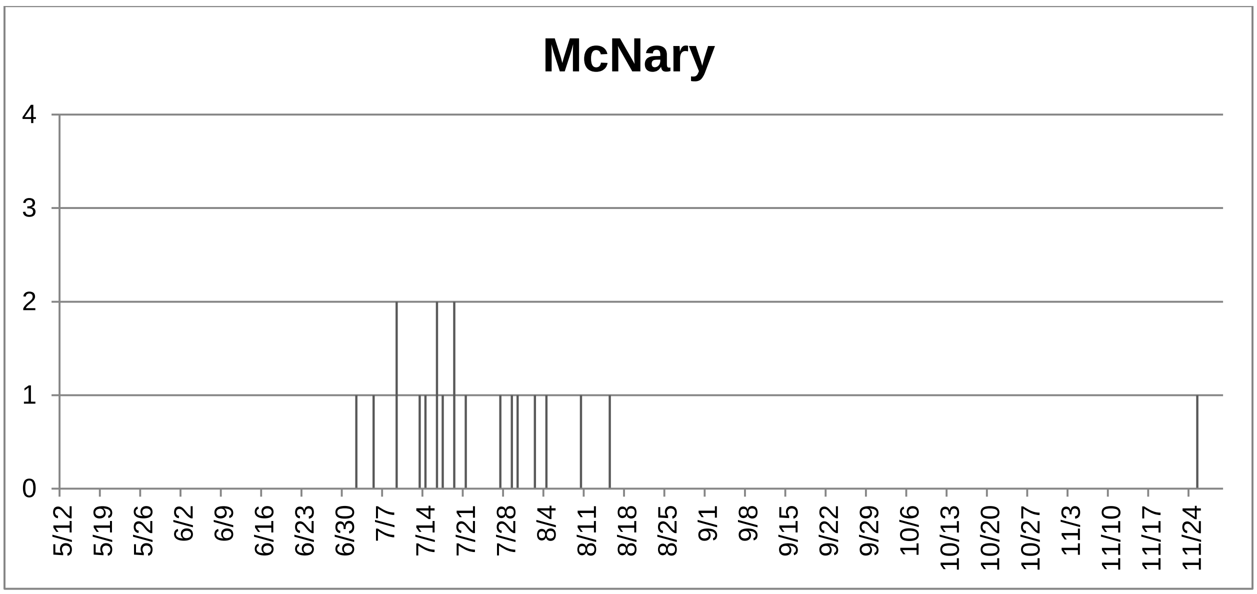


Figure 13. Size distribution of natural origin sub-yearling Chinook tagged during the beach seining effort in 2015

561 PIT tagged juvenile Chinook were detected at the Rocky Reach juvenile bypass system, which was 10.6% of total fish tagged and released. Twenty (0.4%), 25 (0.4%) and 10 (0.2%) were detected at the McNary, John Day and Bonneville Dams respectively. Detections for sub-yearlings occurred primarily in July at Rocky Reach and in August for the other lower river dams (Figure 14). There were 36 detections (3%) in the lower river dams from September through December.


Rocky Reach
60
50
40
30
20
10
0
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1
9/8
9/15
9/22
9/29
10/6
10/13
10/20
10/27
11/3
11/10
11/17
11/24


McNary
4
3
2
1
0
5/12
5/19
5/26
6/2
6/9
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1
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11/24

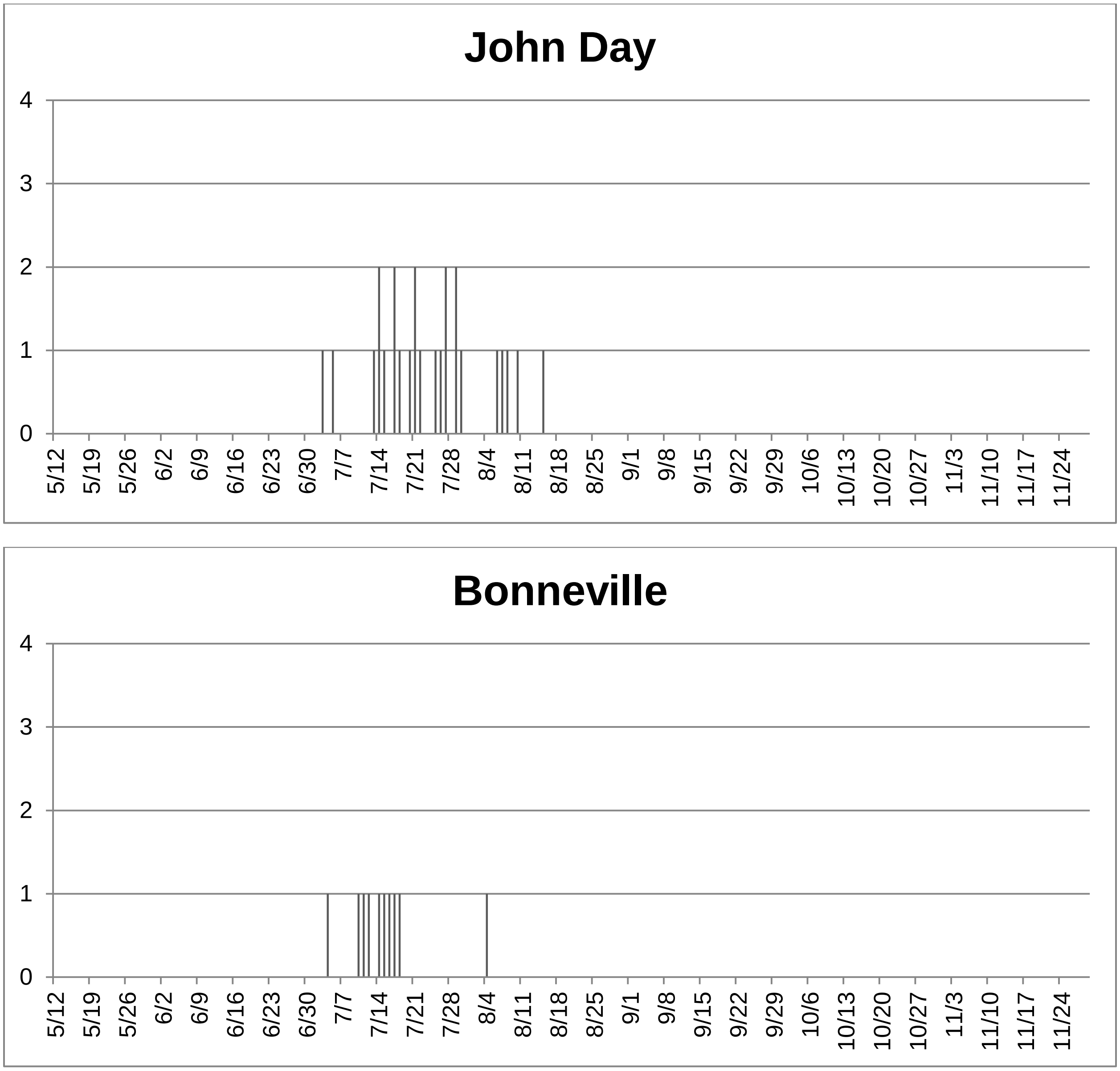


Figure 14. Daily distribution of detections of PIT-tagged sub-yearling Chinook at Rocky Reach, McNary, John Day, and Bonneville Dams in 2014.

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 15). 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 hydro dams.

	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)	21.5 (SE = 0.45; n=526)	5.6	41.9 (SE = 9.33; n=14)	12.6	35.5 (SE = 1.79; n=22)	15.2	36.8 (SE= 2.27; n=5)	17.2
Rocky Reach (762)			9.5 (SE = 1.89; n=4)	33.8				
McNary (470)								
John Day (347)								

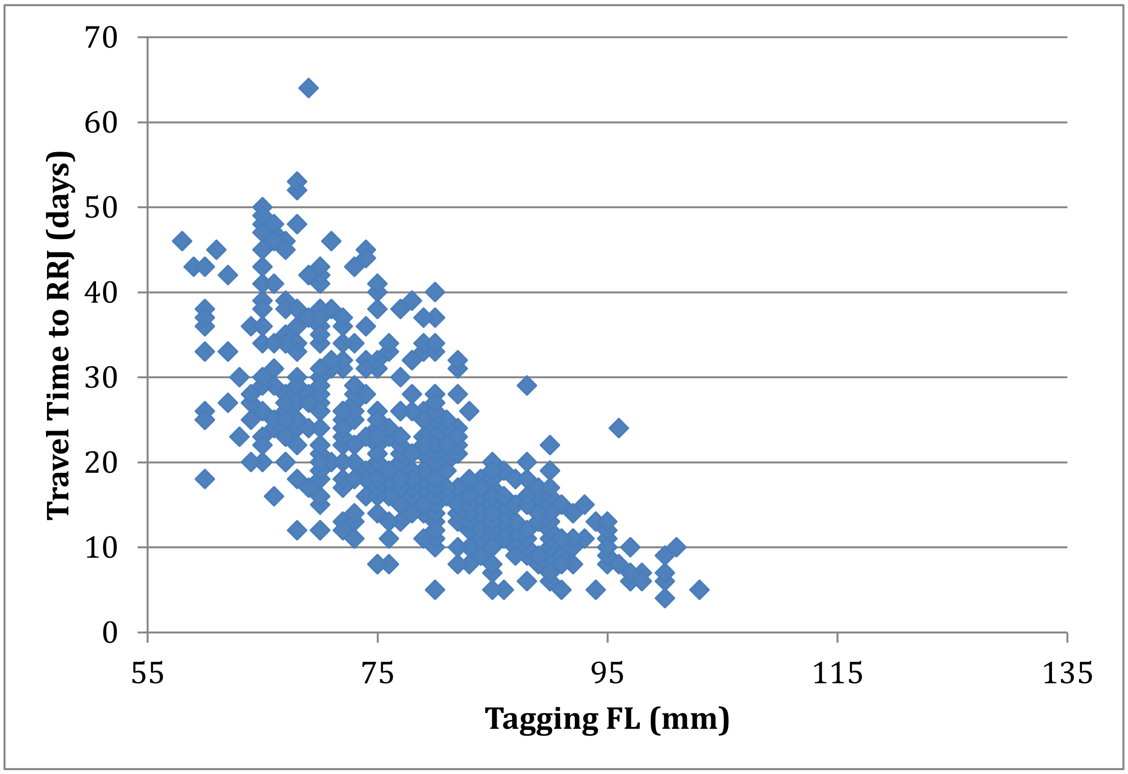


Figure 15. Fish size (fork length) and travel time of tagged Chinook to Rocky Reach Dam.

Lower Okanogan Adult Fish Pilot Weir

The Okanogan River (at Malott) discharge was below normal in 2015 and was below 800 cfs for the trapping season. Staff were able to safely enter the river and begin installation on July 15 when discharge was 1,250 cfs (Figure 16). Discharge continued to drop rapidly throughout the installation period until August 15 when levels stabilized between 500-700 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 (≥~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 2015, temperatures were similar to, though occasionally higher than the median daily temperatures from the last 49 years (Figure 17). Temperature was above 22.5 °C on July 1 when flow was 1,930 cfs. Temperatures stayed above 22.5 °C until July 25. From July 26 to July 28 temperature varied between 20.5 °C and 24.5 °C and then stayed above 22.5 °C on July 29 for one week. Temperature varied again between 24.7°C and 20.9 °C from August 5-7 and then stayed above 22.5 °C on August 8 for several weeks. As of August 21, temperatures stayed below 22.5 °C for the rest of the season.

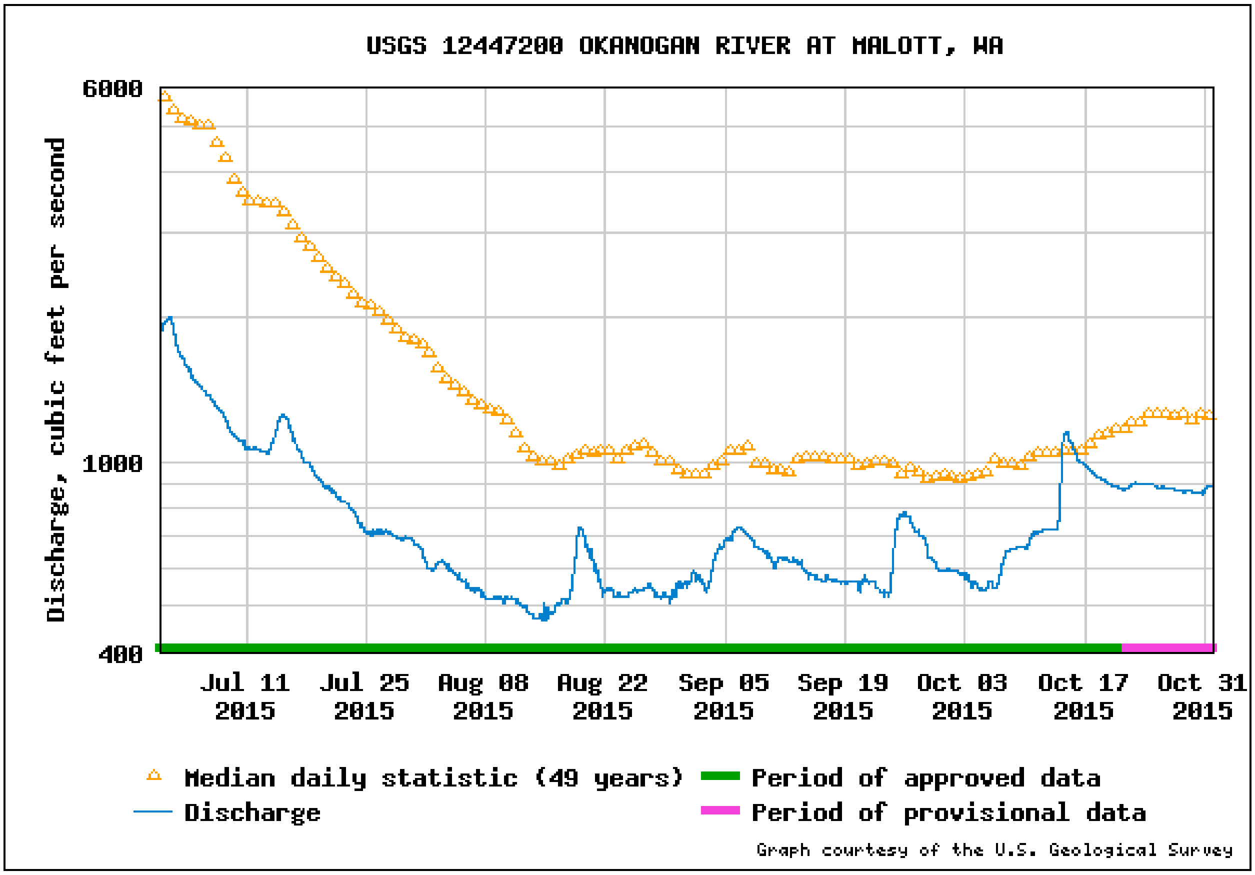


Figure 16. Discharge of the Okanogan River between July 1 and October 31, 2015. This figure was copied directly from the USGS website (http://nwis.waterdata.usgs.gov/wa).

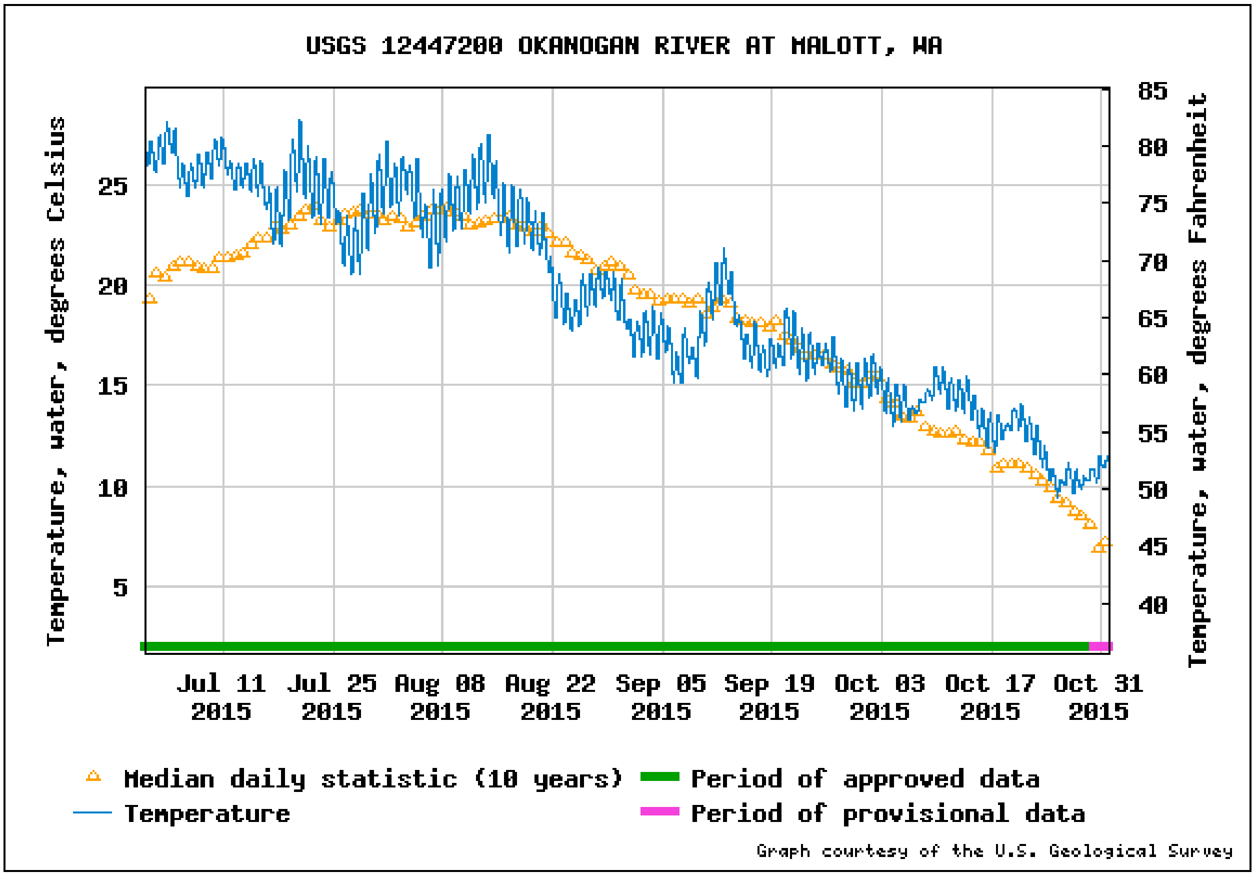


Figure 17. Temperature of the Okanogan River between July 1 and October 31, 2015. This figure was copied directly from the USGS website (http://nwis.waterdata.usgs.gov/wa).

Dissolved Oxygen varied from 5.5 to 10.2 mg/L, total dissolved solids varied from 119-160 ppm and turbidity varied from 0.7 and 2.1 NTUs (Table 1). The head differential ranged from 0-4 cm across the weir panels (Table 2). The maximum water velocity measured was 2.5 ft./sec. (Table 3).

Table 11. Water quality data at or near the lower Okanogan weir in 2015. 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)
7/27	2.2	8.2	139	0.9
7/28	2.2	9.0	135	0.9
7/29	2.2	8.3	139	0.9
7/30	2.1	8.7	134	0.8
7/31	2.1	8.7	140	1.1
8/3	0.6	9.4	147	1.2
8/4	2.1	6.0	146	1.1
8/5	2.0	10.2	127	1.2
8/6	2.0	10.2	143	1.1
8/7	0.6	9.6	129	1.2
8/10	2.0	8.4	154	1.5
8/11	0.6	9.4	152	1.5
8/12	2.0	7.2	160	1.4
8/13	0.6	6.5	160	1.2
8/14	2.0	5.7	160	1.3
8/17	2.0	7.6	158	1.3
8/18	2.1	7.7	154	1.8
8/19	2.2	7.5	150	1.2
8/20	0.6	7.9	148	1.4
8/27	2.0	9.7	144	1.1
8/28	2.0	6.1	138	0.8
8/29	2.0	6.0	141	1.3
8/30	2.1	6.2	140	1.1
8/31	2.1	6.0	140	1.5
9/1	2.1	6.2	134	1.1
9/2	2.1	5.6	131	0.8
9/3	2.1	6.2	137	1.2
9/4	0.8	6.1	130	1.0
9/5	2.2	5.5	133	0.8
9/6	2.2	5.7	123	1.2
9/7	2.2	9.9	122	0.9
9/8	2.2	8.1	119	2.1
9/9	2.2	8.5	120	0.8
9/10	2.2	8.3	124	0.7
9/11	2.2	7.7	128	0.7
9/12	0.7	7.8	131	0.8
9/13	2.1	7.8	131	0.8
9/14	2.1	6.8	130	0.8

Date	Trap Depth (ft.)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (ppm)	Turbidity (NTU)
9/15	2.1	6.6	127	0.9
9/16	2.1	6.8	125	0.9
9/17	2.1	6.8	124	1.4
9/18	2.1	7.6	126	0.8
9/19	2.1	6.9	128	1.1
9/20	2.1	7.1	131	1.2
9/21	2.1	7.1	134	0.9
9/22	2.1	6.6	131	1.1
9/23	2.1	6.7	130	0.9
9/24	2.1	6.9	129	1.1
Min	0.6	5.5	119	0.7
Max	2.2	10.2	160	2.1

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.).
07/23	4.0	3.0	1.0	4.0	3.0	2.90
07/24	2.0	1.5	1.5	1.5	1.5	2.84
07/27	2.0	1.5	1.5	1.5	1.5	2.82
07/28	1.5	1.5	0.5	0.5	1.5	2.80
07/29	1.5	0.5	0.5	0.5	0.5	2.79
07/30	1.5	0.5	1.5	1.5	1.5	2.78
07/31	1.5	0.5	0.5	0.5	0.5	2.74
08/03	1.5	0.5	0.5	0.5	0.5	2.69
08/04	0.5	0.5	0.5	0.5	0.5	2.65
08/05	1.0	0.5	0.5	0.0	0.0	2.63
08/06	1.5	0.5	0.5	0.5	0.5	2.60
08/07	1.5	0.5	0.5	0.5	0.5	2.59
08/10	1.5	0.5	0.5	0.5	0.5	2.57
08/11	1.0	0.0	0.0	0.0	0.5	2.57
08/12	0.5	0.5	0.5	0.5	0.5	2.54
08/13	0.5	0.5	0.0	0.0	0.0	2.52
08/14	1.0	0.5	0.5	0.5	0.5	2.52
08/17	1.5	0.5	0.5	0.5	0.5	2.57
08/18	1.5	0.5	0.5	0.5	0.5	2.74
08/19	1.5	0.5	0.5	0.5	0.5	2.79
08/20	1.5	0.5	0.5	0.5	0.5	2.70
08/28	1.5	0.5	0.5	0.5	0.5	2.58
08/29	1.5	0.5	0.5	0.5	0.5	2.58
08/30	1.5	0.5	0.5	0.5	0.5	2.61
08/31	1.5	0.5	0.5	0.5	0.5	2.62
09/01	1.5	0.5	0.5	0.5	0.5	2.65
09/02	1.5	0.5	0.5	0.5	0.5	2.62
09/03	1.5	0.5	0.5	0.5	0.5	2.68
09/04	1.5	0.5	0.5	0.5	0.5	2.76
09/05	1.5	0.5	0.5	0.5	0.5	2.79
09/06	1.5	0.5	0.5	0.5	0.5	2.84
09/07	1.5	0.5	0.5	0.5	0.5	2.81
09/08	1.5	0.5	0.5	0.5	0.5	2.77
09/09	1.5	0.5	0.5	0.5	0.5	2.74
09/10	1.5	0.5	0.5	0.5	0.5	2.70
09/11	1.5	0.5	0.5	0.5	0.5	2.71

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.).
09/12	1.5	0.5	0.5	0.5	0.5	2.71
09/13	1.5	0.5	0.5	0.5	0.5	2.70
09/14	1.5	0.5	0.5	0.5	0.5	2.66
09/15	1.5	0.5	0.5	0.5	0.5	2.65
09/16	1.5	0.5	0.5	0.5	0.5	2.64
09/17	1.5	0.5	0.5	0.5	0.5	2.64
09/18	1.5	0.5	0.5	0.5	0.5	2.63
09/19	1.5	0.5	0.5	0.5	0.5	2.63
09/20	1.5	0.5	0.5	0.5	0.5	2.62
09/21	1.5	0.5	0.5	0.5	0.5	2.63
09/22	1.5	0.5	0.5	0.5	0.5	2.62
09/23	1.5	0.5	0.5	0.5	0.5	2.59
09/24	1.5	0.5	0.5	0.5	0.5	2.70
Min	0.5	0.0	0.0	0.0	0.0	2.52
Max	4.0	3.0	1.5	4.0	3.0	2.84

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
7/23	2.5	1.3	1.4	2.1	1.6	1.9	1.3
7/24	2.1	1.4	1.4	2.0	0.2	1.9	1.0
7/27	1.9	1.2	1.8	1.5	1.4	2.2	0.8
7/28	0.2	0.2	0.1	1.3	0.8	1.3	0.6
7/29	1.4	1.1	1.9	1.7	1.8	2.0	0.7
7/30	2.1	1.2	1.5	2.0	1.6	1.9	0.7
7/31	1.8	1.4	1.7	1.9	1.5	1.8	0.9
8/3	2.1	0.9	1.7	2.2	1.6	1.9	0.8
8/4	2.0	1.0	1.3	2.0	1.5	2.0	1.0
8/5	1.9	1.2	1.6	1.6	1.3	1.8	1.0
8/6	1.5	1.2	1.5	1.5	1.6	1.9	0.9
8/7	1.8	0.8	1.6	1.4	0.9	1.8	0.6
8/10	1.7	1.3	1.6	1.6	1.2	2.1	0.4
8/11	1.7	1.2	1.5	1.5	1.8	1.7	0.5
8/12	1.6	1.3	1.7	1.7	1.3	1.9	0.5
8/13	1.7	0.9	1.5	1.6	1.8	1.9	0.7
8/14	1.6	1.2	1.5	1.6	1.5	1.9	0.5
8/17	1.6	1.3	1.6	1.6	1.4	1.9	0.4
8/18	1.6	1.2	1.5	1.9	2.1	2.3	0.5
8/19	1.8	1.0	1.4	1.6	1.8	2.1	0.5
8/20	1.9	0.6	1.6	1.7	1.4	1.5	0.5
8/28	2.0	1.8	1.8	1.5	1.2	1.7	1.0
8/29	1.7	1.2	1.3	1.4	0.9	1.1	1.0
8/30	1.9	1.2	1.8	1.5	1.0	1.5	0.6
8/31	1.4	1.1	1.2	1.3	1.3	1.4	0.6
9/1	1.5	1.2	1.7	1.6	1.8	1.5	0.6
9/2	1.9	1.4	1.5	1.4	1.4	2.2	0.6
9/3	1.5	1.2	2.0	1.6	2.0	1.6	0.7
9/4	1.9	1.1	1.2	1.5	0.7	2.3	0.7
9/5	1.6	1.3	1.7	1.9	0.8	1.8	0.7
9/6	1.8	1.2	1.5	1.7	0.7	1.8	0.8
9/7	1.6	1.6	1.6	1.6	0.6	1.9	0.7
9/8	1.5	1.5	1.4	1.8	0.6	1.8	0.7
9/9	1.6	1.2	1.3	1.7	0.7	1.8	0.7
9/10	1.2	1.0	1.6	1.3	0.6	2.1	0.7

Date	River Left US	US Center	River Right US	River Left DS	DS Center	River Right DS	Trap Velocity
9/11	1.1	1.1	1.4	1.4	0.6	2.3	0.7
9/12	1.8	0.5	1.2	1.2	0.8	1.9	0.7
9/13	1.5	1.1	1.4	1.6	0.7	2.0	0.7
9/14	1.2	1.1	1.4	1.7	0.6	2.2	0.7
9/15	1.5	1.1	1.4	1.3	0.7	1.9	0.7
9/16	1.1	1.1	1.6	1.5	0.6	2.2	0.7
9/17	1.5	1.2	1.4	1.5	0.6	2.0	0.7
9/18	1.7	1.2	1.4	1.3	0.5	1.7	0.7
9/19	1.6	1.3	1.1	1.4	0.7	1.6	0.6
9/20	1.6	1.3	1.5	1.4	0.8	1.7	0.7
9/21	1.1	1.2	1.6	1.6	0.6	1.9	0.7
9/22	1.6	1.3	1.5	1.6	0.7	2.1	0.7
9/23	1.5	1.2	1.4	1.8	0.7	1.9	0.7
9/24	1.5	1.2	1.5	1.7	0.8	2.1	0.7
Min	0.2	0.2	0.1	1.2	0.2	1.1	0.4
Max	2.5	1.8	2.0	2.2	2.1	2.3	1.3

Two hundred and sixty-three (263) dead fish were removed from the weir between July 20 and September 18 (Table 14). Sockeye and Chinook Salmon were the most commonly encountered species. There were no Steelhead mortalities removed from the weir in 2015. All fish 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 month before Chinook were encountered in the trap. (Figure 5). The higher mortality observed on August 3-7 was not due to Chinook being handled in the trap because the trap was not in operation at that time (Figure 5). 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 2015. All fish mortalities were considered "wash downs" and collected on the upstream panels of the weir.

Date	Bridgelip Sucker	Carp	Chinook	Mountain Whitefish	Smallmouth Bass	Sockeye	Unknown Sucker
7/20						17	
7/21						13	
7/22			1			38	
7/23			1			17	
7/24			3			7	
7/27			4			7	
7/28			1				
7/29							
7/30						2	
7/31							1
8/3			10			7	
8/4			9				
8/5			22			1	
8/6			10			3	
8/7			21			3	
8/8			3			1	
8/10	2		6		1		
8/11			2			1	
8/12			1				
8/13			1			1	
8/14	1						
8/17			2				
8/18							
8/19	1		1				
8/20			1				
8/21			1				
8/22							
8/23							
8/24							
8/25							
8/26							
8/27						2	
8/28	1						
8/29						3	
8/30							
8/31		1					2
9/1		1	1				1
9/2						1	
9/3							
9/4			1				
9/5						4	

Date	Bridgelip Sucker	Carp	Chinook	Mountain Whitefish	Smallmouth Bass	Sockeye	Unknown Sucker
9/6			2	1		3	
9/7							
9/8			7			13	
9/9						2	
9/10						1	
9/11			3			2	
9/12						1	
9/13							
9/14							
9/15							
9/16							
9/17							1
9/18							1
Total	**5**	**2**	**114**	**1**	**1**	**134**	**6**

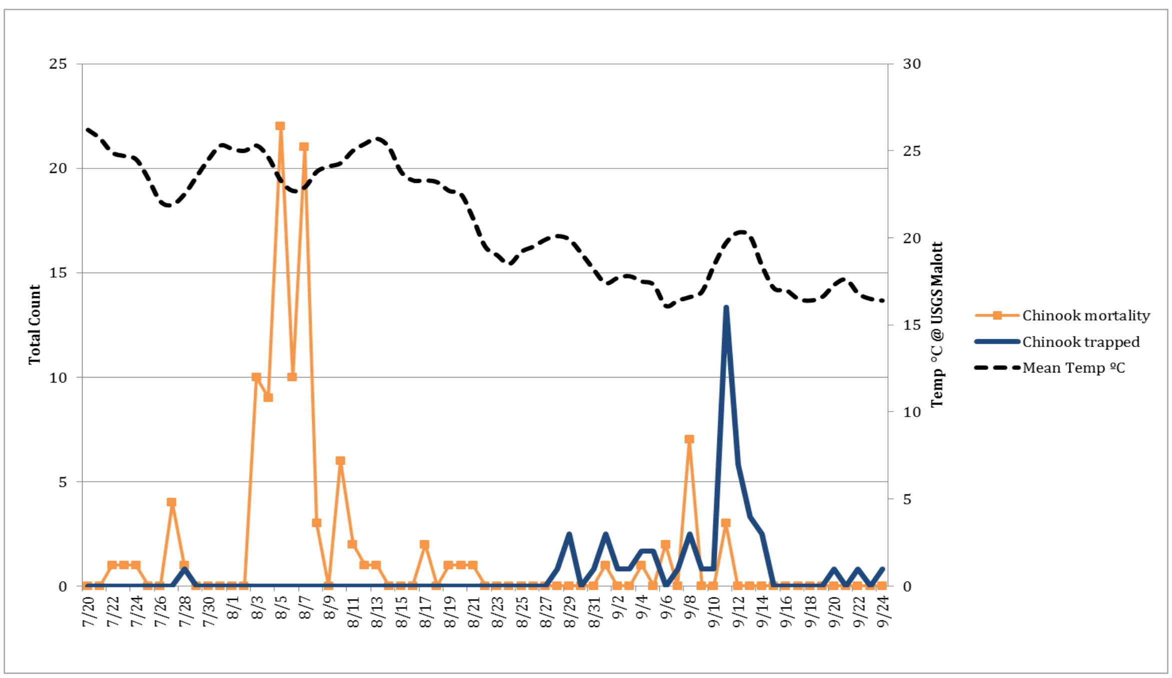


Figure 18. Total number of Chinook trapped and total number of Chinook carcasses collected off the weir panels. The majority of the Chinook carcasses occurred a month before most Chinook were encountered in the trap.

Tower observations showed that most fish were milling in the river right (looking downstream) to center of channel. Estimates were highest during the last week of July and August 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 higher (~95%)

after the thermal barrier breakdown. Trapping operations were conducted intermittently from July 27 to 29, August 6, 7, 19, 20 and August 27 to September 24 when river temperature was ≤ 22.5 °C. The total fish trapped at the weir in 2015 was 67 with 81% of them being Chinook Salmon (Figure 19). A third of the Chinook trapped were released back into the river (Figure 20). Three Steelhead were trapped between 8/29-8/31 and released within 30 minutes of observation. The TOG was notified when Steelhead were trapped, including the total number, origin and condition after release. To reduce handling of fish, trap attendants opened the gate of the crowder and the upstream gate of the trap to allow for complete passage. Fish that were passed upstream were classified as having a vigorous condition, swimming away unharmed. Nineteen natural origin Chinook were transported to the hatchery and held in the 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 with a rubber boot. None of the weir collected fish died at the hatchery as of the second spawn in early October.

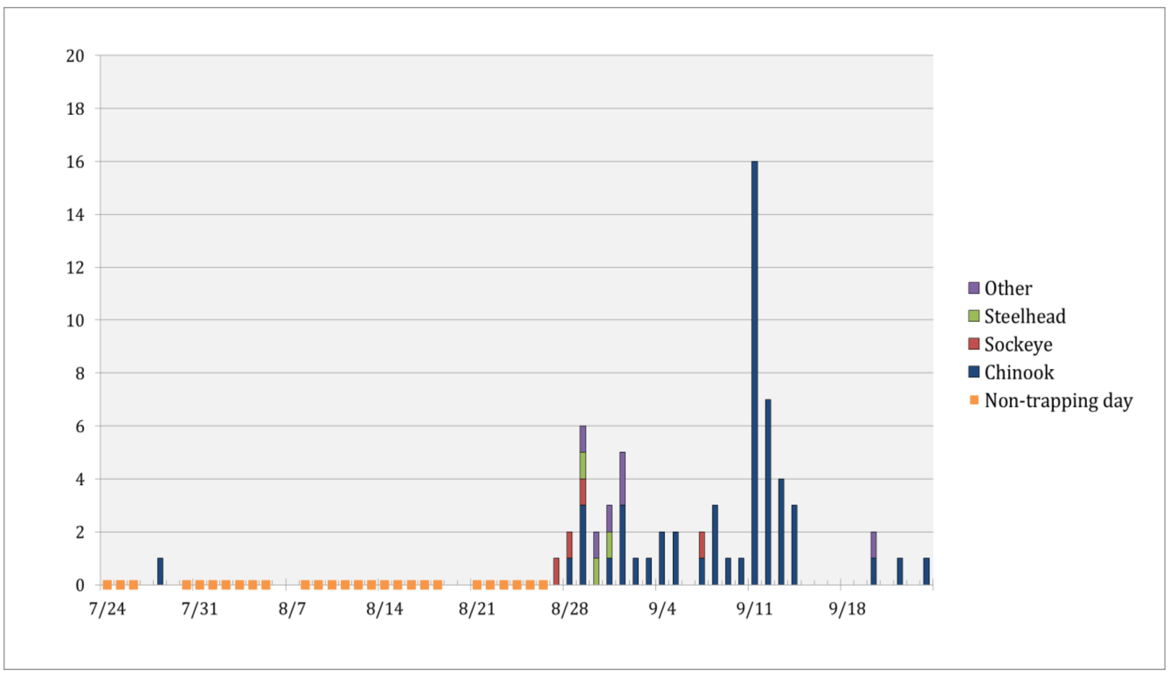


Figure 19. Total number of fish trapped at the Okanogan weir in 2015.

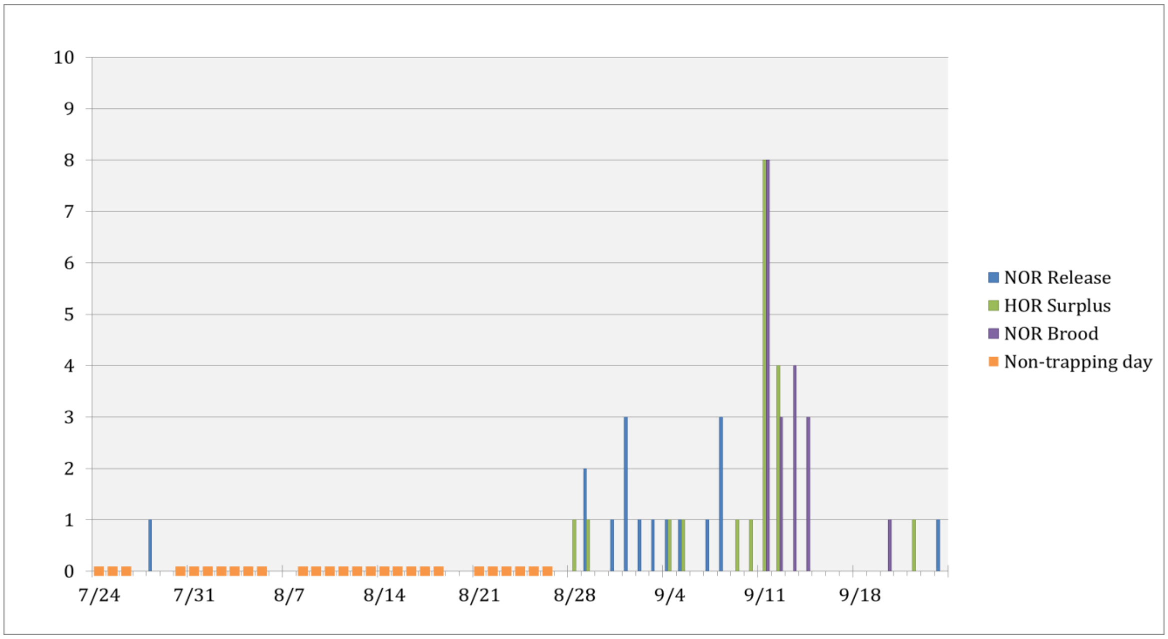


Figure 20. Final destination of Chinook adults captured in the weir trap during trapping operations in 2015.

In 2015, 0.004 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 0.006**.**

Table 15. The number of hatchery and natural origin Chinook Salmon encountered at the lower Okanogan weir in 2015. Weir efficiency and effectiveness were metrics for evaluating the potential for the weir to contribute to the CJHP population management goals in the future.

Survey Year	Number of summer/fall Chinook carcasses					
	Chinook Adults Encountered in the Weir Trap		Chinook Spawning Escapement Estimates[c]		Weir Metrics	
	Natural Origin (NOR)	Hatchery Origin (HOR)	Natural Origin (NOS)	Hatchery Origin (HOS)	Weir Efficiency[a]	Weir Effectiveness[b]
2013	67	17	5,909	2,285	0.009	0.006
2014	1,947	269	10,602	1,561	0.141	0.134
2015	35	19	11,064	2,684	0.004	0.006

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

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

[c] Estimates do not include Chinook Zosel Dam counts.

Redd Surveys

In 2015, 4,276 summer/fall Chinook redds were counted in the Okanogan and Similkameen rivers using a combination of ground and aerial surveys (Table 16. , Figure 21). The number of redds counted in 2015 was higher than the long-term or more recent 5-year average (Table 16.). The majority of Chinook redds were located in S1 (37.6%) and O5 (23.76%). The overall redd distribution across the reaches was similar to previous years with the exception that reach O5 contained a higher proportion of redds than reach O6 for the first time within the survey period (Table 17. , Figure 22).

Estimated spawning escapement was 13,769 (4,276 redds × 3.22 fish per redd) (Table 18.). During the survey period 1989 through 2015, the summer/fall Chinook spawning escapement within the U.S. portion of the Okanogan River Basin averaged 5,697 and ranged from 473 to 13,857 (Table 18).

The majority of summer/fall Chinook redds were counted during spawning ground surveys between October 5 - 9 (Table 19.). No spawning ground surveys were conducted beyond November 12.

Escapement into Canada

In 2015 there were 1,206 adult summer/fall Chinook counted in the fishways of Zosel Dam (Table 20.). While not the highest count on record, 2015 continued a trend showing increasing escapements above Zosel. 7% of the Chinook observed at Zosel Dam had a clipped adipose fin (i.e., hatchery-origin).

Table 16. Total number of redds counted in the Okanogan River Basin, 1989-2015 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
Average	1,099	1,022	2,064
5-yr Average	***2,041***	***1,535***	***3,576***

* Reach-expanded aerial counts.

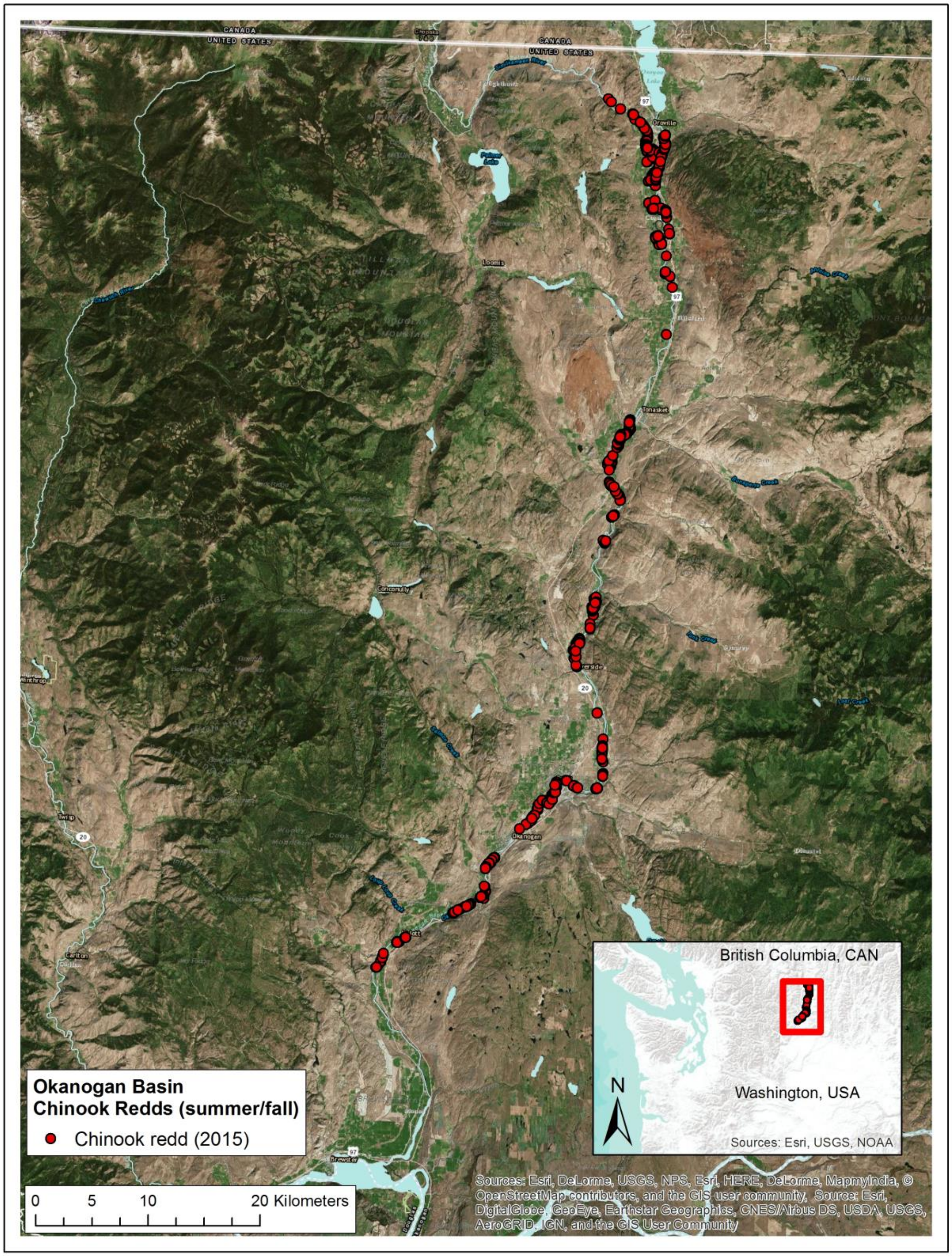


Figure 21. Distribution of summer/fall Chinook redds in 2015. Individual redds are identified by red circles. Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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 2006-2015.

Return Year	Number of Summer Chinook Redds								
	Okanogan						Similkameen		Total
	O-1	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
Average	***9***	***46***	***140***	***89***	***614***	***894***	***1142***	***205***	***3139***

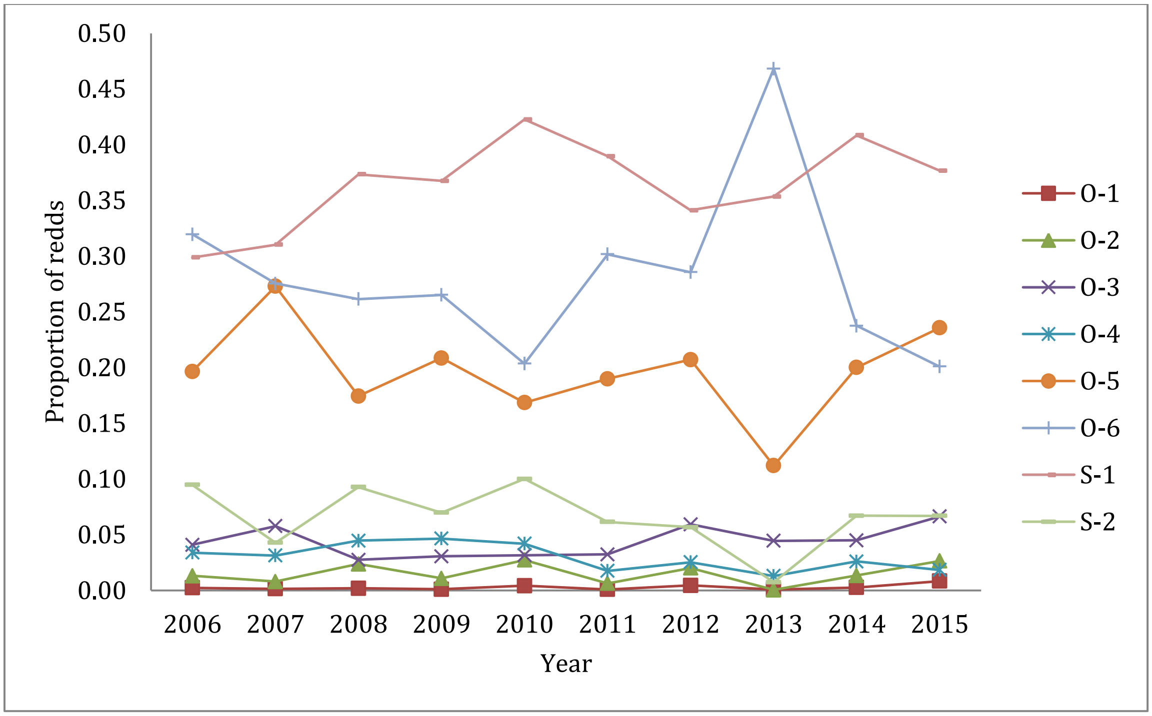


Figure 22. Proportion of redds in each reach of the Okanogan and Similkameen Rivers from 2006 to 2015.

Table 18. Spawning escapements for summer/fall Chinook in the Okanogan and Similkameen Rivers for return years 1989-2015.

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	3.0	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	2.0	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
Average	***3.0***	***2,842***	***2,855***	***5,697***
5-Year Average	***2.91***	***5,909***	***4,498***	***10,406***

* 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 2015.

Reach	River mile	Oct 5-9	Oct 12-16	Oct 20-23	Oct 26-30	Nov 6	Nov 12	Redd Count	Percent
	Okanogan River								
O1	0.0-16.9	4	4	0	26	0	2	36	2%
O2	16.9-26.1	29	19	0	59	6	0	113	5%
O3	26.1-30.7	51	106	0	123	0	4	284	12%
O4	30.7-40.7	8	20	0	51	0	0	79	3%
O5	40.7-56.8	348	75	506	76	1	2	1008	42%
O6	56.8-77.4	357	331	37	134	2	0	861	36%
Total		***797***	***555***	***543***	***469***	***9***	***8***	***2381***	***100%***
	Similkameen River								
S1	0.0-1.8	1205	182	126	96	0	0	1609	85%
S2	1.8-5.7	261	17	0	8	0	0	286	15%
Total		***1466***	***199***	***126***	***104***	***0***	***0***	***1895***	***100%***

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%
Average	***873***	***21%***

[a]2014 data were adjusted for fallback/re ascension, down camera time, and differentiation of spring Chinook from summer/fall Chinook.

Carcass Surveys

In 2015, 3,293 carcasses were recovered including 2,555 natural-origin and 738 hatchery-origin[7]. The overall carcass recovery rate was 24% of the total spawning escapement. Genetic samples (tissue punches) were collected from a portion of the summer/fall Chinook carcasses in 2015. Samples are archived at the USGS Snake River Field Station Genetics Lab in Boise, ID. The majority (*n* = 2,696; 82%) of carcasses were collected from reaches O6 and S1 (Figure 23, also see Appendix C). The proportion of natural-origin carcasses recovered in 2015 was slightly lower in reach O5and higher in reach S1 compared to the 10-year averages (Figure 23, panel A). The proportion of

[7]Origin 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.

hatchery-origin carcasses recovered in 2015 was lower in O4 and O6 and higher in S1 compared to the 10-year averages (Figure 23, panel B).

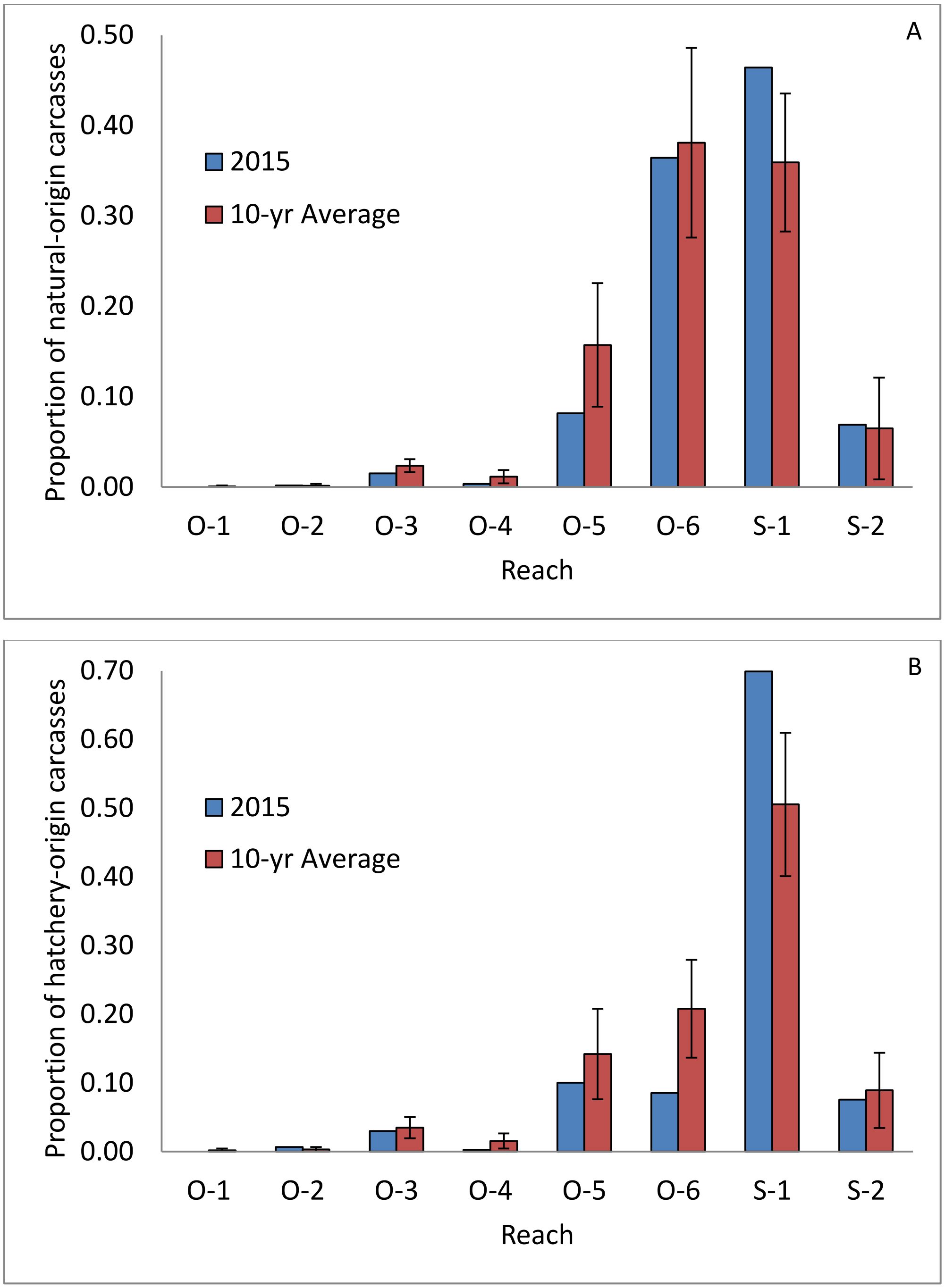


Figure 23. Distribution of natural-origin (A) and hatchery-origin (B) summer/fall Chinook carcasses recovered in the Okanogan (O1-O6) and Similkameen (S1-S2) Rivers in 2015 and the 10-year average (2006-2015).

In the Okanogan basin, 124 of the sampled female carcasses were estimated to have all their eggs, so pre-spawn mortality (for fish that survived to the spawn period) was estimated to be 10.9% for natural-origin females and 5.0% for hatchery-origin females (Table 21.). Overall egg retention of all fish sampled (including fish that had expelled a portion of their eggs) was 10.7%.

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	0.4%	0.0%
	Hatchery-origin	297	237	1,185,000	10,970	0.9%	0.0%
	Total	910	563	2,815,000	17,122	0.6%	0.0%
2014	Natural-origin	2123	1136	5,680,000	373,708	6.6%	1.4%
	Hatchery-origin	329	166	830,000	81,105	9.8%	1.8%
	Total	2452	1302	6,510,000	454,813	7.0%	1.5%
2015	Natural-origin	2554	981	4,905,000	609,869	12.4%	10.9%
	Hatchery-origin	738	340	1,700,000	96,354	5.7%	5.0%
	Total	3292	1321	6,605,000	706,223	10.7%	9.4%

[a]Assuming 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)

[b]A 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 all reaches in the Okanogan and Similkameen rivers in 2015 compared to the 10-year average with the exception of reach O2 (Figure 24), which was based on the recovery of only 10 carcasses. No carcasses were recovered in reach O1. Hatchery-origin spawners comprised 25% of the spawn escapement estimate in the U.S. portion of the Okanogan, which was the third lowest (unadjusted) pHOS observed since 1992 (Table 23). After corrections for hatchery fish effectiveness assumptions (0.80 relative reproductive success rate for hatchery-origin spawners) and reach weighting, the effective, reach weighted pHOS for 2015 was 0.21, which was considerably less than the five-year average (0.30) (Table 23). Although the five-year average failed to meet the biological objective for pHOS (<0.3), recent years' data reveal a trend toward the objective (Figure 25).

The proportion of natural-origin broodstock (pNOB) in 2015 was 98% and the pNOB for Okanogan origin fish was 88% (Table 23.). The resulting PNI for 2015 was 0.82, with a 5-year average PNI of 0.76, both meeting the Biological Objective (>0.67)(Figure 26).

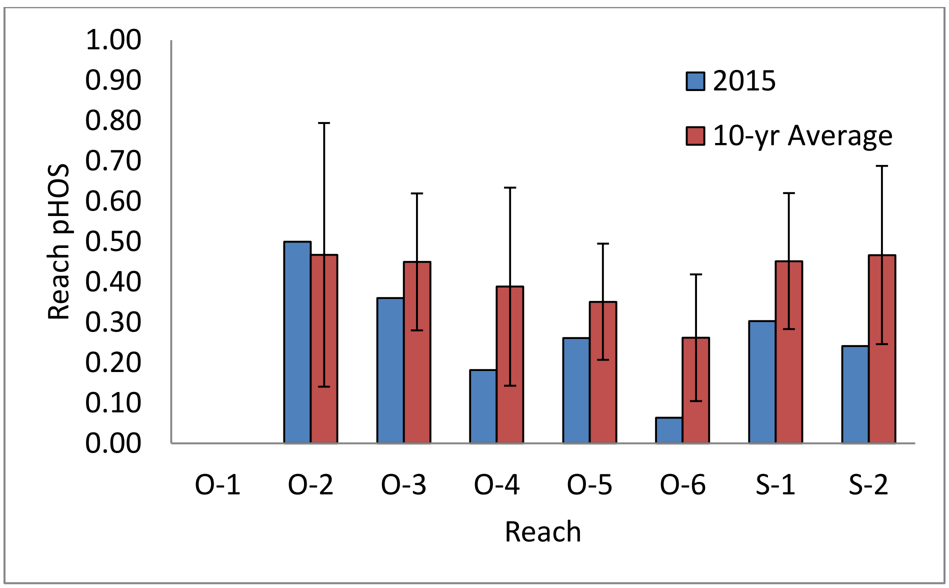


Figure 24. Okanogan (O1-O6) and Similkameen River (S1-S2) summer/fall Chinook unadjusted pHOS by reach for 2015 and 10-year average (2006-2015). Reaches with fewer than 10 carcasses recovered were not shown.

Table 22. Natural- (NOS) and hatchery- (HOS) origin spawner abundance and composition for the Okanogan River Basin, brood years 1989-2015.

Brood Year	Spawners				
	NOS	HOS	Unadjusted pHOS	Effective pHOS	Effective, Reach-weighted 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	0.36	0.31	0.18
2007	2,983	1,434	0.32	0.28	0.32
2008	2,998	3,977	0.57	0.51	0.54
2009	4,204	3,340	0.44	0.39	0.40
2010	3,189	2,763	0.46	0.41	0.41
2011	4,642	5,039	0.52	0.46	0.47
2012	4,840	3,385	0.41	0.36	0.40
2013[a]	5,520	2,674	0.33	0.28	0.27
2014	10,532	1,632	0.13	0.11	0.12
2015	10,350	3,398	0.25	0.21	0.21
Average	***3,274***	***2,422***	***0.43***	***0.37***	***0.32***
5-year Average	***7,177***	***3,226***	***0.31***	***0.26***	***0.30***

[a]2013 data have been updated to reflect origin data acquired from coded wire tag and scale reading since the publication of the 2013 Annual Report.

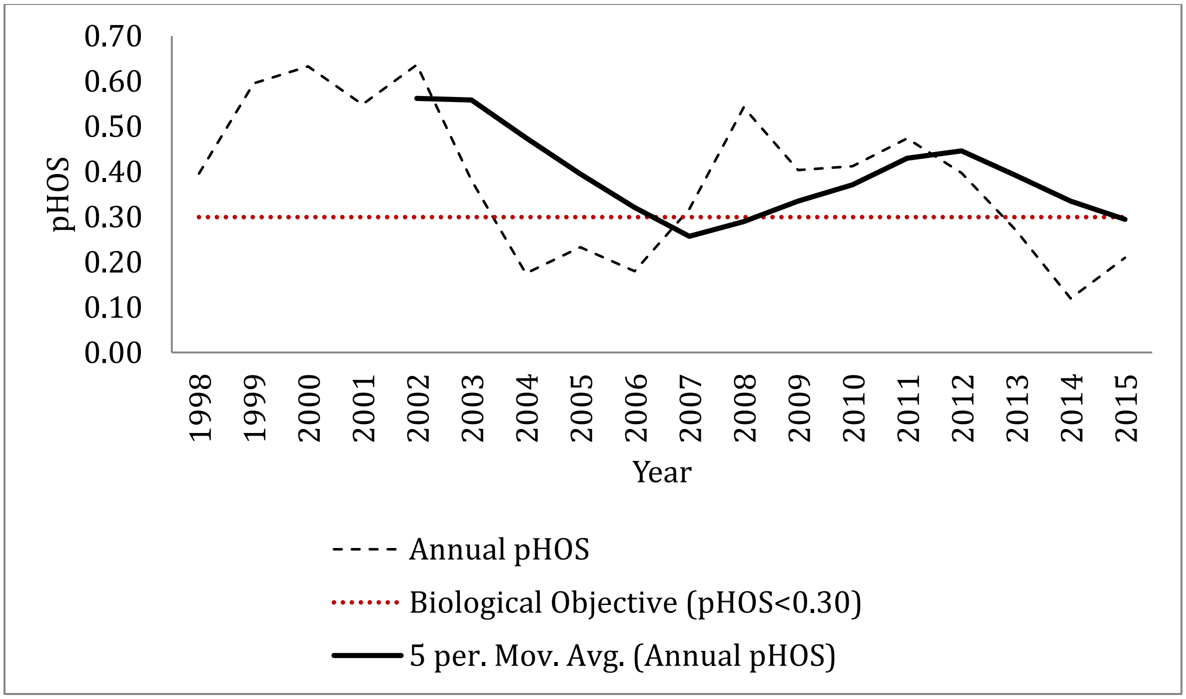


Figure 25. The proportion of hatchery-origin spawners (pHOS) in the Okanogan and Similkameen River (combined) from 1998-2015. pHOS values represent the effective, reach-weighted pHOS, adjusted for the hatchery fish effectiveness assumption (0.8; all years) and the proportion of redds in each reach (2006-2015).

Table 23. Okanogan River summer Chinook spawn escapement and broodstock composition, and calculated pHOS and PNI for Brood Years 1989-2015.

	Spawners			Broodstock						
	NOS	HOS	pHOS[a]	NOB	Okan. NOB	HOB	pNOB	Okan. pNOB	PNI	Okan. PNI
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	0.71	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	5,520	2,674	0.27	353	318	0	1.00	0.90	0.79	0.77
2014	10,532	1,632	0.11	499	449	5	0.99	0.89	0.90	0.89
2015	10,350	3,398	0.21	421	379	9	0.98	0.88	0.82	0.81
Average	***3,274***	***2,422***	***0.39***	***417***	***213***	***157***	***0.73***	***0.48***	***0.65***	***0.56***
5-Year Average	***7,177***	***3,226***	***0.30***	***369***	***315***	***8***	***0.98***	***0.83***	***0.77***	***0.74***

[a]pHOS values are effective from 1989-2006 and Effective, Reach-weighted pHOS from 2006-2015

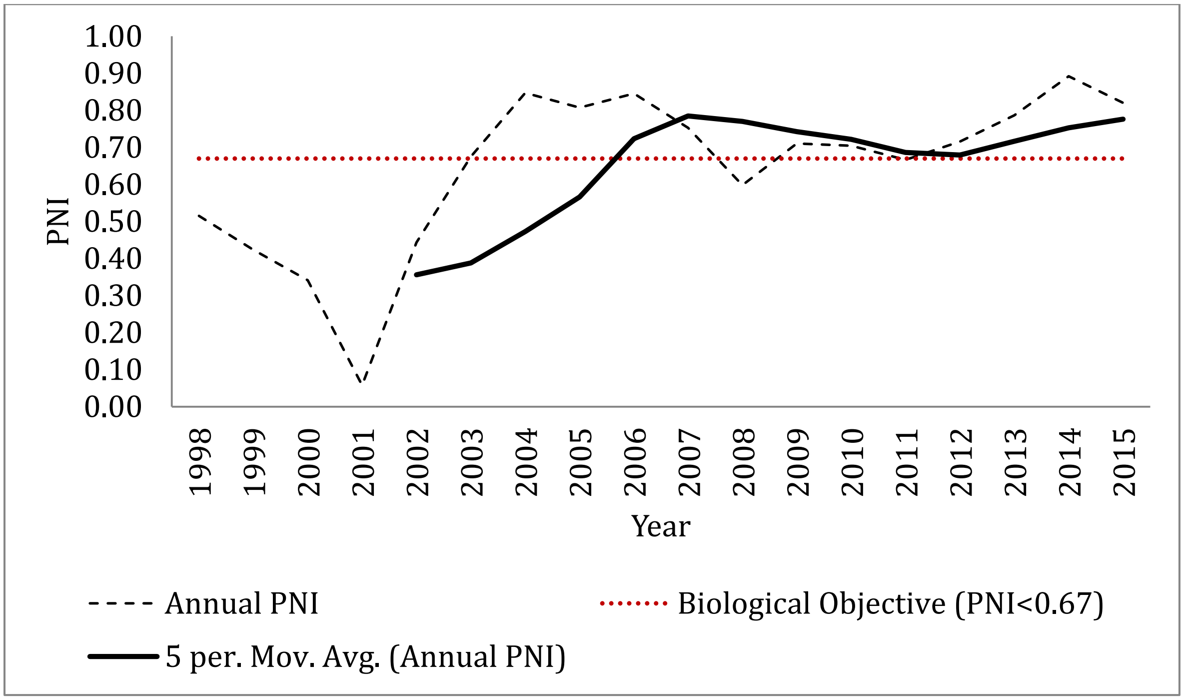
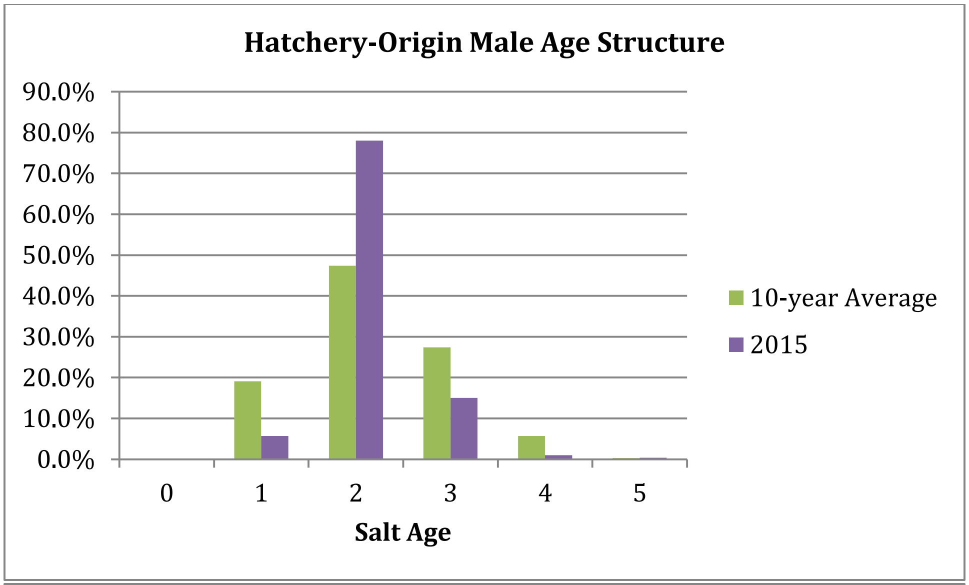


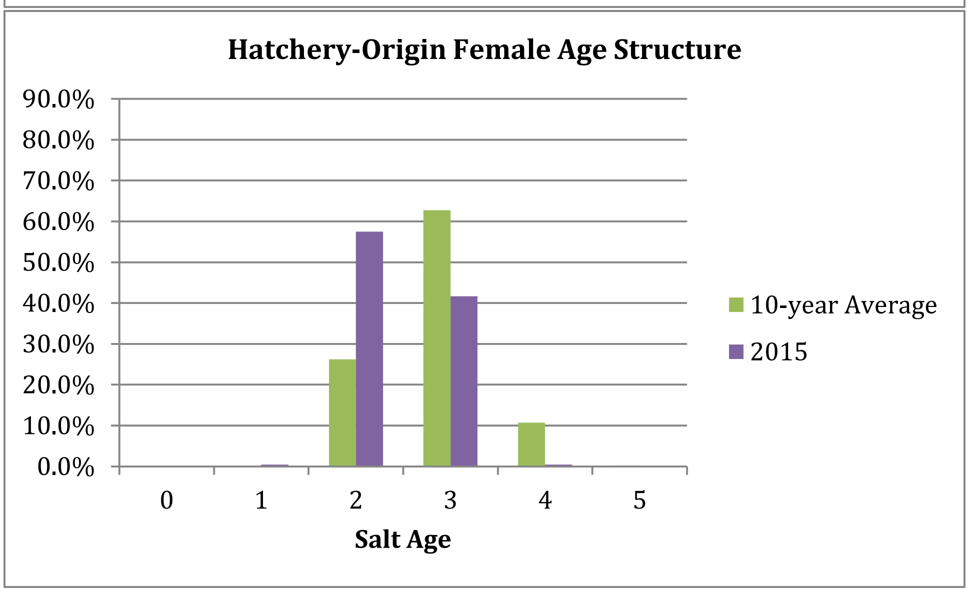
Figure 26. The proportionate natural influence (PNI) in the Okanogan and Similkameen Rivers (combined) from 1998 to 2015.

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 2015, both male and female hatchery-origin fish were more apt to return as 2-salt fish than the 10-year average. Within the natural-origin contingency, male fish were more likely than average to return as 2-salt fish, whereas a higher proportion of recovered female carcasses were older 4-salt fish than the average.


Hatchery-Origin Male Age Structure
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0
1
2
3
4
5
Salt Age
10-year Average
2015


Hatchery-Origin Female Age Structure
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0
1
2
3
4
5
Salt Age
10-year Average
2015

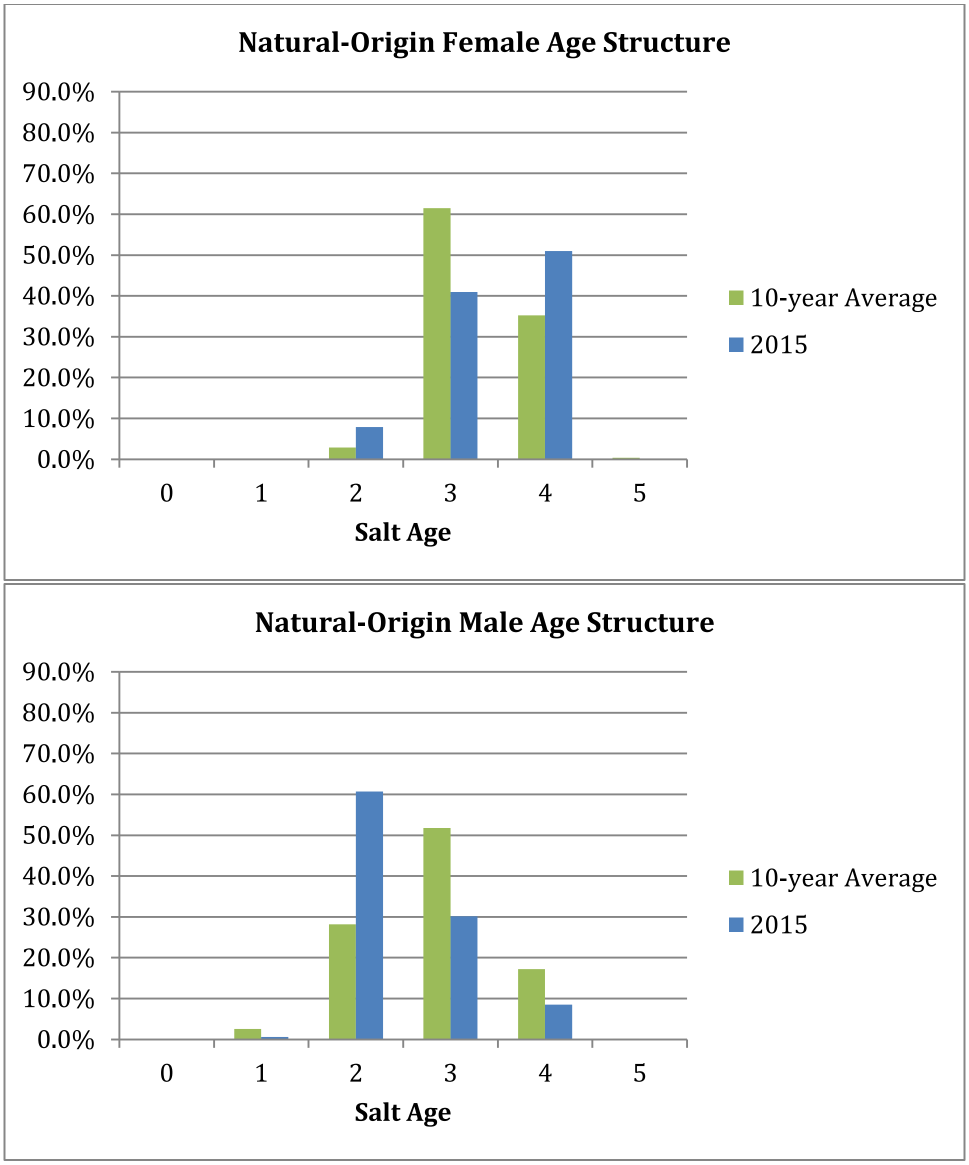


Figure 27. The salt ages of carcasses collected on the spawning grounds of the Okanogan and Similkameen Rivers in 2015 and 10-year averages (2006-2015).

HATCHERY-ORIGIN STRAY RATES

Strays within the Okanogan.—The majority (94%) of hatchery-origin spawners recovered on the spawning grounds in 2015 were from Similkameen (93%) and Bonaparte (1%) pond releases (Table 24.). This was very similar to the average (94%) of recent years (2006-2014). Strays from outside the Okanogan but within the Upper Columbia summer/fall Chinook ESU consisted of fish from Carlton Pond, Entiat NFH, Chelan Hatchery, and Wells Hatchery (5%). Strays from outside the ESU were from releases into the Yakima and Snake Rivers, and the Nooksack and Samish River in the Puget Sound region (2%). Stray hatchery fish comprised 1% of total Okanogan spawner composition (i.e., stray pHOS) (Table 25.). This was less than the recent (2006-2014) average of 2% 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 2010. The 2010 brood year had a stray rate of 1.3%, which was similar to the long term and recent five year averages (Table 26.). RMIS queries revealed an estimate of 9 Okanogan hatchery-origin CWT codes from spawning ground recoveries in non-target spawning areas in 2015. Based on available data, Okanogan basin hatchery program strays comprise ≤1% to other basin population's spawner composition (in 2015 as well as long term average). Okanogan basin hatchery strays comprised ≤1% of either the Entiat or Chelan River spawning aggregates[8] (Table 27.).

[8] The Entiat and Chelan River are evaluated separately here because they were not classified as independent populations within the ESU (Peven et al. 2010) and therefore may not be subject to the same biological targets as the Methow and Wenatchee populations.

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 2006-2015.

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	22 (1%)	2136 (93%)	40 (2%)	13 (1%)	9 (0%)	14 (1%)	18 (1%)	17 (1%)	8 (0%)	29 (1%)
Average	***101 (4%)***	***2112 (90%)***	***22 (1%)***	***19 (1%)***	***1 (0%)***	***21 (1%)***	***60 (3%)***	***0 (0%)***	2 (0%)	0 (0%)

[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 Priest Rapids Hatchery

[i] Includes Releases from Oxbow Hatchery, Tucannon Hatchery, and NPT Hatchery

[j] Includes releases from Glenwood Springs Hatchery, Kendall Creek Hatchery, and Samish 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 2006-2015. For specific hatchery program releases contributing to strays in the Okanogan Basin see Appendix D

Return Year	Release Site										HOS Stray Contribution to Total Spawning Escapement	pHOS
	Summer Chinook Run							Fall 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	0.1%	36.5%	0.7%	0.6%	0.0%	1.9%	1.3%	0.0%	0.1%	0.0%	4.5%	0.41
2011	2.3%	43.9%	0.5%	0.1%	0.0%	0.4%	0.2%	0.0%	0.1%	0.0%	1.2%	0.47
2012	5.2%	32.9%	0.4%	0.3%	0.0%	0.2%	0.7%	0.0%	0.0%	0.0%	1.7%	0.40
2013	3.4%	19.5%	0.1%	0.7%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	1.0%	0.24
2014	0.5%	9.9%	0.2%	0.0%	0.5%	0.1%	0.3%	0.0%	0.0%	0.0%	1.0%	0.11
2015	0.1%	15.5%	0.3%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	1.0%	0.21
Avg.	1.2%	29.4%	0.3%	0.3%	0.1%	0.3%	1.0%	0.0%	0.0%	0.0%	1.9%	32.8%

[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 Priest Rapids Hatchery

[i] Includes Releases from Oxbow Hatchery

[j] Includes releases from Glenwood Springs 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	3,577	96.8%	95	2.6%	20	0.5%	4	0.1%
2009	1,102	79.9%	260	18.9%	14	1.0%	2	0.1%
2010	889	58.0%	624	40.7%	9	0.6%	10	0.7%
Total	***46,548***	***89.4%***	***4,959***	***9.5%***	***504***	***1.0%***	***72***	***0.1%***

Table 27. Number and percent (%) of spawning escapements that consisted of hatchery-origin Okanogan summer/fall Chinook within other non-target basins, return years 1994-2014.

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%
Total	***45***	***0.0%***	***73***	***0.2%***	***279***	***2.6%***	***50***	***0.8%***
5-year Total	***13***	***0.0%***	***9***	***0.1%***	***107***	***1.8%***	***-***	***0.0%***

Smolt-to-Smolt Survival and Travel Time

2015 was the first year of PIT tagged releases from the CJH and was the first time the program could evaluate apparent post release survival of hatchery smolts. For Spring Chinook, survival to RRJ was 0.73 for the segregated program released from CJH and 0.79 for the 10j fish released from Riverside Pond (Table 28.). This survival rate was similar to the nearest Spring Chinook program at Winthrop National Fish Hatchery (WNFH), which was 0.74. Survival to MCN was 0.43 for CJH segregated Spring Chinook, 0.53 for the 10j fish from Riverside Pond and 0.54 for WNFH (Table 28.). For summer Chinook yearlings, the survival of segregated yearlings from CJH to RRJ was 0.71 (Table 29.). Unfortunately, we could not get a smolt survival for Omak integrated yearlings due to a late PIT tagging effort that resulted in disproportionately high mortality for that PIT tagged group (only 77 tags were detected leaving the pond). The mortality event only affected the PIT tagged group, not the entire release group. Survival to MCN for the segregated yearling program was 0.68. Carlton Pond (in the Methow) was the nearest like-program and had a survival that was lower to both dams (0.63 to RRJ and 0.55 to MCN).

Apparent survival to RRJ for sub-yearling summer Chinook released from CJH was 0.28 and survival from Omak Pond was 0.37 (Table 29.). In 2015, wild summer Chinook tagged at the mouth of the Okanogan had an apparent survival to RRJ of 0.26. Unfortunately, an estimate of survival to MCN could not be generated due to insufficient recaptures below MCN. The survival to RRJ observed in 2015 was the lowest since this data collection effort began in 2011 and 2015 was the first year where an estimate to MCN could not be generated (Table 30). In an attempt to remedy this, PIT tags from the beach seine were pooled with those from the rotary screw trap and tagging that occurred in a side-channel at Conservancy Island. This resulted in 1,964 more PIT tags in the release group but only 50 more PIT tags detected at RRJ and 6 more at MCN and did not result in a valid estimate to MCN (Table 30).

Table 28. PIT tag survival estimates for Spring Chinook Salmon smolts released from Chief Joseph hatchery and Winthrop National Fish Hatchery in 2015.

Spring Chinook Release Group	# PIT tags Released	Recap.	Reach Release to:	Survival	Survival Standard Error (SE)	Capture Prob.	Capture Prob. (SE)
Yearlings released at CJH	4420	1365	RRJ	0.73	0.04	0.38	0.02
		198	MCN	0.43	0.07	0.09	0.02
Yearlings released at Riverside (10j)	4395	1673	RRJ	0.79	0.03	0.43	0.02
		220	MCN	0.53	0.07	0.08	0.01
Yearlings released at WNFH	6506	2980	RRJ	0.74	0.02	0.41	0.01
		395	MCN	0.54	0.05	0.07	0.01

Table 29. PIT tag survival estimates for Summer Chinook Salmon smolts released from Chief Joseph hatchery in 2015.

Summer Chinook Release Group	# PIT tags Released	Recap.	Reach Release to:	Survival	Survival Standard Error (SE)	Capture Prob.	Capture Prob. (SE)
Yearlings released at CJH	4609	1316	RRJ	0.71	0.04	0.37	0.02
		145	MCN	0.68	0.14	0.04	0.01
Yearlings released at Omak Pond	77	5	RRJ				
		1	MCN				
Sub-yearlings released at CJH	4256	194	RRJ	0.28	0.08	0.14	0.04
		26	MCN	0.20	0.20	0.03	0.03
Sub-yearlings released at Omak	1089	281	RRJ	0.37	0.09	0.16	0.04
		34	MCN	0.23	0.15	0.03	0.02

Table 30. 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 were only the fish captured in the beach seine and 2015b 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 Released	Recap.	Reach Release to:	Survival	Survival Standard Error (SE)	Capture Prob.	Capture Prob. (SE)
2011	13,221	1,200	RRJ	0.45	0.02	0.20	0.01
		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	inf	(nan)	0	(nan)
2015b	7,787	569	RRJ	0.25	0.05	0.288	0.0628
		19	MCN	(nan)	0	0	(nan)

The travel time of fish released from CJH facilities to RRJ varied from 35 days (3.3 km/day) for sub-yearlings released from the hatchery to 15 days (10.8 km/day) for the 10j Spring Chinook released from Riverside Pond (Table 31.). One noteworthy difference between release sites was that CJH segregated Spring Chinook were nearly 3-fold slower migrating to RRJ than the 10j fish released from Riverside or the WNFH fish released in the Methow. Additionally, sub-yearling summer Chinook from the Omak Pond had the third fastest migration speed (5.7 km/day) of all release groups, outpacing all of the yearling summer Chinook groups (Table 31.). 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 28) Summer Chinook arrived at Rocky Reach over a 5-6 week period; late April to early June for yearlings and early June to late July for sub-yearlings.

For Spring Chinook, the 10j fish released from Riverside Pond arrived at RRJ somewhat earlier than for the CJH segregated releases (Figure 29). Spring Chinook from Riverside Pond had the most contracted arrival period (basically 2 weeks) at RRJ and the segregated Spring Chinook arrived over a 5 week period, similar to the Summer Chinook (Figure 29). 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)(Figure 30)

Table 31. Travel time and migration speed for various Chinook release groups in 2015.

2015 Release Group	First Day of Release 2015	Last Day of Release 2015	Forced or Volitional	To Rocky Reach Dam Mean Travel Time (d)	SE of Mean Travel Time (d)	Distance (km)	Travel Rate (km/day)
CJH Summer Subs	18-May	19-May	F	35.2	0.89	116	3.3
Omak Pond Subs	28-May	28-May	F	26.5	0.64	150	5.7
Wild subs	18-Jun	10-Jul	V	21.6	0.45	98	4.5
CJH Summer Yearlings	15-Apr	7-May	V	29.5	0.23	116	3.9
Carlton Yearlings	5-Apr	15-May	V	41.6	0.10	125	3.0
CJH Spring Chk	15-Apr	30-Apr	V	31.1	0.24	116	3.7
Riverside Spr Chk (10j)	15-Apr	21-Apr	V	15.0	0.11	162	10.8
Winthrop Spring Chk	15-Apr	21-Apr	V	15.9	0.12	163	10.2

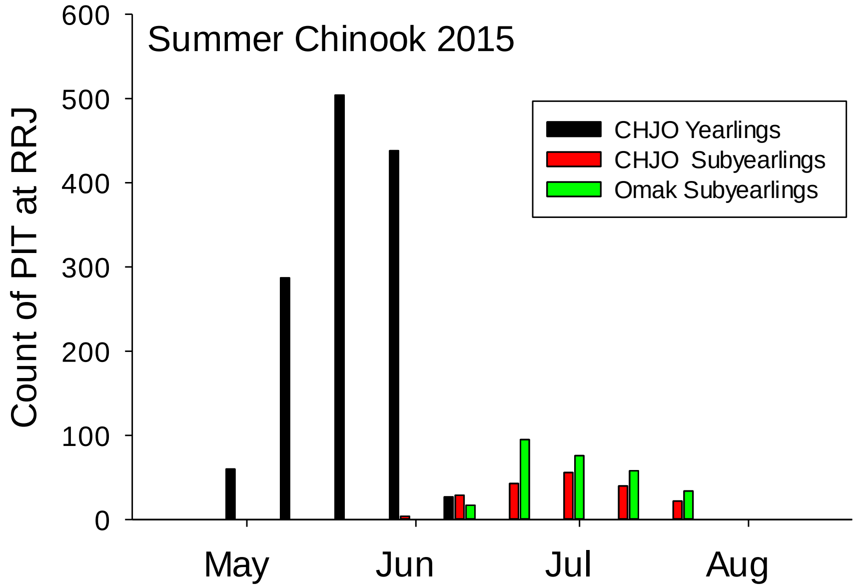


Figure 28. Arrival timing at Rocky Reach Juvenile bypass (RRJ) of PIT tagged summer Chinook released from the Chief Joseph Hatchery in 2015.

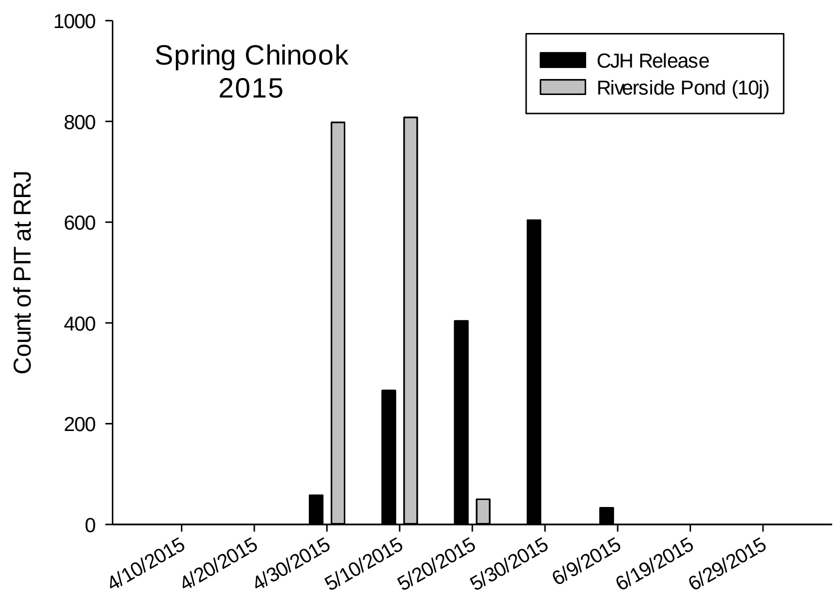


Figure 29. Arrival timing at Rocky Reach Juvenile bypass (RRJ) of PIT tagged Spring Chinook released from the Chief Joseph Hatchery in 2015.

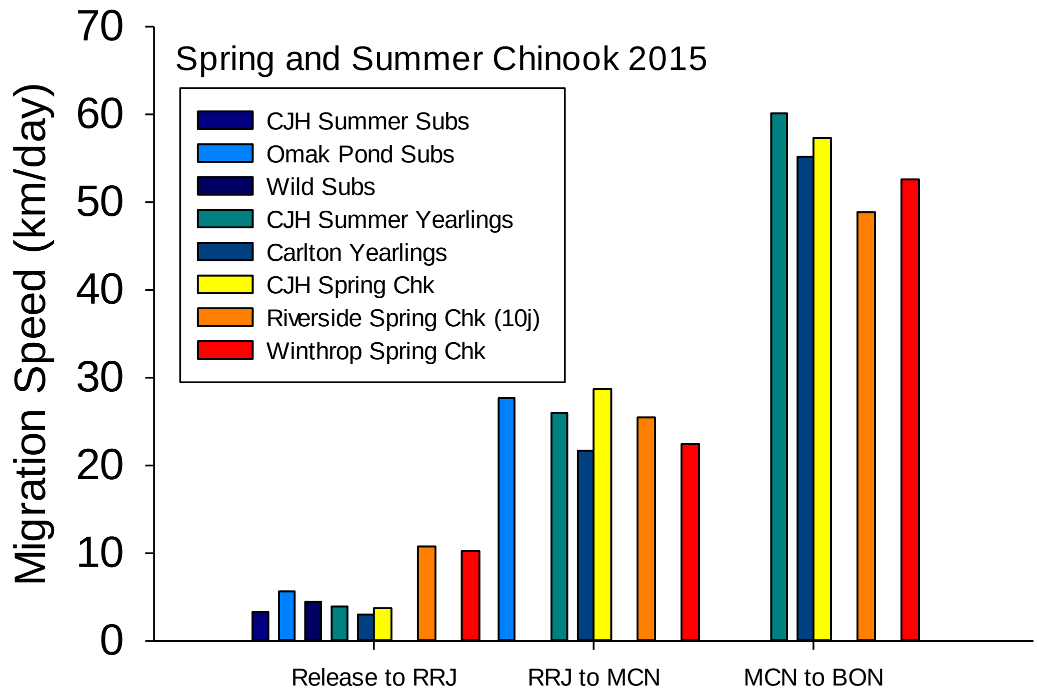


Figure 30. Migration speed for various release groups in three reaches of the Columbia River; their release site to Rocky Reach Juvenile bypass(RRJ), RRJ to McNary Dam (MCN) and MCN to Bonneville Dam (BON). Estimates were not generated for release groups with fewer than 10 individuals at a downstream site.

One hundred fifty two (152) hatchery smolts with a PIT tag were detected at OKL between April 16 and June 12. For Omak Pond sub-yearling Summer Chinook, 98% of the PIT detections occurred within three days of release and the last detection occurred on June 7 (Table 32.). For yearling Spring Chinook released from Riverside Pond, 95% of the PIT detections occurred within seven days of release and the last detection occurred on June 12 (Table 32.).

Table 32. Detections of PIT tags from release groups of hatchery smolts on the Okanogan River in 2015.

Release Group	Detection Date	Number Detected	Percent Detected	Cumulative % Detected
Omak Pond Sub-yearlings Release Date 5/28/2015	5/19/2015	3	3%	3%
	5/28/2015	51	46%	49%
	5/29/2015	43	39%	87%
	5/30/2015	9	8%	95%
	5/31/2015	3	3%	98%
	6/6/2015	1	1%	99%
	6/7/2015	1	1%	100%
Riverside Pond Yearlings Release Date 4/15/2015	4/16/2015	10	24%	24%
	4/17/2015	11	27%	51%
	4/18/2015	6	15%	66%
	4/19/2015	9	22%	88%
	4/20/2015	2	5%	93%
	4/22/2015	1	2%	95%
	5/3/2015	1	2%	98%
	6/12/2015	1	2%	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 33).

Table 33. 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%
Total	***10,053,000***	***111,181***	***1.2%***
5-year Total	***3,135,228***	***41,863***	***1.8%***

[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 analysis in an effort 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 reintroduction efforts. Analysis of eDNA data revealed that while spring-Chinook were listed as extirpated within the Okanogan ESU, 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 5 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 8 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.

PIT Tag Detections

PTAGIS contained 47 unique records of adult and jack spring-Chinook detected in the Okanogan basin in 2015 (Table 29). The majority (n=30; 64%) 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 detected in the Okanogan were re-detected in the Methow basin at a later date and one was detected moving downstream at OKL two weeks after moving upstream at OKL but was never subsequently detected in a tributary (Table 29).

Spring Chinook were detected at the Lower Okanogan array between May 9 and August 24, 2014 with a median run timing of June 1. The two fish that passed Zosel Dam did so on June 23 and 26, they were both tagged as an adult at Wells Dam and one was wild and the other was hatchery. 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.

There were zero PIT detections in the tributaries of the Okanogan in 2015. In past years, adult spring-Chinook have been detected in Salmon, Omak, Antoine, and Loup Loup creeks. In 2015 the tributary arrays were functioning in these creeks and several others but with the low flow conditions in 2015 it is possible that access to smaller tributaries was not favorable for Spring Chinook.

Four (9%) of the detections had been tagged and released as juveniles somewhere outside the Okanogan, including three that were released from hatchery facilities in the Methow and one in the Yakima (Table 34).

Table 34. Final PIT tag detections in the Okanogan for spring-Chinook in 2015. OKC/VDS3 is at vertical drop structure 3 in British Columbia upstream of Lake Osoyoos.

Origin	Release Location	Final Detection Location(s)							
		Lower Okan. River	Lower Okan., then Methow	Zosel Dam	Salmon Ck.	Omak Ck.	Other U.S. Trib	OKC /VDS 3	B.C. Trib
Hatchery Spring Chinook	Methow/ Winthrop Juvenile		3	1					
	Wells Dam Adult	28	12						
	Other (Clark Flat)	1							
Natural Spring Chinook	Wells Dam Adult	1		1					
	Twisp R. Juv.								
	Entiat R. Juv.								
	Rock Isl. Dam Juv.								
	Methow R. Juv.								
Summer Chinook (mis-classified)	NA								
	NA								
	Total	30	15	2					

*note: One fish was also detected moving downstream at OKL 2 weeks after being detected moving upstream at OKL but never re-detected in a tributary

DISCUSSION

Rotary Screw Traps (RST)

The pooled trap efficiency of approximately 0.73% is similar, but slightly lower than previous observations (Rayton and Arterburn 2008, Johnson and Rayton 2007; http://www.colvilletribes.com/media/files/2006_Screw_Trap_Report_Final.pdf; http://www.colvilletribes.com/media/files/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 (985,813). This indicates that, due to the difficulties in accurately estimating trap efficiency and juvenile production, the results of screw trapping activities in 2015 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 larger release groups ($n \geq 500$).

Similar to 2014, an attempt was made in 2015 to collect the data necessary to use a new flow regression model that may be capable of a lower CV that meets the NOAA recommendation of 15% or less (Murdoch et al. 2012). However, because of the inability of river flow to explain variance in trap efficiency, we were unable to use the flow-based regression model. 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.

Finally, Pacific lamprey (*Entosphenus tridentatus*) were captured in the RST in both 2006 and 2007, but were not observed from 2008 to 2015. 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. More than 7,000 sub-yearling Chinook were captured from Gebber's Landing over a four-week period. Of these fish, 5,823 were PIT tagged and released into the Columbia River in June and July.

Mortality related to capture, handling and tagging was higher than expected (13%) and would have been lower if loading densities and holding time were reduced after capture and before transfer to the net pens. Also, maintaining water temperatures below 18 °C, and further limiting exposure to anesthetic during tagging likely would have decreased our post tagging mortality. Improved handling and tagging procedures is expected in 2016.

Fish size increased through the tagging period, but the number of fish captured decreased at the beginning of July. Nine percent of all released fish were detected at Rocky Reach Dam. Most migrating fish detected at Rocky Reach occurred there in the month of July (87%), with detections continuing through August 22. There was evidence of one fish potentially overwintering in the Columbia River, with a detection on November 25 at McNary Dam.

Although capture locations in 2015 were limited, 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.

Lower Okanogan Adult Fish Pilot Weir

Discharge conditions on the Okanogan River in 2015 were low, allowing for installation and operation of the weir in mid-July, which was 3-4 weeks earlier than previous years. Temperatures on the Okanogan River were fairly high in July and most of August which limited Chinook movement and trapping operations. Temperature slowly dropped below 22.5 °C in late August. During this time trapping operations were suspended for one week due to the hazardous working conditions created by the Okanogan Complex wildfires. 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 the mode of fish passage occurred during this trapping suspension, within a week after the mean daily temperature dropped below 22.0 °C. Tower and bank fish observations were generally higher after the thermal barrier broke on August 20. 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 gage 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.

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 (263) of dead fish at the weir was higher in 2015 than previous years. This was due primarily to the very warm water conditions in 2015 and because the weir was installed much earlier in 2015. Mortality was highest during non-trapping periods in July and early August, indicating that trap operation and handling were not the cause of mortality. We do not believe that dead 'wash ups' were a good indicator of weir effects. A fish kill upstream that had nothing to do with the weir could cause many fish to wash up on the upstream side of the weir. Conversely, any adverse effects of the weir would not have been detected if fish carcasses were stranded on shore or taken by scavengers before washing up on the weir. However, behavioral observations and the lack of fish impinged between pickets (head upstream) were good indicators that this weir configuration and picket spacing were not a major cause of direct mortality. No data were collected to assess indirect mortality.

Weir trapping and fish handling commenced when temperatures were sufficient. Natural-origin Chinook were successfully trapped and released into the river. Natural-origin broodstock were successfully collected and there was 100% survival to spawning. There were few observations of Sockeye at the weir and only four were trapped in 2015. Unfortunately, this did not allow for confirmation of the observations made in 2014 of large numbers of Sockeye (and Chinook) swimming through the 2.5 and 3.0 inch picket spacing. Most sockeye passed the weir when the pickets were pulled adjacent to the trap (i.e., non-trapping configuration) and therefore did not need to pass through the trap or the 2.5-3.0 inch picket spacing. It is also possible that more sockeye moved more at night in 2015 which would have precluded observations of movement through the weir. A few jack and small adult Chinook escaped through the 3.0 inch spacing of weir panels that were intended to allow Sockeye passage. We recommend testing a weir configuration that does not include the 3.0 inch weir panels to increase the efficiency of Chinook trapping without causing too many Sockeye to also use the trap. Based on 2014 observations the 2.5 inch picket spacing was adequate to allow passage of sockeye when the weir was in trapping configuration.

There was no way to know how many fish escaped past the weir before it was installed or how many fish swam through, around or jumped over the wings after it was installed. The number of Chinook handled at the weir (n = 54) was considerably less than previous years (2014 = 2,324; 2013 = 91). The potential weir effectiveness measure of .70% was low because there was not a thermal barrier break with cool enough temperatures to allow trapping and subsequently the mode of fish passed the weir during a period of suspended trapping operations due to fires. Thus, despite the early deployment of the weir was not an effective tool for pHOS management in 2015. Fortunately, this did not hinder fish management objectives in 2015 because pHOS was already low and only 14% 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 collection objective through the trap post thermal barrier breakdown was relatively low, collecting only 19 fish. The 100% survival rate provided confidence that the weir can be used for broodstock collection in the future. We recommend a continued risk-averse approach to broodstock collection at the weir in 2016, particularly if natural origin broodstock are collected. The effects on survival and egg viability due to prolonged prespawn holding in the Columbia River and late migration into the relatively warm Okanogan have not been evaluated.

Although the weir was not very successful at trapping Chinook in 2015, 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 2016.— In December 2015, 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 2015 weir operations was presented at the 6th Annual Chief Joseph Hatchery Program's Annual Review. This presentation is posted on the programs website at: www.colvilletribes.com/cjhp.php

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 2014 and 2015, to occur this year. The following recommendations are derived from the 2014 and 2015 post-season analysis and the subsequent findings from CCT's research, monitoring and evaluation activities:

1. Install additional walkway access point sections
2. Live box(s) fabrication
3. Walkway fish transport carts
4. Consider alternative power source locations
5. Consider alternative trap locations
6. Add two more sections of trap walk way
7. Additional trap panel closure aprons (to block fish from going under the trap)
8. Trap access ladder for personnel
9. Recessed video and lighting housings
10. Adjusting entry and crowder gate alignment
11. Install weir panels adjacent to trap box and direct water velocity through the trap
12. Install a fish transport system from the trap to the east bank, which will be used to move dead fish to the workup facility on the east bank or live fish to a tanker truck for subsequent transport to the hatchery.

Redd Surveys

Summer Chinook spawning activity was high again in 2015, with the highest redd count observed in the Okanogan River Basin since 2006 and above average redd counts in all reaches but O-4 (Table 17.).

The redd count in reach O-5 was the highest on record, and this continued an increasing trend of redd building in that reach. One objective of the new CJHP is to increase spawning distribution in the lower reaches of the Okanogan where a low proportion of the spawning activity has traditionally occurred. Continued monitoring of redd and carcass distribution will be critical to evaluation of this metric.

Although aerial surveys contributed a relatively small portion of the observed redds, they were very important for documenting that little to no spawning is occurring in areas not surveyed with a ground crew, and for enumerating redds in non-floated, low density spawning areas. In 2015, we extended aerial surveys into the second week in November to look for late spawning Chinook redds. While there was not significant redd-building activity detected in the last survey, the new detected redds occurred further downstream in the basin, which, though anecdotal in nature, confirmed the current belief that later-arriving spawners spawn further downstream (Table 19).

Spawning surveys should have started earlier because the majority of redds were created by the second week of surveys. Ideally, redd surveys should begin at the onset of spawning to better assess the entire spawning period. Earlier redd count efforts would also help us to better assess pre-spawn mortality.

The fish per redd expansion was based on the sex ratio at 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. Informal discussions with Canadian biologists indicate that small numbers (i.e., substantially fewer than the Zosel Dam video counts) of Chinook spawners have been detected 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 don't re-ascend).
b) Conduct more extensive surveys in Canadian Okanagan River of larger substrate areas during peak summer Chinook spawning (mid-late October). It is not clear where, when, or if there are gaps in time and space that would allow Chinook spawning to go undetected.
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

3,293 carcasses were recovered out of an estimated 13,769 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).

Egg retention and pre-spawn mortality results should be interpreted cautiously. Carcass collection for examination did not begin in 2015 until October 5. Redd surveys show this date to be later than the onset of spawning activity. 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 5,000 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. The program met the biological target for PNI (>0.67) for the second year in a row. The 5-year mean (0.74) 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 (94%) from the Okanogan Basin releases. Stray hatchery-origin fish from outside the Okanogan made up only 1.07% of total estimated spawners. Likewise, Okanogan Basin hatchery-origin fish strayed to other areas at a low rate (0.6%) and were a small percentage of the spawner composition in other Upper Columbia tributaries. Thirteen fish released from Similkameen Pond were detected on spawning grounds surveys at the Wenatchee, Methow, and Chelan Rivers in 2015 (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 2015 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 2015 estimates of CJH programs were similar to nearby programs. In the future, 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. Future evaluations should also look for residual fish or fish that migrate out of the system the following year, particularly for the sub-yearling releases. With the first year of data, it appeared that all hatchery fish migrated out of the system relatively quickly, 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.

Low snowpack from winter conditions in 2014 and 2015 with above normal temperatures and below normal precipitation in 2015 resulted in record low stream flow conditions in the Okanogan basin. This contributed to warmer water temperatures compared to the average in the Okanogan River. These conditions could have adversely affected the survival of CJH juveniles that were released in 2015 (i.e. growth rates, spatial and temporal distribution, smoltification, increased risk of disease and predation). It's difficult to conclude the degree at which these elevated temperatures affected survival with only one year of data, but water temperature in the Okanogan River should continue to be monitored so that comparisons can be made with future releases of CJH juveniles.

The vast majority (>95%) of PIT tagged hatchery smolts released from Omak Pond (sub-yearling Summer Chinook) and Riverside Pond (Spring Chinook yearlings) migrated to the lower Okanogan River within one week of release. There were zero detections of juvenile hatchery fish at OKL after June 12. 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.

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 2016 with the purpose of reviewing data collection efforts and results from 2015 and developing the hatchery implementation and monitoring plan for 2016 (Figure 31). 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 32). 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 2015. APR materials with more details than what is provided within this report can be found at www.colvilletribes.com/cjhp.php.

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[9]
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. How should the program be operated in the coming year?

[9] 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.

Figure 31. The Chief Joseph Hatchery's annual planning process and work flow.

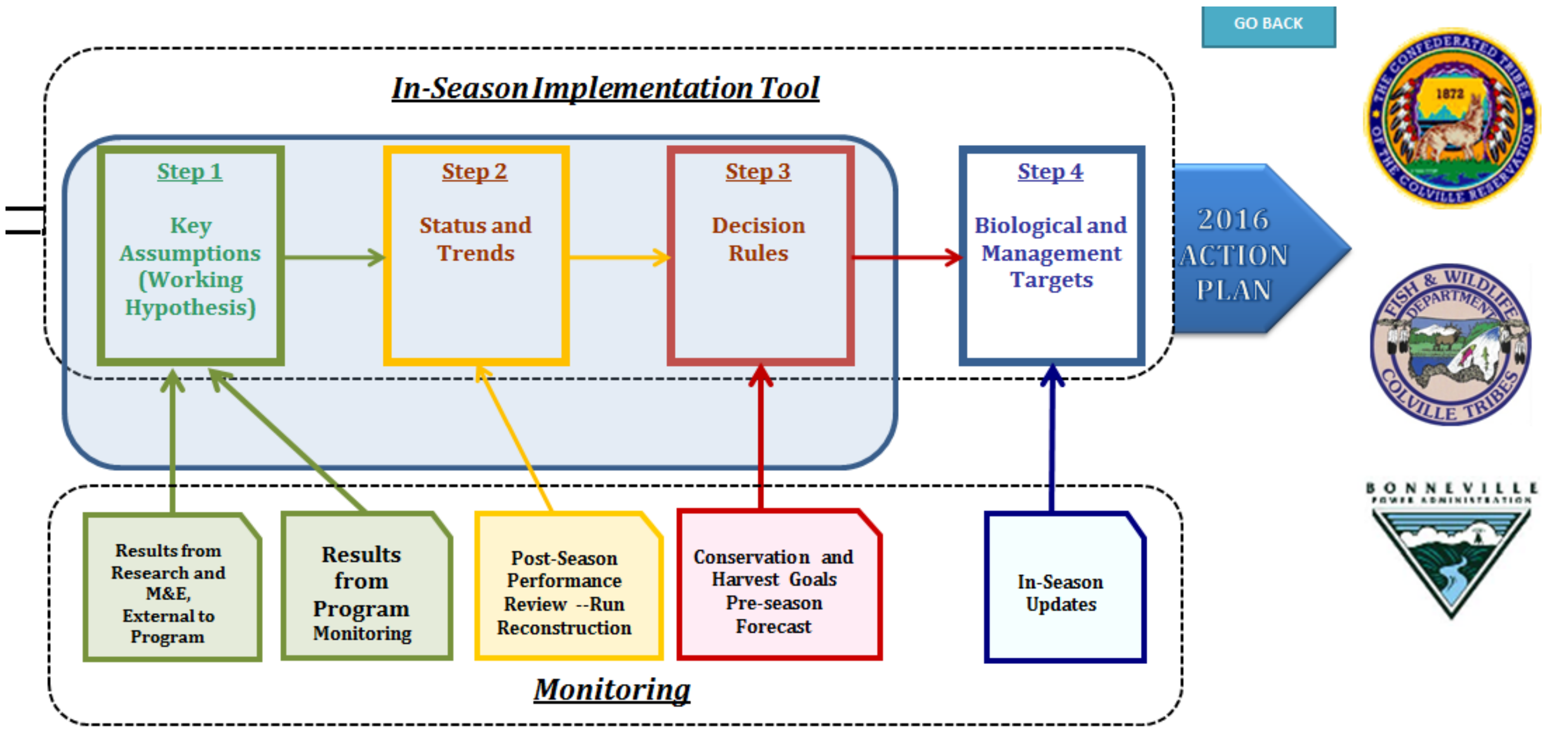


Figure 32. The Chief Joseph Hatchery's analytical work flow.

2016 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 93,300. 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 93,300 upper Columbia would yield 12,357 NORs and 4,423 HORs (Figure 33). 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 (602 NOB) with 100% pNOB (Figure 33). Likewise, the segregated program should achieve full production with 491 HOB. The model predicted that 1,198 HORs would be captured in the terminal (above Wells Dam) fisheries and that 247 HORs could be removed at the weir. These efforts could result in 10,012 NOS and 1,215 HOS for a pHOS of 9% and a PNI of 0.92. 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, 2016. 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).

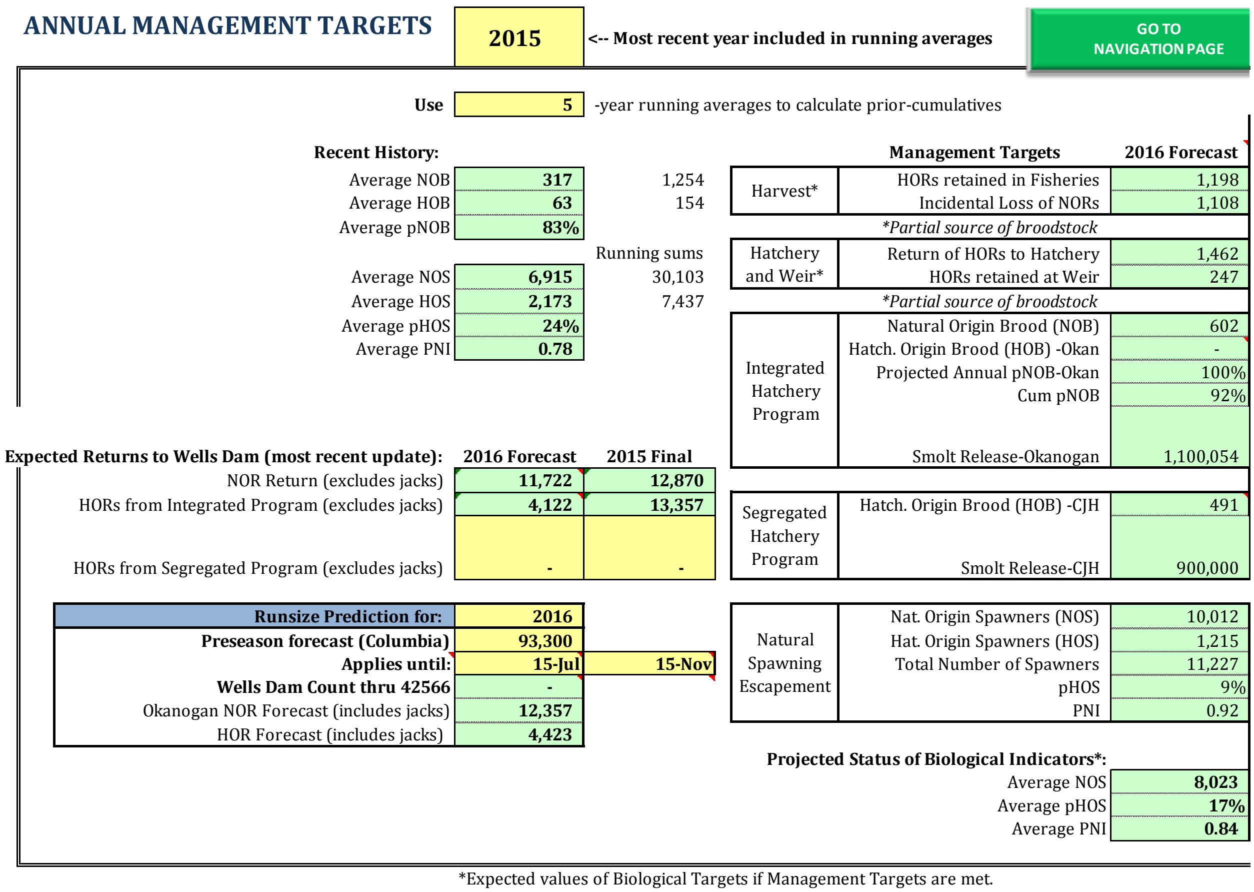


Figure 33. The in-season updates management worksheet used to set biological targets for the upcoming year (2016) in the In-Season Implementation Tool.

2016 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 34).

KEY ASSUMPTIONS

GO TO NAVIGATION PAGE

Return to Previous Screen

	Baseline		Biological Targets	Transition 1	Transition 2	Long-term	Segregated Prog
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	0.71			0.84	0.86	0.91	
PNI	0.52	<	0.67	0.63	0.64	0.64	
Total pHOS	47%	>	30%	58%	57%	55%	
Segr. pHOS	5%	<	5%	7%	6%	6%	
Ocean Harvest Rate	30%			30%	30%	30%	
Lower Columbia Harvest Rate (Zones 1-6, Mouth to MCN)	8%			8%	8%	8%	
Upper Columbia Harvest Rate (MCN to Wells)	28%			28%	28%	28%	
Terminal Harvest Rate (Post Wells)	6%			6%	6%	6%	
Natural Origin Spawners	880	<	5,250	409	642	728	
Hatchery Production							
Local Brood	316			602	549	549	330
Yearling Release	576,000			800,000	1,000,000	1,000,000	500,000
Sub-yearling Release	-			300,000	0	0	400,000
SAR (yearling)	1.65%			1.65%	1.65%	1.65%	1.65%
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	158			602	549	549	
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)	8%			8%	8%	8%	8%
Upper Columbia Harvest Rate (MCN to Wells)	28%			28%	28%	28%	28%
Pre-terminal Harvest Rate (Ocean to Wells)	54%			54%	54%	54%	54%
Terminal Harvest Rate (Post Wells)	29%			29%	29%	29%	90%
Hatchery Surplus	685			849	1,312	1,060	199
Average Terminal HOR Run	4,415			6,132	7,665	7,665	3,832
Expected HOS	1,566			1,807	2,259	2,259	462
Fisheries and Weirs							
Weir Factor	0%			17%	17%	17%	
NOR Harvest Release Mortality	5%			5%	5%	5%	

Figure 34. 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 35).

Return year		FPC Reported Dam Count at Wells thru 7/15	% of final count	PUD Counts at Wells Dam: NOR All Origins (includes jacks)	PUD Counts at Wells Dam: HOR All Origins (includes jacks)	Estimated Return of Okanogan Origin Fish to: **Okan. NORs**	Estimated Return of Okanogan Origin Fish to: Okan. HORs
1998	3	**1,060**	0.25	970	5,519	679	696
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	6,473	6,419
2012	17	**10,082**	0.24	14,424	27,716	6,863	7,393
2013	18	**25,571**	0.38	34,965	30,179	8,258	8,072
2014	19	**26,010**	0.39	36,060	21,015	12,797	7,867
2015	20	**25,153**	0.38	46,030	31,625	13,567	14,332
2016	21	-		-		-	-

Return year	Terminal Harvest Above Wells – Tribal Harvest: **Total Tribal Harvest**	Total NORs	Total HORs	Okan. NORs	Okan. HORs	Recreational Harvest: **Total Rec. Harvest**	Total NORs	Total HORs	Okan. NORs	Okan HORs	Harvest Rates: NOR	Harvest Rates: HOR
1998	-	0	0	-	-	-	-	-	-	-	0%	0%
1999	-	0	0	-	-	-	-	-	-	-	0%	0%
2000	-	0	0	-	-	-	-	-	-	-	0%	0%
2001	-	0	0	-	-	-	-	-	-	-	0%	0%
2002	**1,753**	653	1100	118	990	-	-	-	-	-	2%	8%
2003	**2,130**	785	1345	141	1,211	-	-	-	-	-	6%	41%
2004	**242**	0	242	-	218	**2,803**	1,895	908	1,706	817	22%	40%
2005	**784**	392	392	71	353	**1,419**	1,025	394	923	355	12%	21%
2006	**1,389**	563	826	101	743	**2,119**	1,809	310	1,628	54	21%	19%
2007	**1,078**	467	611	84	550	**1,803**	887	916	798	726	20%	44%
2008	**2,299**	588	1711	106	1,540	**1,665**	698	967	628	561	17%	33%
2009	**2,598**	363	2235	65	2,012	**1,062**	648	414	583	244	12%	40%
2010	**2,912**	354	2558	64	2,174	**1,019**	612	407	551	204	14%	44%
2011	**1,097**	449	648	81	577	**1,017**	200	817	180	556	4%	18%
2012	**3,184**	656	2528	118	2,250	**2,470**	829	1,641	746	1,264	13%	48%
2013	**3,176**	832	2344	150	2,110	**2,107**	179	1,928	161	1,735	4%	48%
2014	**2,963**	1508	1455	271	1,310	**1,383**	321	1,062	289	956	4%	29%
2015	**9,729**	6257	3472	1,126	3,125	**1,660**	289	1,371	260	1,234	10%	30%
2016							-	0%			-	-

Return year	Broodstock – Okanog./Similk Integrated Program: Total NORs	Okan. NORs	Total HORs	Total Brood	Okanogan origin pNOB	Okanogan Natural Spawning Escapement: NOS	HOS	Census pHOS	Effective pHOS	PNI
1998	153	77	211	364	21%	542	437	45%	39%	35%
1999	224	112	289	513	22%	1,182	2,142	64%	59%	27%
2000	164	82	339	503	16%	926	1,726	65%	60%	21%
2001	91	46	266	357	13%	4,048	6,047	60%	54%	19%
2002	247	124	241	488	25%	4,337	9,473	69%	64%	28%
2003	381	191	101	482	40%	1,892	1,463	44%	38%	51%
2004	506	253	16	522	48%	5,182	1,392	21%	18%	73%
2005	391	196	9	400	49%	6,364	2,416	28%	23%	68%
2006	500	250	10	510	49%	5,303	2,970	36%	31%	61%
2007	456	228	17	473	48%	2,774	1,282	32%	27%	64%
2008	404	202	41	445	45%	2,866	3,734	57%	51%	47%
2009	507	254	-	507	50%	4,002	3,036	43%	38%	57%
2010	484	242	8	492	49%	3,087	2,614	46%	40%	55%
2011	467	332	26	493	67%	4,470	4,283	49%	43%	61%
2012	107	96	-	107	90%	4,743	3,317	41%	36%	71%
2013	366	329	1	367	90%	5,091	1,926	27%	23%	79%
2014	499	449	5	504	89%	9,648	1,530	14%	11%	89%
2015	421	379	9	430	88%	10,621	2,523	19%	16%	85%
2016					-	-	-	-	-	-

Figure 35. 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 36).

Edit the yellow cells to change the phase triggers and management control variables.

Population Designation: Primary
Select the Current Phase: Transition 1

Criteria for changing program phase	Current phase Transition 1	Baseline	Recolonization Transition 1	Local Adapt. Transition 2	Recovered Long term
Year	2013	2013	2013	2025	-
Move up one phase if NORs greater than:	5,250	-	5,250	7,000	-
Move down one phase if NORs less than:	800	-	800	3,000	6,000

	Management Control Variables	Current Phase Transition 1	Baseline	Phase 1 Transition 1	Phase 2 Transition 2	Phase 3 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	215,000	800,000	1,000,000	1,000,000
	Maximum Sub-yearling Releases	300,000		300,000	-	-
	Broodstock Required	602	118	602	549	549
	pNOB Trigger (NOR run)	3,000	1,100	3,000	3,000	3,000
	pNOB above Trigger	100%	50%	100%	100%	100%
	pNOB below Trigger	30%	30%	30%	100%	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	17%	17%	17%	17%	17%
	Term. Harvest Rate Integrated HORs	29%	29%	29%	29%	29%
	Term. Harvest Rate Segregated HORs	29%	29%	29%	29%	29%

CONSERVATION AND HARVEST GOALS (based on 5-year running averages)

	Program Targets	Status in 2015	Projected Status in 2016	Projected Status in 2016-2040	
				Median*	Range*
NOS	> 5250	6,915	8,023	5,587	844 - 11,682
pHOS	< 0.3	24%	17%	36%	10% - 56%
PNI	> 0.67	0.78	0.84	0.73	0.64 - 0.91
Terminal Catch	> 3000	1,198	2,306	5,662	785 - 12,614

*Median, minimum and maximum values from 2016 to 2040 based on a single model run.

Figure 36. 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 2015, 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. Both the 10(j) spring Chinook reintroduction program and the segregated Spring Chinook programs were near full program.

Spring Chinook Salmon

BY 2014 Leavenworth Spring Chinook Rearing and Release

Due to the extremely high pre-spawn mortality on the 2014 brood Leavenworth Spring Chinook, a request was made to USFWS for any surplus of Carson Stock to backfill the shortage. Leavenworth National Fish Hatchery did have excess eyed eggs, but the ELISA profiles were too high to risk a transfer. Carson National fish Hatchery did have eggs available, and on October 17th, CJH staff transported 352,900 eyed eggs to the hatchery. At marking, the Leavenworth stock and Carson stock Spring Chinook were combined into rearing pond "A". A combined total of 576,395 Spring Chinook were Ad-clipped, with a total of 205,000 also receiving a CWT. This group also received 5,000 PIT Tags, with a total of 4,732 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. Volitional release began on April 15th, with all fish out of the pond on April 21st.

Table A 1. Chief Joseph Hatchery BY 2014 Spring Chinook rearing summary, April 2016.

	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
Month	Total	Total	Total	Total	Total
LVNW/CR					
July 31	576,395	2,460	1,298	80	96.5%
Aug 31	564,650	1,000	2,624	50	95.2%
Sept 30	564,537	113	3,205	40	95.2%
Oct 31	564,415	122	2,580	30	95.2%
Nov 30	527,355	37,060	2,904	25	88.9%
Dec 31	526,217	1,138	1,731	20	88.7%
Jan 31	526,209	8	1,716	17	88.7%
Feb 29	526,203	6	440	17	88.7%
Mar 31	526,158	45	1,320	16	88.6%
Apr 21	**526,136***	22	1,733	15	88.6%
Cumulative	526,136	45,341	25,979	15	88.6%

*Released

Cumulative egg to smolt survival

The cumulative egg to smolt survival for the 2014 brood Leavenworth / Carson Spring Chinook was 88.6%. 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).

BY 2014 10J MET COMP SPRING CHINOOK REARING AND RELEASE

On October 31st, 2014, CCT staff transported 218,881 MetComp Spring Chinook from the USFWS Winthrop Hatchery 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 began volitional release on April 15th, with the final release on April 21st, 2015. Table A 2 illustrates feed fed, feeding rate, and mortality to date. After subtracting mortality and shed tags, a total of 3,965 PIT tags were released.

Table A 2. Riverside Acclimation Pond BY 2014 Integrated Spring Chinook rearing summary, April 2016.

	Total on hand	**Mortality**	**Feed Fed**	**Fish per pound**	**Cumulative Survival (%)**
Month	**Total**	**Total**	**Total**	**Total**	**Total**
Mar. 31	212,514	3,891	169	350	97.1%
April 30	212,025	489	388	250	96.8%
May 31	211,949	76	483	150	96.8%
June 30	206,691*	1,142	884	100	96.2%
July 31	206,539	152	741	70	96.1%
Aug 31	206,442	97	867	50	96.1%
Sept 30	206,406	36	1,500	40	96.0%
Oct 31	206,399	104	1,110	30	96.0%
Nov 30	204,880	1,519	616	27	95.3%
Dec 31	203,854	1,026	44	28	94.9%
Jan 31	203,649	205	176	28	94.8%
Feb 29	203,607	42	968	27	94.8%
Mar. 31	203,400	207	2,640	20	94.7%
Apr 21	**203,311****	89	3,080	13.8	94.6%
Cumulative	203,311	8,981	12,799	13.8	94.6%

2015 Brood Collection

The segregated spring Chinook production goal for the 2015 brood is a release of 700,000 yearlings in April of 2017. 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 estimates were based on LNFH data. 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 648 spring Chinook broodstock were transferred from LNFH to CJH between May 21 and May 26, 2015; including 318 females, 330 males (Table A 3). The 648 spring Chinook transferred represents 101.3% 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 54.5° 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 a minimum of 3 days per week with formalin to control fungus, at a rate of 1:6000, for one exchange.

On June 25, 2015 and again on July 30, 2015, USFWS DVM Sonia Mumford assisted hatchery staff with inoculations for all spring Chinook brood. Each female was inoculated with Gallimycin – 100 at a rate of .50 ml per 10 lbs. / fish IP, for reduction of BKD, and Vetrimycin – 200 (Oxytetracycline) IP; at the same dosages, for reduction of pre-spawn mortality due to furunculosis. Changing our water supply to 100% well water has prevented the outbreaks of furunculosis that we have experienced in the past, and pre-spawn mortality was extremely low. Overall survival was 96.8% for females and 99.4% for males, with a combined survival of 98.1% (Table A 5)

Table A 3. Chief Joseph Hatchery spring Chinook broodstock transfer summary for 2015.

Date	Trapping site	Receiving Facility	Males Adult	Males Jack	Males Total	Females	Total Broodstock	Holding Temp (°F)	Transport Temp. (°F)	Transport Density (lbs./gal)
5/21/2015	LNFH	CJH	164	0	164	161	325	48	51	0.48
5/26/2015	LNFH	CJH	166	0	166	157	323	48	51	0.48
Total			**330**	**0**	**330**	**318**	**648**			

Table A 4. Spring Chinook broodstock adult holding conditions for 2015.

Transfer Date	Adult Pond	Males Adult	Males Jack	Males Total	Females	Total Broodstock	Transport Temp (°F)	Holding Temp. (°F)	Flow Index	Density Index
5/21/2015	#5	164	0	164	161	325	51	56	0.26	0.05
5/26/2015	#6	166	0	166	157	323	51	56	0.26	0.05

Table A 5. Chief Joseph Hatchery spring Chinook broodstock holding and survival summary for 2015. (M= adult males, J = jacks, and F = adult females). The survival standard for this life stage was 90%.

Beginning			Ending			Mortality			Cumulative Survival (%)		
M	J	F	M	J	F	M	J	F	M	J	F
330	0	318	328	0	308	2	0	10	99.4%	NA	96.8%

Spawning

Spring Chinook spawning occurred between August 18 and September 9, 2015 (Table A 6). The spawn consisted of 308 females and 307 males, with ten non-viable (green) females killed resulting in a green egg take of approximately 1,159,000 (Table A 6).

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 trey. The eggs from 2 females were culled due to high or moderate ELISA results (culled eggs from Elisa results are not included in Table A 6). This was approximately 0.6% of the females spawned and was 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 40° F degrees. This process was done over a several hour period the day after spawning. The second egg take was left on well water (54° 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 40° 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 91.4% (Table A 6). This survival was slightly higher than the key assumption (90%).

As a result of the lower than normal pre-spawn mortality, coupled with a much lower culling rate than expected and higher green to eyed survival, 87,966 eyed eggs were culled.

Rearing

Due to the manipulation of TUs, all groups of spring Chinook was brought out of incubation and transferred into early rearing troughs on February 5, 2016, and the second group on February 12, 2016. During the month, this 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. No inventory was taken at this time to prevent excess handling stress. Survival from incubation to ponding was 98.5% which exceeded the standard (95%) for this life stage (Table A 7).

Table A 6. Chief Joseph Hatchery spring Chinook spawning and survival summary for 2015 (M = adult males, J = jacks and F = adult females). The target survival standard for this life stage was 90%.

	Total Adults Spawned			Green Egg Take	Eyed Egg	Mortality (Pick off)	Cumulative Survival (%)
Month	M	J	F	Total	Total	Total	Total
August 18	66	0	66	250,800	209,828	21,458	90.7%
August 25	113	0	111	421,800	297,300	25,731	92.0%
Sept. 1	100	0	100	380,000	295,042	27,513	91.4%
Sept. 9	28	0	31	106,400	77,848	7,917	90.7%

Table A 7. Chief Joseph Hatchery spring Chinook ponding summary for BY 2015.

	Total Fry Ponded	Ponding Mortality	Monthly Feed	Monthly Mortality	Ponding Loss (%)	Cumulative Survival (%)
Production Group	Total	Total	Total	Total	Total	Total
LVNW	869,007	11,011	273	13,762	1.2%	97.8%

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

Spring Chinook were fed BioVita diet, and converted at an average of 0.57:1. 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 2015 segregated spring Chinook rearing summary as of April 2016.

	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
Month	Total	Total	Total	Total	Total
LVNW					
Apr. 30	761,868	19,173	2,26 0	250	97.8%

Summer/Fall Chinook Salmon

BY 2014 SUMMER/FALL CHINOOK SALMON REARING AND RELEASE

A total of 736,567 sub-yearling summer/fall Chinook were brought out of incubation from January 9th, 2015 through January 21st, 2015. An addition 1,019,755 yearling summer/fall Chinook were also brought out of incubation from March 13th, 2015 through May 1st, 2015.

Rearing proceeded on schedule, with the marking and releasing of both the integrated and segregated sub-yearlings in April. On May 12th, a total of 306,165 integrated sub-yearlings were transferred to the Omak Acclimation Pond, at 85 fpp. This group was released on May 28th, 2015, with a post transfer survival of 99.8%, and a cumulative survival from ponding of 91.9%.

Table A 9. Chief Joseph Hatchery brood year 2014 Integrated summer/fall sub-yearling rearing summary.

	Total Planted	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
Month	**Total**	**Total**	**Total**	**Total**	**Total**
May 28	305,732	433	1,100	39.5	99.85
Cumulative	305,732	16,597	4,797	46.3	94.67

A total of 375,327 segregated summer/fall sub-yearlings were marked and transferred into rearing pond B, for final rearing and release. This group was released on May 24th, 2015, at 46 fpp. Cumulative rearing survival was 93.5%.

Table A 10. Chief Joseph Hatchery brood year 2014 Segregated summer/fall sub-yearling rearing summary.

	Total Planted	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
Month	**Total**	**Total**	**Total**	**Total**	**Total**
May 24	375,315	26,067	5,419	46.0	93.5
Cumulative	375,315	26,067	5,419	46.0	93.5

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 15th, 2015. 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 Table A 11, 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 ponds B & C, 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 from April 15th thru April 21st, 2016. Approximately 5,000 PIT tags were added to each group in October 2015. After subtracting shed tags and mortality, a total of 4,449 PIT tags were released from the segregated group. Final conversion from rearing stage to release was 1.22.

The integrated Summer Chinook were shipped to the Omak Acclimation Pond, and the Similkameen Acclimation Pond, on November 5th, 2015. Reporting for the Similkameen Pond will reside with WDFW through release. Volitional release began April 15th, 2016 at the Omak Pond, with all fish released by April 22nd, 2016.

Table A 11. Chief Joseph Hatchery BY 2014 Segregated Summer/Fall Chinook rearing summary.

	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
HORs					
Month	**Total**	**Total**	**Total**	**Total**	**Total**
Apr. 30	205,513	4,237	96	650	97.9%
May 31	405,787	6,237	776	270	97.4%
June 30	404,999	788	1,199	150	97.3%
July 31	404,787	212	1,415	100	97.2%
Aug. 31	413,416*	1,153	1,011	60	96.9%
Sept. 30	413,298	118	3,397	40	96.9%
Oct. 31	413,183	115	2,346	30	96.9%
Nov. 30	402,886	10,297	3,084	25	94.5%
Dec. 31	401,613	1,273	1,745	20	94.2%
Jan. 31	401,371	242	1,452	17	94.2%
Feb. 28	401,339	32	352	17	94.1%
Mar. 31	401,248	91	2,464	15	94.0%
Apr. 21	**401,215^**	33	1,882	12.3	94.0%
Total	401,215	24,828	21,219	12.3	94.0%

* Overage of 9,782 ^ Released

Omak Acclimation Pond

On November 5th, 2015 Chief Joseph Hatchery staff transferred 265,726 Integrated BY 14 Summer Chinook from Chief Joseph Hatchery to the Omak Acclimation Pond. At the time of transfer, the fish were approximately 26 fpp, and were programmed to be reared over winter, with a target size at release of 10 fpp. An additional 342,556 BY 14 Summer Chinook were transferred to WDFW's Similkameen Pond, as part of the cost share agreement. These fish began volitional release April 15th, and ended on April 21st, 2016. 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 2,512 PIT tags were released.

Table A 12. Omak Acclimation Pond BY 14 Integrated Summer/Fall Chinook rearing summary.

	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
Month	Total	Total	Total	Total	Total
Nov. 30	256,924	8,802	1,320	27	95.6%
Dec. 31	251,934	4,990	44	27	95.1%
Jan. 31	245,771	6,163	264	27	94.5%
Feb. 28	242,541	3,230	1,276	26	93.3%
Mar. 31	234,323	8,218	3,608	20	92.0%
April 21	**232,353^**	1,970	3,300	12.4	91.4%
Cumulative	232,353	33,373	9,812	12.4	91.4%

Riverside Acclimation Pond

Riverside Acclimation Pond was not used to rear BY 2014 summer/fall Chinook, but was utilized to rear BY 14 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 2014 were collected via the CCT purse seine as part of the transition to the collaborative CJH program. On November 3rd and 4th, 2015, Chief Joseph Hatchery staff transferred 342,556 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 26.2 fpp, and were programmed for over winter acclimation, with a target size at release of 10 fpp. These fish began volitional release on April 15th, with an end release date of April 22nd, 2016. Cumulative survival, at the date of transfer, was 96.0%. Survival from transfer to release was 74.81%.

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 2014 sub-yearlings, was 94.08%. The cumulative egg to smolt survival, for the BY 2014 yearlings, was 92.7%.

BY 2015 SUMMER/FALL CHINOOK SALMON

2015 Broodstock collection

Collection of summer/fall Chinook for BY 2015 occurred between June 24th, 2015 and August 17th, 2015 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 m 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 off loaded, 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 on a mixture of well water and reservoir water, but as the reservoir water warmed, the groundwater contribution was gradually increased to maintain proper temperature profiles. All adult ponds were treated a minimum of five days per week with formalin to control fungus at a rate of 1:6000, for one exchange. On July 22, USFW DVM Joy Evered assisted hatchery staff with inoculations for all summer/fall Chinook brood. Each female was inoculated with Gallimycin – 100 at a rate of .50 ml per 10 lb. / fish IP, for reduction of BKD, and Vetrimycin – 200 (Oxytetracycline) IP, at the same dosages for reduction of pre-spawn mortality due to furunculosis. A total of 554 HOB were collected including 277 females, 270 adult males and 7 jacks (Table A 14). A total of 575 NOB was collected including 288 females, 278 adult males, and 9 jacks (Table A 15). No steelhead or Bull trout were encountered during broodstock collection efforts.

Additionally, 19 NOR Chinook were collected from the weir trap between September 11th and September 21st 2015. The adults were transported to shore via a fish boot (rubber tire inner tube) and placed into a 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. In our brood collection objectives, we had identified 84 NOR adults to be collected via the weir. Due to the low flows and extremely warm water temperatures, collection was suspended early, and the remainder of the objective (67) was collected at the CJH ladder. 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. All fish that sampled true NORs, and were included in the integrated program, and the remainder were placed into the segregated program.

Table A 13. Chief Joseph Hatchery summer/fall Chinook weekly broodstock collection objectives and results for brood year 2015.

Week	Weekly Quota			Cumulative Proportion	Cumulative Collection	
	Natural Origin [2/]	Hatchery Origin [3/]			Natural Origin	Hatchery Origin
June 21 - June 27	22	22	0.03	0.03	22	22
June 28 - July 4	40	39	0.07	0.10	62	61
July 5 - July 11	50	48	0.08	0.18	112	109
July 12 - July 18	60	58	0.10	0.28	172	167
July 19 – July 25	135	130	0.22	0.50	307	297
July 26 - Aug. 1	130	125	0.21	0.71	437	422
Aug. 2 - Aug. 8	60	58	0.10	0.81	497	480
Aug. 9 - Aug. 15	40	38	0.06	0.87	537	518
Aug. 16- Aug. 22	25	24	0.04	0.91	562	542
Aug. 23- Aug. 29	10	10	0.02	0.93	572	552
*Sept. 1 – Sept. 30	84		0.07	1.00	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

*NOR weir collections = 12.8% total NOR brood

Table A 14. Chief Joseph Hatchery summer/fall Chinook Hatchery-Origin Broodstock (HOB) transfer summary for brood year 2015.

Date	Trapping site	Receiving Facility	Males	Females	Jacks	Total Broodstock	River Temp (f0)	Barge Temp (F0)	Transport Temp. (F0)	Adult Pond Temp (f0)
6/24/2015	SEINE	CJH	7	12	0	19	72	62	58	57
6/25/2015	SEINE	CJH	2	1	0	22	72	62	58	57
6/29/2015	SEINE	CJH	2	2	0	26	72	62	58	57
6/30/2015	SEINE	CJH	4	7	0	37	72	66	60	57
7/1/2015	SEINE	CJH	8	15	0	60	74	64	59	57
7/4/2015	SEINE	CJH	15	10	0	85	74	64	59	57
7/8/2015	SEINE	CJH	5	19	0	109	74	64	59	57
7/13/2015	SEINE	CJH	14	26	0	149	76	64	59	57
7/14/2015	SEINE	CJH	6	13	0	168	76	64	59	57
7/20/2015	SEINE	CJH	17	12	0	197	76	64	59	57
7/21/2015	SEINE	CJH	16	15	0	228	78	64	59	57
7/22/2015	SEINE	CJH	20	16	0	264	78	64	59	57
7/23/2015	SEINE	CJH	22	12	0	298	78	64	59	57
7/27/2015	SEINE	CJH	44	42	0	384	78	64	59	57
7/28/2015	SEINE	CJH	22	14	0	420	78	64	59	57
8/3/2015	SEINE	CJH	18	13	0	451	78	64	59	57
8/4/2015	SEINE	CJH	16	13	0	480	78	64	59	57
8/10/2015	SEINE	CJH	29	10	0	519	78	64	59	57
8/17/2015	SEINE	CJH	18	12	0	549	80	64	59	57
Total			**285**	**264**	**0**	**549**				

Table A 15. Chief Joseph Hatchery summer/fall Chinook Natural-Origin Broodstock (NOB) transfer summary for brood year 2015.

Date	Trapping site	Receiving Facility	Males	Females	Jacks	Total Broodstock	River Temp (f0)	Barge Temp (F0)	Transport Temp. (F0)	Adult Pond Temp (f0)
6/24/2015	SEINE	CJH	7	16	0	23	72	62	58	57
6/29/2015	SEINE	CJH	12	8	0	43	72	62	58	57
6/30/2015	SEINE	CJH	5	14	0	62	72	62	58	57
7/7/2015	SEINE	CJH	18	32	0	112	74	66	60	57
7/13/2015	SEINE	CJH	19	40	0	171	76	64	59	57
7/20/2015	SEINE	CJH	35	60	0	266	76	64	59	57
7/21/2015	SEINE	CJH	45	0	0	311	76	64	59	57
7/27/2015	SEINE	CJH	58	70	0	439	76	64	59	57
8/3/2015	SEINE	CJH	36	25	0	500	76	64	59	57
8/10/2015	SEINE	CJH	32	9	0	541	76	64	59	57
8/17/2015	SEINE	CJH	15	17	0	573	76	64	59	57
Total			**282**	**291**	**0**	**573**				

The cumulative pre spawn holding survival, for all Summer/Fall brood collected, was 65.9% for HOB and 64.3% for NOB (Table A 16). Similar to the Spring Chinook in 2014, the Summer/Fall brood experienced an outbreak of Columnaris. Due to the extremely low flow and warm water in the lower Columbia, these adults were heavily infected with Columnaris upon arrival. Despite being held on 100% well water, and an aggressive treatment schedule with Chloramine T, loss continued unabated through spawning. Neither brood met the survival standard (90%). The majority of loss occurred with females in October, as spawning operations began with the additional stress of handling.

Table A 16. Chief Joseph Hatchery summer/fall Chinook Hatchery (HOB) and Natural (NOB) origin broodstock holding survival summary for brood year 2015. (M = adult males, J = jacks and F = adult females). The survival standard for this life stage was 90%.

	Beginning Month			Ending Month			Mortality			Monthly Survival (%)			Cumulative Survival (%)		
Month	**M**	**J**	**F**	**M**	**J**	**F**	**M**	**J**	**F**	**M**	**J**	**F**	**M**	**J**	**F**
HOR															
July	204	0	216	204	0	216	0	0	0	100%	100%	100%	100%	100%	100%
Aug.	285	0	264	282	0	260	3	0	4	98.9%	100%	98.4%	98.9%	100%	98.4%
Sept.	282	0	260	282	0	260	0	0	0	100%	100%	100%	98.9%	100%	98.4%
Oct.	282	0	260	250	0	200	32	0	60	88.6%	100%	76.9%	88.7%	100%	75.7%
Nov.	250	0	200	234	0	174	16	0	26	93.6%	100%	87.0%	82.1%	100%	65.9%
NOR															
July	199	0	240	199	0	236	0	0	4	100%	100%	98.4%	100%	100%	98.4%
Aug.	282	0	287	280	0	274	2	0	13	99.2%	100%	95.4%	99.2%	100%	94.1%
Sept.	280	0	274	280	0	274	0	0	0	100%	100%	100%	99.2%	100%	94.1%
Oct.	311*	0	303*	289	0	236	22	0	67	92.1%	100%	75.5%	91.4%	100%	72.1%
Nov.	289	0	236	243	0	145	46	0	91	84.0%	100%	61.4%	77.6%	100%	45.8%

* Weir Brood added

Spawning

Spawning of Summer Chinook began on October 7th, 2015, and continued through November 18th, 2015. As with the Spring Chinook, the Summer Chinook program is also 100% ELISA sampled. For the 2015 brood, we experienced a much lower than normal disease profile, and as a result no females were culled.

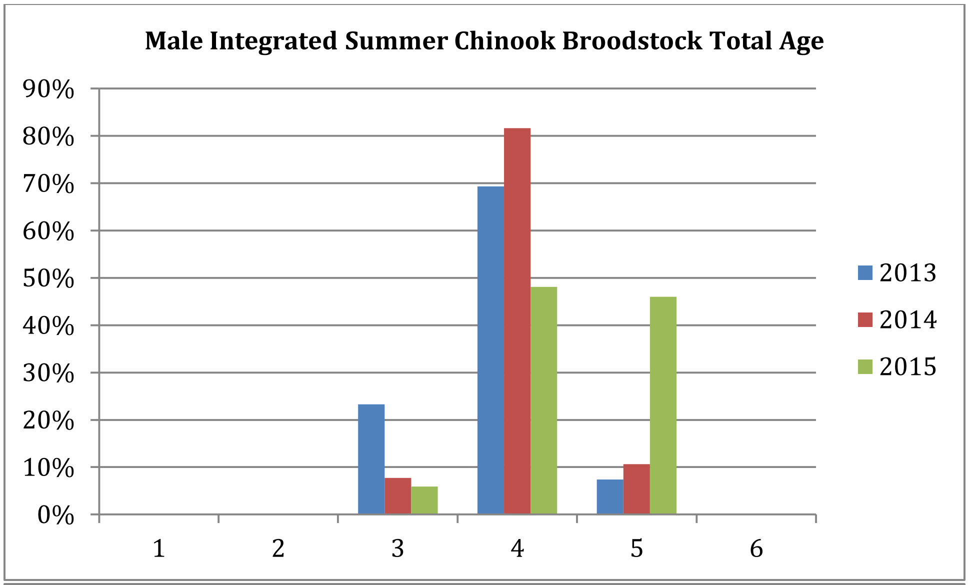
Total NOB spawned included 208 males, zero jacks, and 203 females. (Table A 17) Total HOR spawn included 170 males, zero jacks, and 166 females. In addition, five non-viable NOR females and two non-viable HOR females were spawned. Total eyed egg take for the season was 1,061,459. Egg survival from green 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.

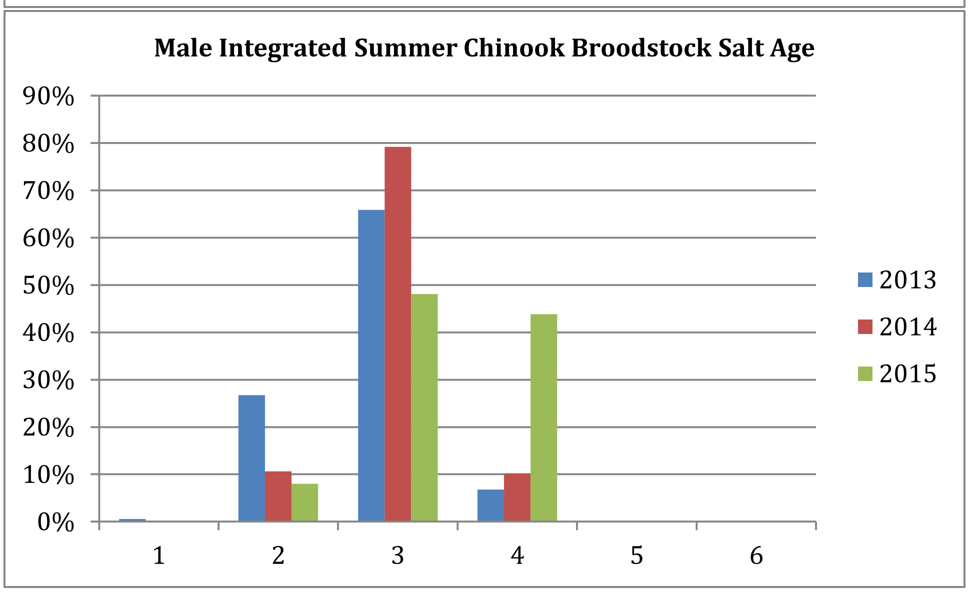
Table A 17. Chief Joseph Hatchery brood year 2015 summer/fall Chinook spawning results.

	Total Adults Spawned			Green Egg Take	Eyed Egg	Mortality (Pick Off)	Cumulative Survival (%)
Month	M	J	F	Total	Total	Total	Total
NOR							
Oct. 7	2	0	2	10,000	9,629	545	94.64%
Oct. 14	20	0	19	95,000	65,953	8,842	88.18%
Oct. 21	43	0	43	215,000	119,283	54,301	57.85%
Oct. 28	55	0	55	275,000	199,179	52,503	62.15%
Nov 4	54	0	53	265,000	145,012	60,074	70.70%
Nov 10	22	0	22	110,000	60,461	20,829	74.37%
Nov 18	12	0	9	45,000	24,139	9,309	72.16%
Sub-total	208	0	203	1,015,000	623,656	206,403	75.13%
HOR							
Oct. 7	10	0	11	55,000	35,761	5,858	85.92%
Oct. 14	43	0	42	210,000	109,978	19,550	84.90%
Oct. 21	38	0	38	190,000	100,826	20,890	82.83%
Oct. 28	31	0	30	150,000	86,263	30,936	73.60%
Nov 4	12	0	10	50,000	20,042	11,500	63.54%
Nov 10	16	0	16	80,000	40,196	4,147	90.64%
Nov 18	20	0	19	95,000	44,737	8,129	84.62%
Sub-total	170	0	166	830,000	437,803	101,010	81.25%
Total	378	0	369	1,845,000	1,061,459	307,413	77.54%

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 2015, both male and female broodstock were markedly older than in previous years; five year-old fish comprised a larger than average proportion of the total broodstock (Figure A 1).


Male Integrated Summer Chinook Broodstock Total Age
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
2
3
4
5
6
2013
2014
2015


Male Integrated Summer Chinook Broodstock Salt Age
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1
2
3
4
5
6
2013
2014
2015

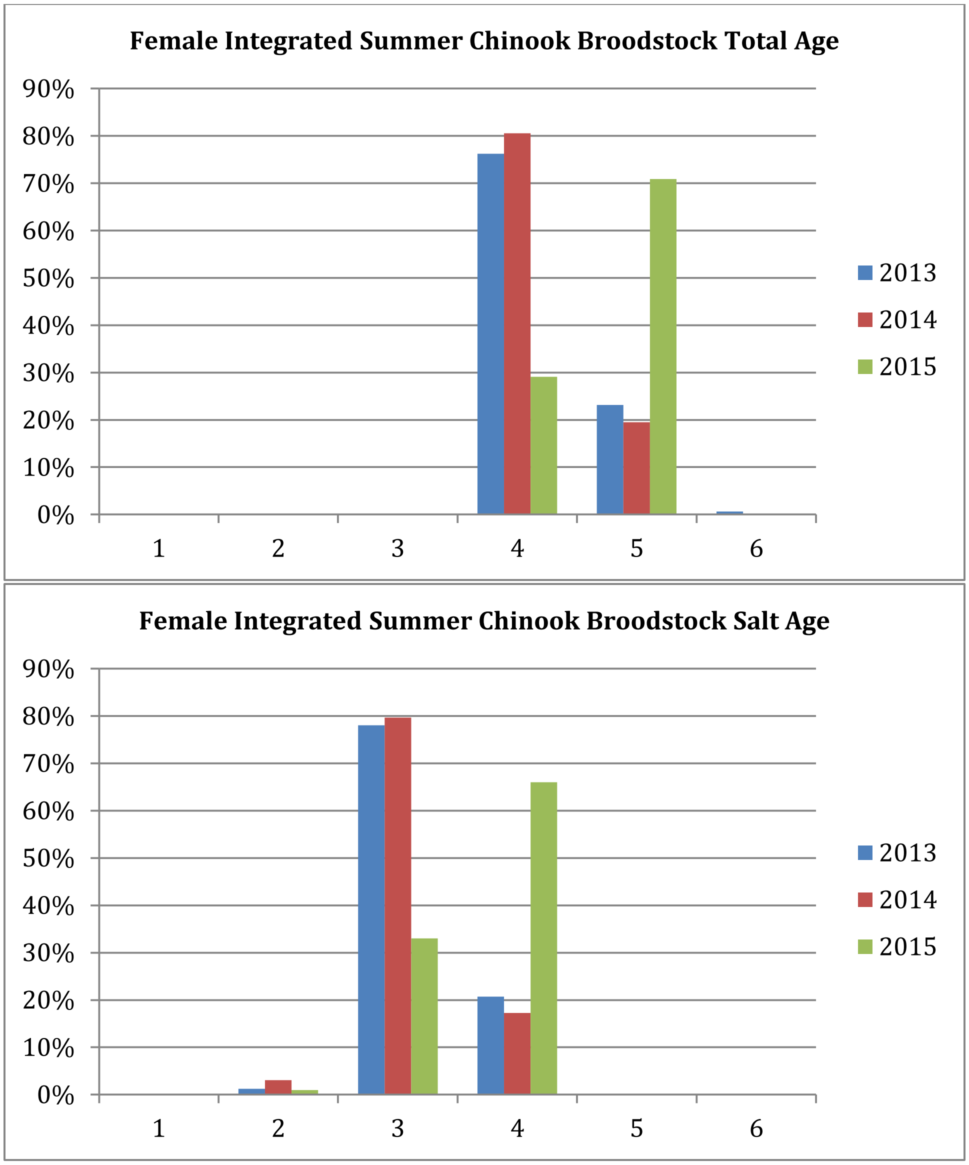
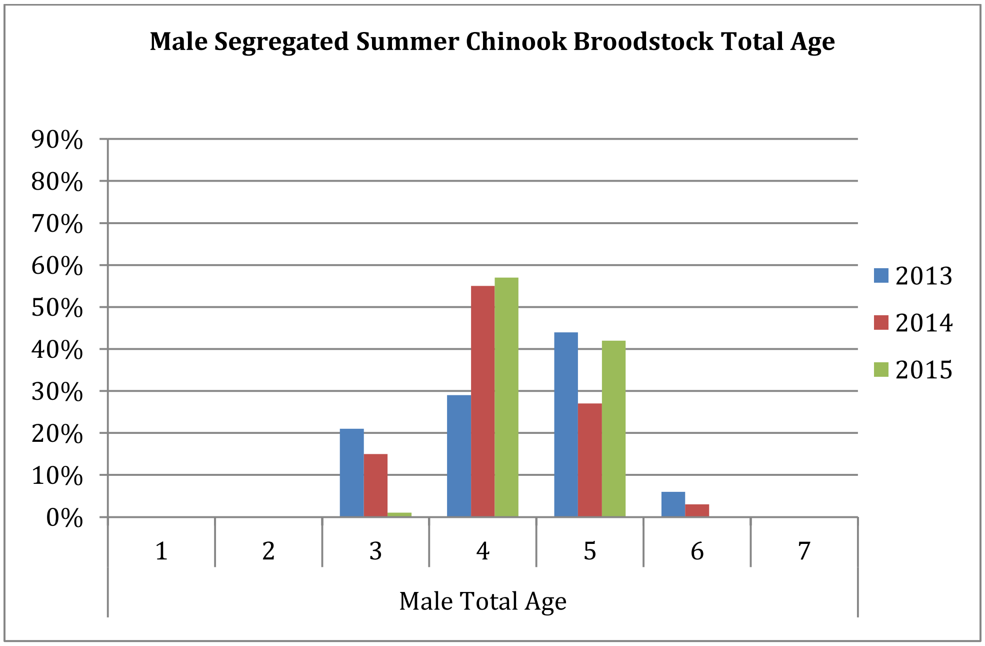
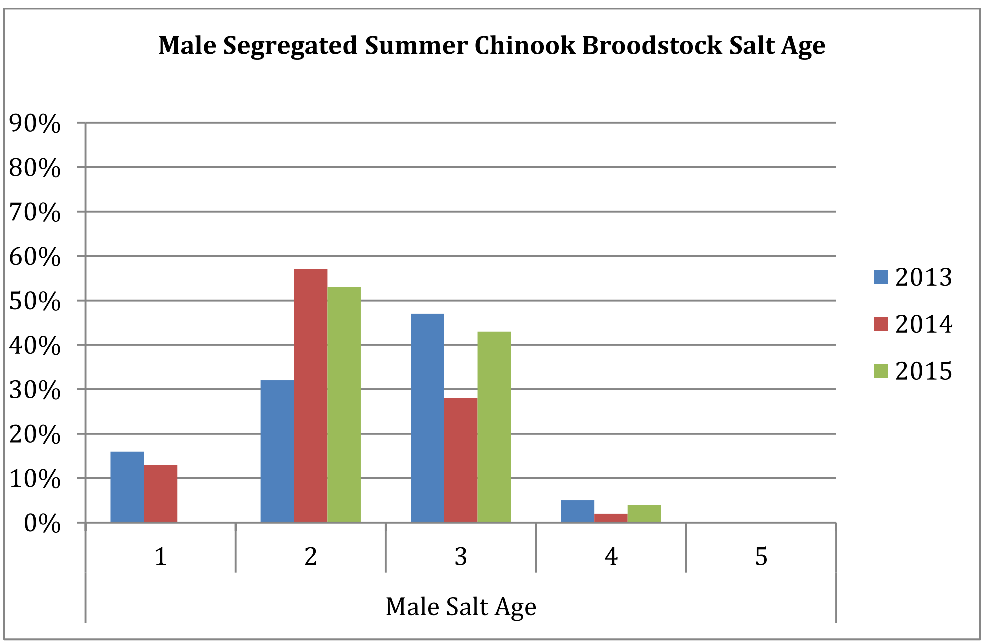


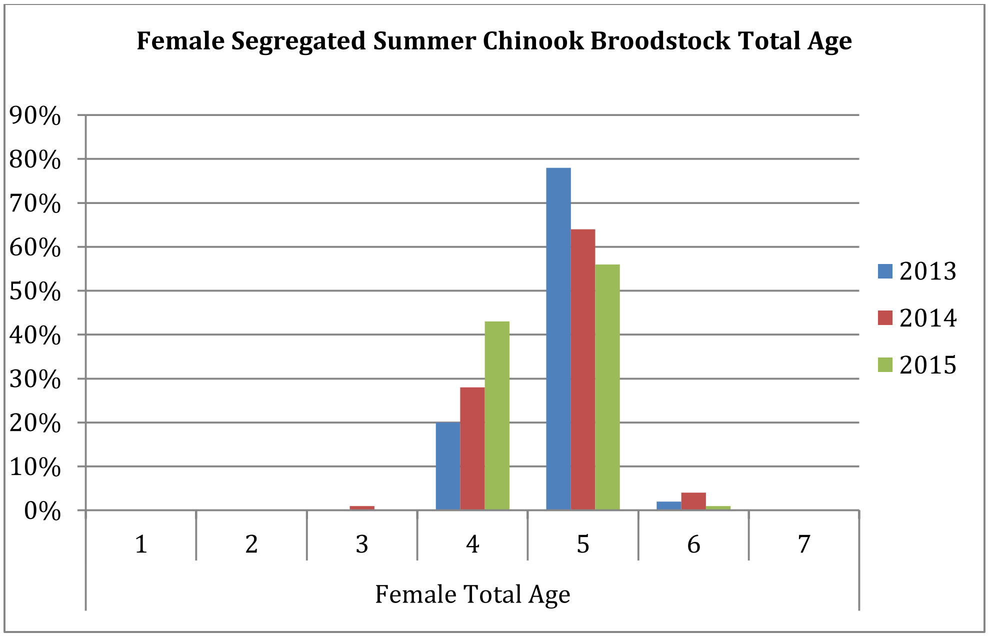
Figure A 1. The total and salt ages of the 2015 broodstock, males and females, collected for the Chief Joseph Hatchery integrated program.

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. Hatchery-origin broodstock tend to spend fewer winters in the salt water than their natural-origin broodstock counterparts.







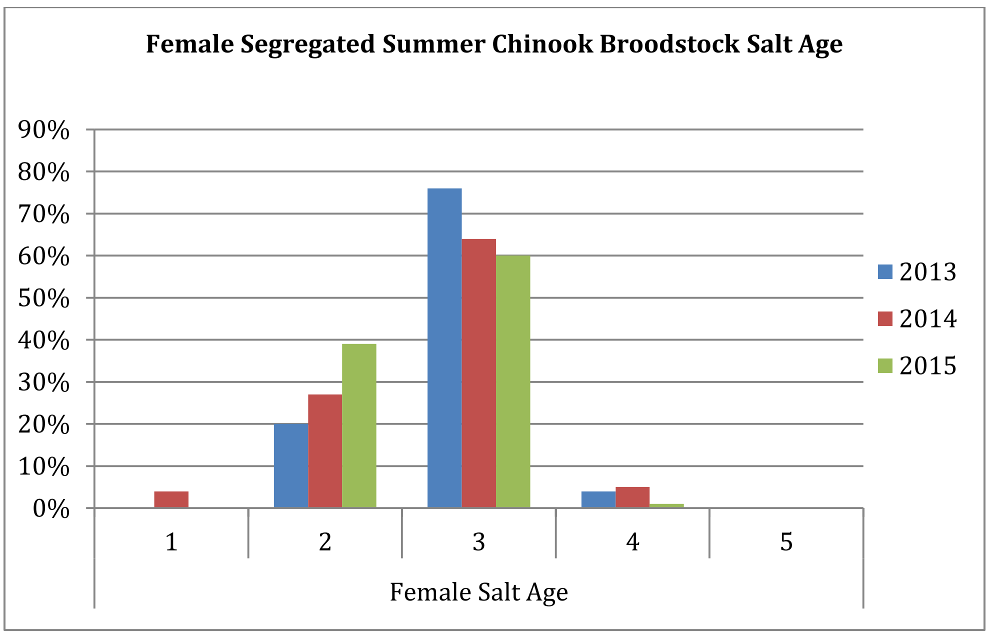


Figure A 2. The total and salt ages of the 2015 broodstock, males and females, collected for the Chief Joseph Hatchery segregated program.

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 2015 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 5,800 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 2015 and to achieve the size-at-release target for both yearling and sub-yearling summer Chinook programs. On the day of spawning and over a several hour period, the incubation water temperatures were gradually reduced on yearling egg takes to a temperature of 40° F. Sub-yearling groups were not chilled until each take achieved 230 Temperature Units (TU). Once each take achieved 230 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 December 23rd, 2015. During the month of January, this group was introduced to feed in the early rearing troughs, and reared for a period of two weeks. Ponding continued into early February. 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 will be released in May of 2016. The integrated sub-yearlings will be transferred to the Omak Acclimation pond after marking. In addition, both groups will also include a 5,000 PIT tag component. PIT tagging was contracted to USFWS, and was completed on April 20th, 2016.

Table A 18. Chief Joseph Hatchery brood year 2015 summer/fall Chinook sub-yearling ponding summary. The survival standard for this life stage was 95%.

	Total Fry Ponded	Ponding Mortality	Monthly Feed	Monthly Mortality	Ponding Loss (%)	Cumulative Survival (%)
Production Group	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
NOR						
Subs	71,803	3,779	87	1,857	4.9%	93.8%
Subs	108,474	11,100	110	13,136	7.2%	87.9%
Sub-total	180,277	14,879	213	17,505	7.6%	90.2%
HOR						
Subs	70,838	3,728	71	546	4.9%	94.3%
Subs	172,543	11,341	145	14,769	6.1%	91.4%
Sub-total	243,381	15,069	230	18,803	5.8%	92.3%
Total	423,658	29,948	443	36,308	6.6%	91.4%

Table A 19. Chief Joseph Hatchery brood year 2015 summer/fall Chinook sub-yearling rearing summary.

	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
Month	**Total**	**Total**	**Total**	**Total**	**Total**
HORs					
Jan. 31	224,580	18,803	230	800	92.3%
Feb. 29	222,476	2,104	476	200	91.4%
Mar. 31	220,735	1,741	478	100	90.7%
Apr 30	218,459*	1,672	808	60	90.4%
May 16	**218,393^**	66	959	54	90.3%
sub-total	**218,393**	24,386	2,951	54	90.3%
NORs					
Jan. 31	162,772	17,505	213	800	90.3%
Feb. 29	160,913	1,859	388	300	89.3%
Mar. 31	159,148	868	382	150	88.3%
Apr 30	175,872**	1,707	743	60	88.0%
May 23	**175,771^**	101	924	44	87.9%
sub-total	**175,771**	22,040	2,650	44	87.9%
Cumulative	**394,164^**	46,426	5,601	49	89.1%

* Shortage of 1,756 at marking
**overage at marking of 18,431
^Released

The first group of integrated yearlings was brought out of incubation and transferred into early rearing troughs on March 23, 2015, and continued into April. 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 were transferred outside to the standard raceways via the fry transfer line. Ponding survival ranged from 96% to 98% and averaged 97% across all groups which exceeded the survival standard (95%) for this life stage (Table A 20).

Post ponding rearing was on schedule as of April 2015, with no fish health issues to date with very (<1%) little mortality (Table A 21). Summer/fall Chinook were fed Bio Pro 2 diet, and were converting at an average of 0.61:1 to date.

Table A 20. Chief Joseph Hatchery brood year 2015 summer/fall Chinook yearling ponding summary. The survival standard for this life stage was 95%.

	Total Fry Ponded	Ponding Mortality	Monthly Feed	Monthly Mortality	Ponding Loss (%)	Cumulative Survival (%)
Production Group	**Total**	**Total**	**Total**	**Total**	**Total**	**Total**
NORs						
April	401,057	15,258	148	1,597	3.80%	95.8%
Sub-total	401,057	15,258	148	1,597	3.80%	95.8%
HORs						
April	222,020	4,398	120	1,333	1.98%	97.4%
Sub-total	222,020	4,398	120	1,333	1.98%	97.4%
Total	623,077	19,656	268	2,930	2.89%	96.6%

Table A 21. Chief Joseph Hatchery brood year 2015 summer/fall Chinook yearling rearing summary.

	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
HORs					
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%
Sub Total	214,660	2,964	615	270	98.6%
NORs					
Apr. 30	384,201	1,597	148	725	99.6%
May 31	382,122	2,079	781	350	99.0%
Sub Total	382,122	3,676	929	350	99.0%
Total	596,782	6,640	1,544	310	98.8%

Chief Joseph Hatchery Ladder

The CJH fish ladder was put into operation on July 6th 2015, with the first adult management activities occurring on July 10th. The intention for the ladder is twofold; to collect Segregated Brood if needed, and to facilitate adult management by removing hatchery origin fish, and thereby potentially increasing PNI in the Okanogan. At this point the ladder is strictly for fish that volunteer in; there have been no releases from the facility and fish entering the ladder are most likely Similkameen or Wells Hatchery returns. All hatchery Chinook, in excess of any brood needs, are removed from the ladder and sent to Tribal distribution or processing. Any Sockeye that enter the ladder are also utilized for Tribal subsistence purposes. All steelhead, regardless of origin, are returned to the river, as were as all NOR Chinook.

From July 6th thru October 20th, 2015, a total of 8,424 hatchery-origin Summer/Fall Chinook and 152 Sockeye were removed at the CJH ladder and utilized for Tribal subsistence purposes. A total of 2,040 natural-origin Summer/Fall Chinook, and 96 NOR steelhead were trapped, handled and released back to the Columbia River. (Table A 22). Of the AD-present Steelhead handled and released, 29% were determined to be of hatchery origin, based on the stock composition developed by WDFW at Wells Dam.

The encounter/handling and release of 96 NOR steelhead represents 96 percent of the allowable incidental take provided in the Biological Opinion (BiOp) for Chief Joseph Hatchery collection facilities. (NMFS 2008). There were no observed steelhead mortalities during the ladder operations in 2015.

The ladder was closed and dewatered on October 20th, 2015, 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 initially sent to the WDFW laboratory in Olympia for CWT extraction and reading, but due to the backlog of snouts and the subsequent delays in obtaining the data needed for management decisions, we elected to bring the snouts back and read them in-house. Results are not available yet but will be included in the M&E section of future reports.

Table A 22. Chief Joseph Hatchery adult summer/fall Chinook ladder operations from July to October 2015.

Date	HOR Males surplused	HOR Females surplused	HOR Jacks (1) surplused	NOR Males RTS	NOR Females RTS	NOR Jacks RTS
July/2015	1,574	1,419	573	206	181	80
Aug/2015	1,309	1,258	682	346	284	157
Sept/2015	386	395	287	196	151	83
Oct/2015	278	154	109	161	146	49
Total	**3,547**	**3,226**	**1,651**	**909**	**762**	**369**

(1)Includes mini-jacks

RTS= Return to stream

Table A 23. Chief Joseph Hatchery adult sockeye and steelhead ladder operations from July to October 2015.

Date	Sockeye	AD Present Steelhead RTS	AD Absent Steelhead RTS	Coho RTS
July/2015	35	2	1	0
Aug/2015	118	28	51	1
Sept/2015	25	48	191	0
Oct/2015	2	41	158	1
Total	**180**	**119***	**401***	**2**

*24% AD Present Steelhead were HORs

RTS= Return to stream

Table A 24. Chief Joseph Hatchery annual summer/fall Chinook, sockeye, and steelhead ladder operations from July to October.

Date	HOR Chinook surplused	HOR jacks [1] surplused	NOR Chinook RTS	NOR jack RTS	Sockeye	AD Present Steelhead RTS	AD Absent Steelhead RTS	Coho RTS
2013	1,472	526	622	108	11	16	22	0
2014	2,835	1,778	861	245	31	69	122	181
2015	6,773	1,651	1,671	369	180	119[2]	401	2
Total	**11,080**	**3,955**	**3,154**	**722**	**222**	**243**	**618**	**183**

(1) Includes mini-jacks
(2) 24% AD Present Steelhead were HORs
RTS= Return to stream

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APPENDIX B

2016 Production Plan

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

Chief Joseph Hatchery Production Plan

Brood Year:	2016						**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**
04/15/18	04/30/18	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 Ponded	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)

Chief Joseph Hatchery Production Plan

Brood Year:	2016						**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
04/15/18	04/30/18	266,000	10	45	26,600	11,970	yearlings	Omak	Ad Clipped	CWT
05/15/17	06/01/17	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 Ponded	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)

Chief Joseph Hatchery Production Plan

Brood Year:	2016						**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**	
04/15/18	04/30/18	250,000	10	45	25,000	11,250	yearlings	CJ hatchery	Ad Clipped		
05/15/17	06/01/17	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 Ponded	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)

Chief Joseph Hatchery Production Plan

Brood Year:	2016						**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**
04/15/18	04/30/18	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 Ponded	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)

Chief Joseph Hatchery Production Plan

Brood Year:	2016						**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**	
04/15/18	04/30/18	250,000	10	45	25,000	11,250	yearlings	CJ hatchery	Ad Clipped		
05/15/17	06/01/17	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 Ponded	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)

Chief Joseph Hatchery Production Plan

Brood Year:	2016	**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
04/15/18	04/30/18	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 Ponded	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)

Chief Joseph Hatchery Production Plan											
Brood Year:	2016						**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**	
04/15/18	04/30/18	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 Ponded	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 2014.

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]	18.8%	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%	
Average % Redds		***0.3%***	***1.4%***	***4.3%***	***3.0%***	***19.2%***	***29.8%***	***35.5%***	***6.5%***		
Average Effective pHOS		***44.5%***	***54.8%***	***39.6%***	***37.1%***	***32.4%***	***21.9%***	***40.1%***	***33.6%***		
Average Reach Weighted Effective pHOS =											***31.9%***

Table C 2 Number of hatchery- and natural-origin (wild) summer Chinook carcasses collected in each reach of the Okanogan (O1-O6) and Similkameen rivers from 1993 to 2014.

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	2123
	Hatchery	0	5	22	2	74	63	516	56	329
Average	***Wild***	***1***	***2***	***17***	***8***	***98***	***228***	***341***	***72***	***768***
	Hatchery	***1***	***3***	***18***	***7***	***62***	***89***	***332***	***57***	***569***

[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 multifilis* 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

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	45	3	1	300
Average	***1***	***28***	***117***	***77***	***7***	***0***	***230***

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	100	1	0	240
Average	***0***	***0***	***55***	***220***	***29***	***0***	***305***

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
Average	***0***	***9***	***103***	***163***	***51***	***1***	***328***

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
Average	***0***	***0***	***17***	***220***	***130***	***1***	***369***

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%	15%	1%	0%	1
Average	***0%***	***12%***	***42%***	***39%***	***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%	58%	42%	0%	0%	1
Average	*0%*	*0%*	*23%*	*62%*	*15%*	*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
Average	*0%*	*3%*	*29%*	*52%*	*15%*	*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
Average	***0%***	***0%***	***7%***	***65%***	***28%***	***0%***	***1***

Table C 5 Estimated number (and percent of annual total) of hatchery-origin spawners from different hatcheries recovered on the Okanogan/Similkameen spawning grounds, based on CWT recoveries and expansions, for return years 2006-2015.

Return Year	Rearing Hatchery															Total
	Homing Fish		Within ESU Stray										Out of ESU Stray			
	Okanogan River Basin		Methow	Wenatchee	Entiat	Chelan River			Columbia River Summer Chinook				Fall Chinook			
	Bonaparte Pond	Similkameen Pond	Carlton Pond	Dryden Pond	Entiat NFH	Chelan River NP	Chelan PUD Hatchery	Chelan Hatchery	Wells Hatchery	Turtle Rock Hatchery	Eastbank Hatchery	Grant County PUD Hatchery	Priest Rapids Hatchery	Glenwood Springs Hatchery	Oxbow Hatchery	
2006	0 (0%)	709 (87%)	12 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	12 (2%)	56 (7%)	12 (2%)	12 (2%)	0 (0%)	0 (0%)	0 (0%)	814
2007	0 (0%)	1121 (95%)	17 (1%)	3 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (0%)	37 (3%)	2 (0%)	3 (0%)	0 (0%)	0 (0%)	0 (0%)	1,186
2008[a]	0 (0%)	3224 (95%)	11 (0%)	24 (1%)	0 (0%)	0 (0%)	4 (0%)	0 (0%)	75 (2%)	59 (2%)	0 (0%)	0 (0%)	3 (0%)	0 (0%)	0 (0%)	3,404
2009	0 (0%)	2733 (95%)	14 (0%)	4 (0%)	0 (0%)	0 (0%)	9 (0%)	0 (0%)	76 (3%)	23 (1%)	9 (0%)	0 (0%)	0 (0%)	4 (0%)	5 (0%)	2,878
2010	4 (0%)	2165 (89%)	44 (2%)	4 (0%)	0 (0%)	0 (0%)	75 (3%)	35 (1%)	75 (3%)	0 (0%)	31 (1%)	0 (0%)	0 (0%)	0 (0%)	4 (0%)	2,434
2011	219 (5%)	4196 (93%)	44 (1%)	0 (0%)	0 (0%)	0 (0%)	6 (0%)	28 (1%)	17 (0%)	5 (0%)	5 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (0%)	4,526
2012	379 (13%)	2397 (83%)	29 (1%)	23 (1%)	0 (0%)	6 (0%)	6 (0%)	6 (0%)	29 (1%)	23 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2,897
2013	254 (14%)	1437 (81%)	10 (1%)	54 (3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	10 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1,763
2014	54 (5%)	990 (90%)	15 (1%)	0 (0%)	5 (0%)	0 (0%)	0 (0%)	11 (1%)	16 (1%)	11 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1,102
2015	4 (0%)	2136 (92%)	40 (2%)	13 (1%)	9 (0%)	0 (0%)	\0 (0%)	14 (1%)	18 (1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2,311
Average	**91 (4%)**	**2111 (90%)**	**24 (1%)**	**13 (1%)**	**1 (0%)**	**1 (0%)**	**11 (0%)**	**9 (0%)**	**32 (1%)**	**22 (2%)**	**6 (0%)**	**2 (0%)**	**0 (0%)**	**0 (0%)**	**2 (0%)**	**2,332**

[a] Three spring Chinook recovered in 2008 were excluded from analysis. They were reared at Entiat NFH and released from Omak Creek in 2005.

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 - pNOB/ (pNOB + pHOS).

pNOB = proportion of hatchery broodstock composed of NORs. Equals NOB/ (HOB + 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 = Okanagan 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