

THE CHIEF JOSEPH HATCHERY PROGRAM SUMMER/FALL CHINOOK 2021 ANNUAL REPORT

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This report includes both hatchery production/operations and the corresponding monitoring activities completed through April of 2022. It is structured to meet the RM&E technical report formatting requirements for BPA, and therefore the hatchery production portion is included in Appendix A.

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

All photos are credited to Confederated Tribes of the Colville Reservation Fish and Wildlife Department – Chief Joseph Hatchery Program unless otherwise noted.

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EXECUTIVE SUMMARY

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

The CJH production level was set at 100% in 2021 during the ninth year of operation for the Summer/Fall Chinook program. In July and August the CCT used a purse seine vessel to collect 1,365 summer/fall Chinook for broodstock for both the integrated and segregated programs (including Similkameen). Additionally, 11 summer/fall Chinook were collected at the Okanogan adult weir in September. The summer/fall Chinook program collected enough brood to meet full production level. The cumulative pre spawn holding survival, for all Summer/Fall brood collected, was 88.4% for hatchery-origin broodstock (HOB) and 87.0% for natural-origin broodstock (NOB). The survival standard (90%) was not met by both the hatchery-origin and natural-origin brood. Total green egg take for the season was 1,470,713 (54% of full program). Egg survival from green egg to eyed egg averaged 72.1% for NOB and 74.5% for HOB, both under the survival standard (90%) for this life stage. After in-hatchery mortalities from pre-spawn holding through ponding there were 1,081,528 fish on hand at the end of May for the yearling releases in 2023 (83% of the yearling program) and 134,709 fish on hand for the segregated sub-yearling releases in May 2022 (34% of full program). There are no fish on hand for the integrated sub-yearling releases in May 2022.

2021 was the seventh year for Summer/Fall Chinook hatchery yearlings released from the CJH, Similkameen and Omak acclimation ponds. In April, 207,773 integrated yearling summer/fall Chinook were released from the Omak acclimation pond and 386,943 were released by Washington Department of Fish & Wildlife (WDFW) from the Similkameen Pond; combined these programs were at 74% of the full program goal of 800,000 integrated yearlings. There were 88,474 integrated and 177,932 segregated sub-yearlings from brood year (BY) 2020 released in May 2021. There were 453,575 yearling Chinook released directly from Chief Joseph Hatchery (91% of full program).

After release, the yearling program from CJH had higher survival when compared to previous years and other programs despite a slightly slower than average travel time. In

contrast, subyearling survival was less than previous years. The vast majority (>90%) of PIT tagged hatchery smolts released from Omak Pond migrated to the lower Okanogan River within seven days of release. Although these results were affected by some detections (11%) at the lower Okanogan PIT array before the documented release date, indicating that there was an inadvertent and undocumented early release of some portion of the program. The undocumented early release did not appear to have a major effect on outmigration timing, based on the relatively normal arrival timing at Rocky Reach Juvenile bypass. Overall, 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 six major activities; 1) rotary screw traps (juvenile outmigration, natural-origin smolt PIT tagging) 2) beach seine (natural-origin smolt PIT tagging, smolt to adult return) 3) lower Okanogan adult fish pilot weir (adult escapement, proportion of hatchery-origin spawners [pHOS], broodstock) 4) spawning ground surveys (redd and carcass surveys)(viable salmonid population [VSP] parameters) 5) eDNA collection (VSP parameter—distribution/spatial structure) and 6) coded wire tag lab (extraction and reading).

Rotary screw trap operations began on April 1 and continued through June 19, capturing 3,880 natural-origin Chinook and 290 hatchery-origin Chinook. After conducting 2 mark-recapture events, the efficiency of the trapping configuration was calculated to be approximately 0.65%. Because of the inability to collect sufficient data to confidently estimate juvenile outmigration, abundance estimates were not produced for the 2019 outmigration. 934 steelhead (*O. mykiss*) were also captured in the rotary screw trap including 32 natural-origin (adipose fin present and no CWT) and 902 hatchery-origin (adipose fin clipped and/or CWT present). Other species commonly caught in the rotary screw traps included Sockeye (*O. nerka*) (961), Yellow Perch (*P. flavescens*) (59), Northern Pikeminnow (*P. oregonensis*) (279), Bridgelip Sucker (*C. columbianus*) (38), and Mountain Whitefish (*Prosopium williamsoni*) (519).

Beach seining captured 29,043 natural-origin juvenile Chinook and 20,213 (70%) were PIT tagged and released. Pre- and post-tag mortality was 11.5% and 5.2% respectively. In 2021, wild summer Chinook tagged at the mouth of the Okanogan had a minimum apparent survival of 41% (6% SE) to Rocky Reach Juvenile Bypass (RRJ). Unfortunately survival could not be calculated from RRJ to McNary (MCN) due to abnormal spill events and resulted in low detection.

The lower Okanogan Adult Fish Weir was deployed on August 2 when discharge was 927 cfs. The thermal barrier was present in the lower Okanogan after installation until August 8th when the mean Okanogan River temperature began dropping below 22.5 °C for a couple days. It went back up above threshold on August 11th and stayed above it until August 17th when the dropped below the threshold, allowing Chinook to migrate up the Okanogan. Temperatures stayed below 22.5 °C for the rest of the season. Trapping began on August 18 and continued until September 23 with the majority (66%) being caught from August 18-August 31. Fifty six adult Chinook were trapped in 2021. Ten natural-origin Chinook were transported to the

hatchery and held as broodstock for the integrated program. Adult brood were transported from the weir trap to the hatchery brood truck by foot using a rubber boot. There were no immediate mortalities of these fish within the first week after transport to the hatchery. All other natural-origin fish were released upstream of the weir unharmed. Fourteen hatchery-origin were removed from the weir trap for adult management purposes. 0.6% 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. Thirty-two dead fish were removed from the weir between August 13 and September 11. The majority of the mortalities (22) were sockeye and 7 of the mortalities were mountain whitefish. There were no Chinook mortalities removed from the weir in 2021. 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 23.

Spawning ground surveys estimated 3,050 summer/fall Chinook redds and 1,273 carcasses were recovered (830 natural-origin and 443 hatchery-origin). Adult summer/fall Chinook spawning escapement in 2021 was estimated to be 7,046, with 4,525 natural-origin spawners and 2,521 hatchery origin spawners. In 2021, the effective pHOS (0.31) did not meet the program objective (<0.30 pHOS), but the proportion of natural influence (PNI) (0.76) did meet the program objectives (>0.67 PNI). The five-year average for effective pHOS (0.29) and PNI (0.73) met the long-term goal (<0.30 pHOS; >0.67 PNI). Selective harvest activities by CCT and WDFW contributed to the reduced pHOS and increased PNI in 2021. CCT removed 1,704 hatchery fish, including 145 jacks, during surplus events at the CJH ladder and trap, and tribal members removed another 1,313, including 30 jacks, at the Chief Joseph Dam tailrace fishery. The Harvest program's purse seine removed 103 hatchery fish, including 70 jacks. 197 natural-origin fish, including 13 jacks, were released during surplus at the Chief Joseph Hatchery ladder. The purse seine released 296 natural-origin fish, including 179 jacks during their efforts. The Okanogan temporary weir encountered 56 fish in 2021, in which 14 hatchery fish, including 5 jacks, were removed and 32 natural-origin fish, including 13 jacks were released back to the river. Within the WDFW state fishery above Wells Dam in the Columbia River, 1,966 hatchery Chinook (segregated and integrated fish), including 132 jacks, were harvested and 1,516 natural-origin Chinook, including 13 jacks were released back to the river.

The management strategy for the CJH integrated hatchery program in the Okanogan River appears to be having some of the intended effects on the spawning grounds. The intent of adding the Omak Acclimation Pond was to reduce spawning density and pHOS in the high density reaches of the upper Okanogan (O6) and lower Similkameen (S1) and to increase spawning in the under-utilized lower and middle reaches of the Okanogan (O2-O5).

Indeed, spawner distributions have changed during the CJH-era (2016-2021) compared to years prior. We found an increased proportion of redds in reaches O2 thru O6, and reduced

proportions in reaches S1 and S2 for years 2016-2021 compared to years 2006-2015. Additionally, carcass recovery data showed shifts in the composition of spawners, with increased pHOS in the lower basin (Reach O2) and reduced pHOS upstream. These changes in composition and distribution of spawners across the basin are likely the results of hatchery acclimation strategies, specifically with hatchery fish relating to their Omak Pond acclimation site in the lower basin and should help with the effectiveness of natural-origin spawners in the prime spawning habitat in the upper basin (Reach O6 and S1).

The CJH coded wire tag lab was in its sixth year of operation in 2021. Coded wire tags were extracted and read from Chinook snout recoveries from broodstock, ladder surplus, purse seine harvest, and creel and spawning ground surveys. The development of in-house CWT reading continues to be a huge success, providing age- and origin data within 2-3 months of the spawning ground surveys utilizing Colville tribal staff, rather than outsourcing to another lab. The majority of the summer Chinook adult returns to the CJH ladder were CJH Segregated (59%) followed by Wells Hatchery (18%), Chelan Falls (9%), Okanogan integrated (6%), and three other programs made up the remaining 8%.

The majority (79%) of hatchery-origin spawners recovered on the spawning grounds in 2021 were from Similkameen (61%) and Okanogan (18%). Chief Joseph Hatchery segregated Chinook comprised 13% of the HOS on the Okanogan spawning grounds. The overall proportion of segregated hatchery fish on the spawning grounds (0.67%) did meet the program objective of <5% segregated pHOS. Future management efforts should continue to focus on reducing the stray rate of segregated hatchery fish to the Okanogan spawning grounds. Overall, the majority of fish acclimated at Similkameen Pond ended up spawning throughout the upper reaches of the Okanogan (reaches O5 & O6) (27%) and Similkameen Rivers (70%). Reach S1, the location of the Similkameen acclimation site in the Similkameen River accounted for over half of the estimated spawning by Similkameen Pond fish (66%).

Fish released within the Okanogan Basin have consistently homed to their natal stream, and 2021 was not an exception. One of the goals of the CJHP is to redistribute Chinook spawners to the middle and lower portion of the Okanogan River instead of inundating the already saturated Similkameen River with additional spawners. Juvenile Chinook releases from the Omak Pond acclimation site are primarily spawning in the Okanogan River (average 88%, 2018-2021) rather than the Similkameen River. Specifically, the Omak Pond-reared Chinook have spawned almost exclusively in the lower (O3 reach) and middle (O5 reach) sections of the Okanogan River.

The most recent brood year that could be fully assessed (through age 5) for stray rate of Okanogan/Similkameen fish to spawning areas outside the Okanogan was 2016. The 2016 brood year had a stray of 0.3% to non-target basins and 0.8% to non-target hatcheries, which was similar to the long term and recent five-year average (0.9% for non-target basins and 0.4% to non-target hatcheries).

An Annual Program Review (APR) was held in April 2022 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 an average pre-season forecast of 57,500 Upper Columbia summer/fall Chinook, the plan for 2022 is to operate the hatchery at full program levels of 2 million summer/fall Chinook with 100% pNOB. CCT will plan to harvest their allocation of 3,075 with the selective harvest program, including removals at 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 (Moberg 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 2017, the summer/fall and spring Chinook program's production level was set at full production capacity.

The CJHP will increase harvest opportunity for all anglers throughout the Columbia River and Pacific Ocean. Additionally, the Colville Tribes and other salmon co-managers have worked with the mid-Columbia Public Utility Districts to meet some of their hydro-system mitigation through hatchery production (CPUD 2002a; CPUD 2002b; DPUD 2002).

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

1. Monitor, evaluate and adaptively manage hatchery and science programs
2. Manage hatchery broodstock to achieve proper genetic integration with, or segregation from natural populations
3. Promote local adaptation of natural and hatchery populations
4. Minimize adverse ecological interactions between hatchery- and natural-origin fish

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

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 six primary field activities to provide data for answering key management questions. These activities included:

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

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

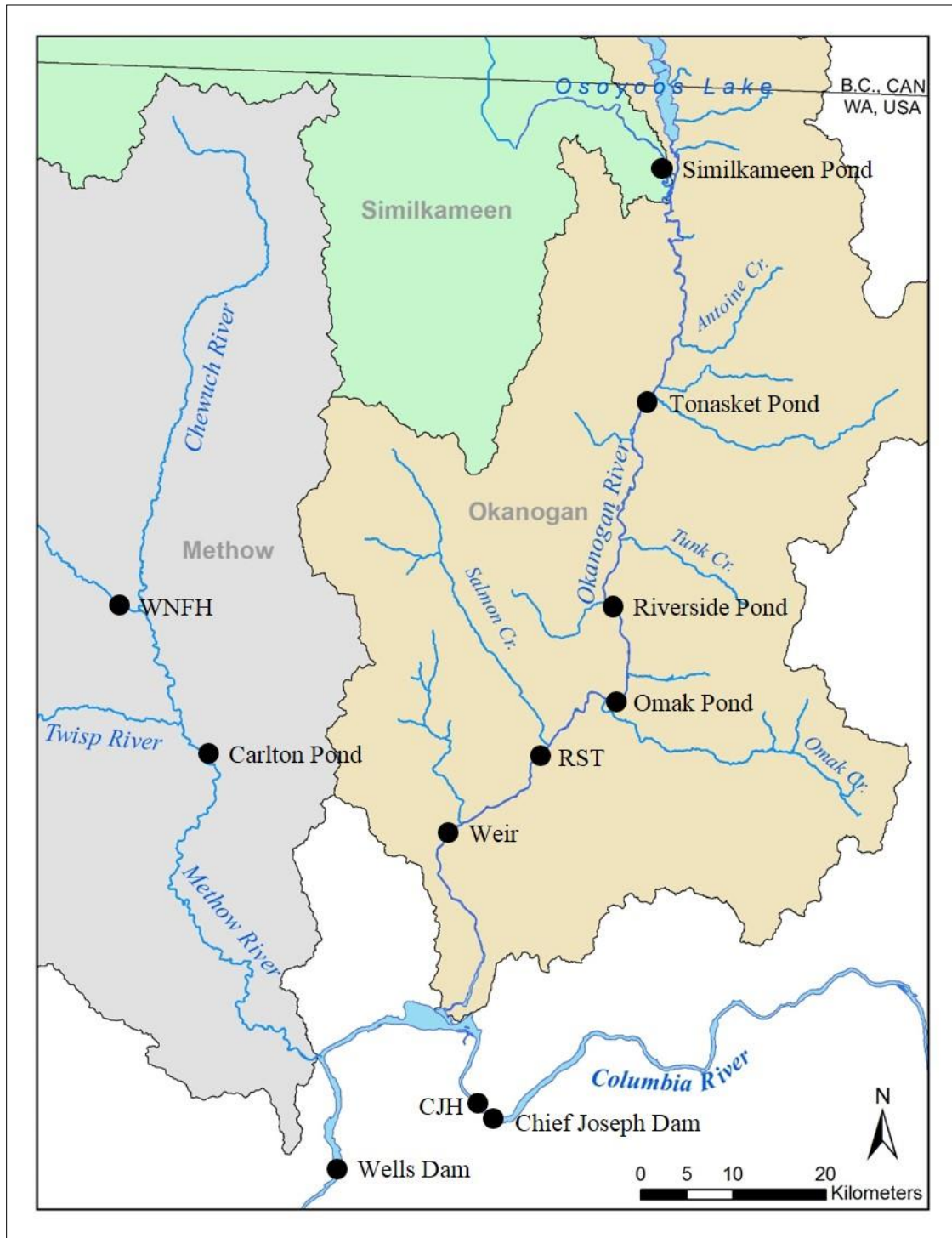


Figure 1. Map of the U.S. portion of the Okanogan River Basin, the Chief Joseph Hatchery (CJH), Winthrop National Fish Hatchery (WNFH), Okanogan adult weir (Weir), Rotary screw trap (RST), and Chinook Salmon acclimation sites. Horizontal coordinate information is referenced to the North American Datum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

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

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

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

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

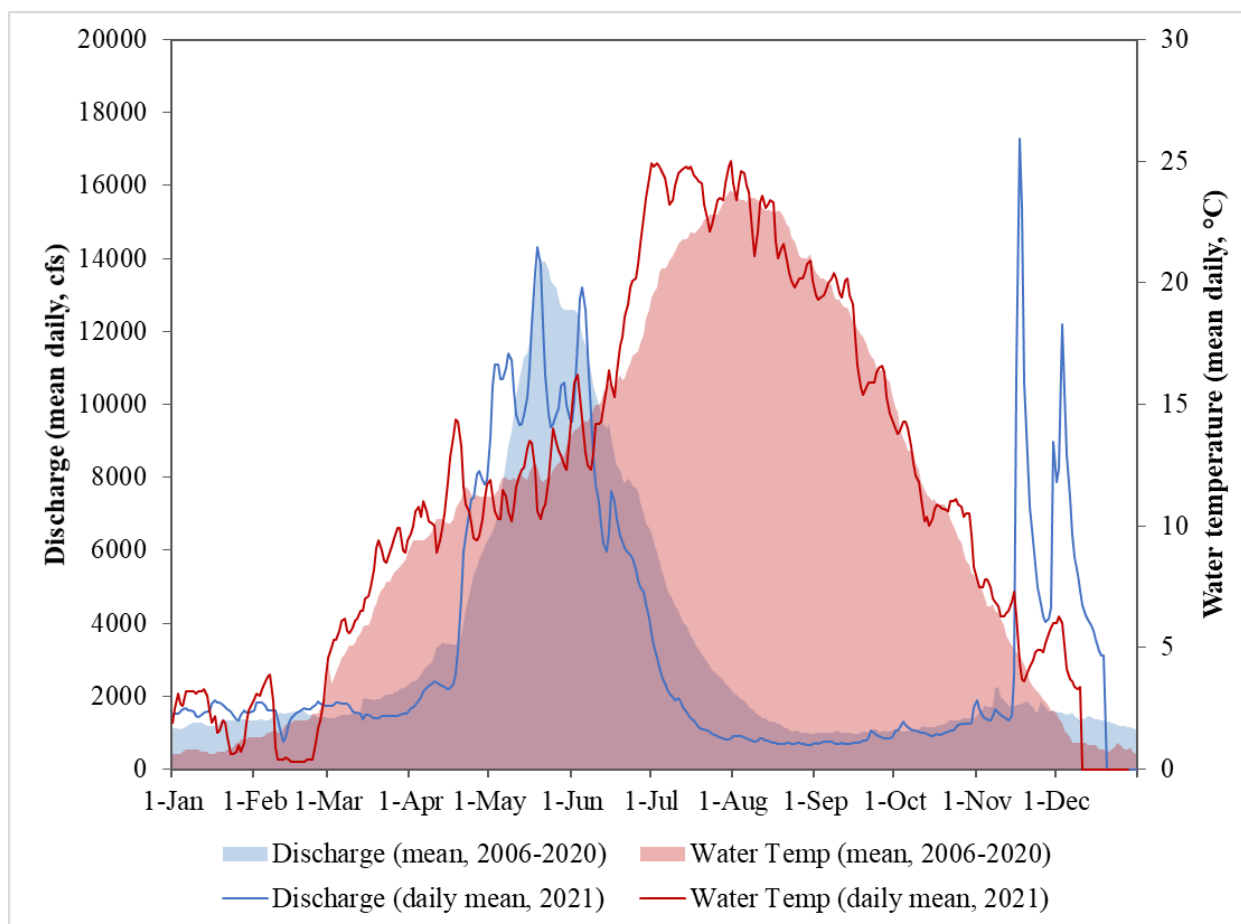


Figure 2. Okanogan River mean daily discharge (blue lines) and water temperature (red lines) at Malott, WA (USGS Stream Gage 12447200).

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	400,000	Yearling	100%	100%	
Omak Pond	400,000	Yearling	100%	100%	5,000
	300,000	Sub-yearling	100%	100%	5,000
Chief Joseph Segregated	500,000	Yearling	20%	100%	5,000
	400,000	Sub-yearling	25%	100%	5,000
Natural-Origin	RST and Confluence Seine	N/A	0%	0%	≤ 25,000

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

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

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 occurs at the rotary screw trap and the juvenile beach seine annually. 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 the Chief Joseph Hatchery Science Program office in Omak, WA. Annual tissue collection targets are approximately $n = 200$ samples for: (1) natural-origin sub-yearling Chinook handled at the rotary screw trap/beach seine; (2) natural-origin yearling (>130 mm) Chinook handled at the rotary screw trap/beach seine and (3) natural- and hatchery-origin (100 each) Chinook encountered during carcass surveys on the spawning grounds and (4) natural-origin Chinook encountered during juvenile electrofishing surveys.

The CJHP has also supported requests from Columbia River Inter-tribal Fish Commission (CRITFC) to provide genetic samples (caudal punches) from CJH summer-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 deployed from April 12 to June 17, 2021. Trapping typically occurred continuously from Mondays at 0500 until Friday at 1300. 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 and fish that were between 50-65 mm total length received a 9 mm full duplex PIT tag, provided water temperatures were below 17°C. A tissue sample (fin clip) was collected from any yearling unmarked Chinook for future genetic analyses.

EFFICIENCY ESTIMATES. — An estimate of the daily number of juvenile out migrants passing the trap location requires an estimate of the proportion of fish caught by the traps. This was accomplished using mark-recapture methodologies developed by Rayton and Wagner (2006), maintaining continuity with the techniques employed at this RST operation in previous years. This mark-recapture procedure (hereafter referred to as an efficiency trial) was conducted using both natural-origin sub yearling Chinook and hatchery-origin yearling Chinook. Only fish with a fork length of at least 45 mm were used in efficiency trials.

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

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

Trap efficiency was calculated by the equation

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

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

Trap efficiencies were recorded for each individual trap as it operated, and for both traps operating in unison. Trap efficiencies for each individual trap were further refined by including

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

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

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

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

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

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

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

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

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

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

Estimates and confidence intervals were calculated for all trapping configurations and then summed to generate an overall estimate for the trapping season. During periods when neither trap was operating, an estimate was calculated based on the average catch of an equal time

period immediately prior and following the inoperable period. For example, if no traps were operable on April 30, catch for that day would be estimated to be the average of total catch on April 29 and May 1.

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

Juvenile Beach Seine and PIT Tagging

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

Beach seining took place from June 9- July 1 in the area near the confluence of the Okanogan and Columbia Rivers. Efforts at the confluence were 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). This area is known as Gebber's Landing. 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 based on results from stable isotope analysis conducted in 2018.



Figure 4. Seining location downstream (Gebber's Landing) of the confluence.

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

To capture fish, one end of the seine was tied off to an anchor point onshore, 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 shoreline (Figure 5). The seine bridle was handed from the boat to a shore crew that would retrieve the seine. Juvenile Chinook were transferred to a 10-gallon tub filled with river water and transferred to a nearby floating net pen. Handling/holding time in the tub

was generally <15 minutes. Floating net pens were approximately 5 m³ and consisted of a PVC pipe frame covered with black 19.1-mm and 3.2-mm mesh. The mesh allowed for adequate water exchange, retained juvenile Chinook, and prevented the entrance of predators. Noticeable bycatch, most commonly three-spine stickleback (*Gasterosteus aculeatus*) were released from the seine without enumeration. Any bycatch inadvertently transferred to the floating net pen were later sorted and released during tagging (untagged).



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

In most circumstances, juvenile Chinook were held 24 hours prior to tagging to assess capture/handling effects. Occasionally, due to staff availability or other complicating circumstances, fish were held for two days or released shortly after recovery from anesthesia. Chinook ≥ 65 mm were tagged with a full duplex 12 mm PIT tag, and Chinook between 50 and 65 mm were tagged with a full duplex 9mm PIT tag. After tagging, fish were returned to a floating net pen for 24 hours post-tagging to assess tag loss and tag application/handling mortality rates. Fish were then released to the Columbia River (Wells Pool) several hundred meters downstream of their capture location.

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

The 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 9 mm or 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, although 9 mm PIT tags were used in fish that were smaller. Detection efficiencies at both of the former sites would dramatically suffer when using the smaller PIT tags available. The tagging crew consisted of one or two taggers and one data collector. The data collector interrogated the tag in each tagged fish, recorded its fork length 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 PITTAG4 (P4) software (Pacific States Marine Fisheries Commission). After completion of the tagging events, tag files were consolidated, uploaded to PTAGIS (www.ptagis.org).

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, expelled (shed) tags from live fish were recovered from the mesh floor via a powerful magnet. After that was completed, 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. Carcasses of summer Chinook were returned back to the river.

Lower Okanogan Adult Fish Pilot Weir

The Okanogan adult fish pilot weir (herein referred to as the ‘weir’) was in its tenth year of design modifications and testing in 2021. Continued operation and improvements to the weir are a central part of CCT’s strategy for the successful implementation of the CJHP summer/fall Chinook Salmon (*Oncorhynchus tshawytscha*) programs. Pilot weir test results are essential for updating key assumptions, operations, and design of the weir.

Objectives for the pilot weir in 2020 included:

1. Install the weir in early July and operate until late September under allowable flow conditions (<3,000 cfs) and temperature (<22.5 °C);
2. Document environmental effects of the weir through collection of physical and chemical data in the vicinity of the weir;
3. Test weir trapping operations and the Whooshh™ fish transport system including live Chinook capture, handling and release;
4. Direct observations and fish counts for estimating species composition, abundance, health, and timing to inform management decisions and future program operations;
5. Collect NOR and/or HOR brood stock at the weir and transport safely to the CJH;
6. Test the weir configuration, including the location of the trap box, to meet the program’s biological and brood-take goals
7. Test fish entrainment through the trap entrance chute and into the trap box

The lower Okanogan fish weir was installed approximately 1.5 km downstream of Malott, WA (48°16’21.54 N; 119°43’31.98 W) in approximately the same location as previous years. Weir installation began on August 2nd at a river flow of 927 cfs. and was completed with the underwater video system on August 10th. An aluminum trap was installed near the center of the channel at the downstream end of the deep pool in the thalweg of the channel. The trap was 3 m wide, 6 m long and 3 m high (Figure 6). A fifteen-foot aluminum accelerator chute was installed at the downstream trap gate. The wings of the weir stretched out from either side of the chute towards the riverbanks, angling downstream in a slight V configuration. The wings consisted of steel tripods with aluminum rails that supported the 3 m long Acrylonitrile butadiene styrene (ABS) pickets. Each panel was zip-tied to the adjacent panel for strength and stability. Gravel bags were placed between panels when needed to fill gaps that exceeded the target picket spacing. Picket spacings included 2.5 cm (1 inch) and 5.1 cm (2 inch) sizes (Figure 7). Pickets were manually forced into the river substrate upon deployment and then as needed to prevent fish passage under the weir.

The river-right wing consisted entirely of 2.5 cm. picket spacing (Figure 7). A 3 m gap

between the last panel and the right shoreline remained to allow for portage of small vessels around the weir. This was a very shallow gravelly area and under most flow conditions it did not appear to be a viable path for adult salmon passage. However, a set up floating panels that were attached to the substrate extended from the last panel to the river-right shore to limit escapement via this route. The river left wing had variable picket spacing to accommodate non-Chinook fish passage through the pickets. The primary objective of the wider picket spacing was to allow sockeye (*O. nerka*) to pass through the weir and reduce the number of sockeye that would enter the trap. River left was selected for this spacing to better accommodate observation/data collection regarding successful passage of smaller fish through the panels.



Figure 6. Lower Okanogan adult fish pilot weir, 2021. Photo taken in early August during deployment.

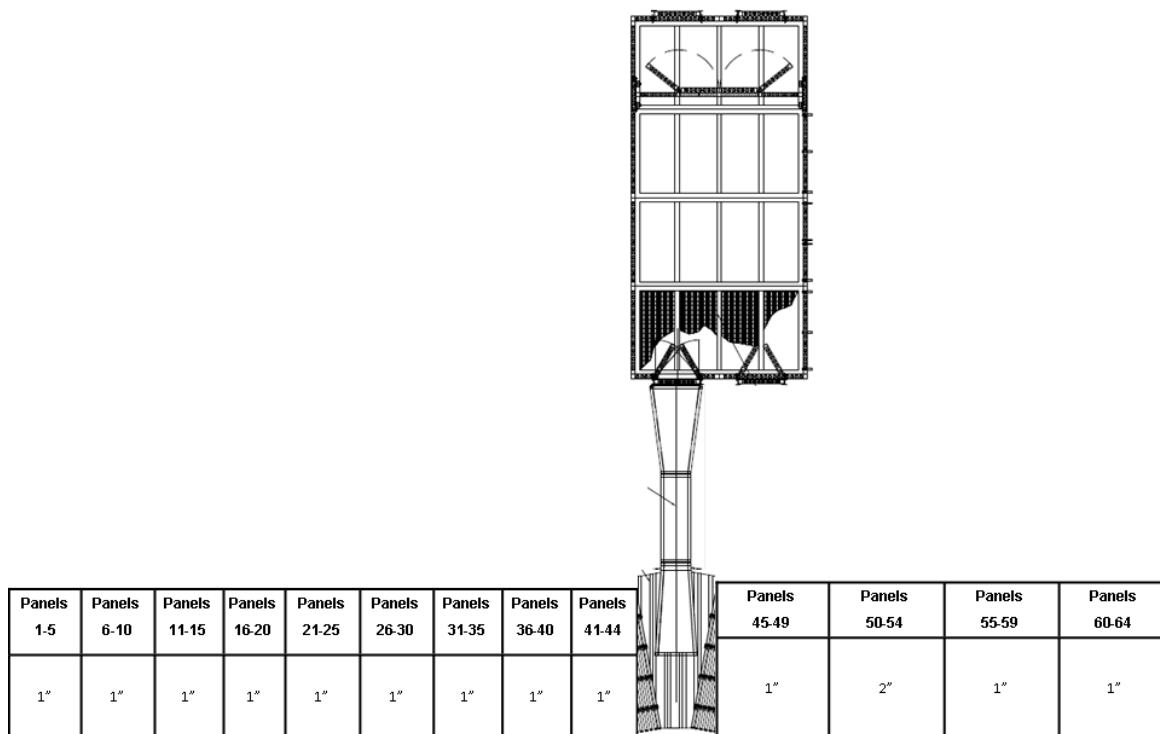


Figure 7. Conceptual diagram of picket (ABS pipe) spacing within each panel (or set of 5 panels) at the Lower Okanogan adult fish pilot weir. A 15 ft. entrance chute was installed at the lower trap gate in 2021.

Physical and chemical data were collected in the vicinity of the weir including the water depth (ft.) inside the trap, water velocity (ft./sec) upstream, downstream and in the weir trap, dissolved Oxygen (mg/L), total dissolved solids (TDS)(ppm), turbidity (NTU), temperature (°C), discharge (cfs) and head differential (cm). Temperature and discharge were taken from the online data for the USGS gauge at Malott (http://waterdata.usgs.gov/wa/nwis/uv?site_no=12447200). When river temperature exceeded 22.5° C, trapping operations ceased and weir pickets on panels adjacent to the trap on both sides were raised to allow for unrestricted fish passage. In 2021 the program experienced a higher-than-normal density of algae in the Okanogan River during weir operations. If the density was too high and too difficult to clear in order to maintain the weir panels within the operating criteria for head differential (<10cm.), pickets within the panels were raised until the algal density decreased, and trapping was ceased.

Five-minute tower observations were conducted at least two times a day, in the morning (0600-0800) and early afternoon (1200-1400) and an estimate of the number fish observed was recorded. Ten-minute bank observations were conducted about 0.8 river km. downstream of the weir, around two pools, at least twice a day, in the morning and afternoon. An estimate of the number of fish observed below the weir was recorded. Algae and debris were cleared off of the weir at least once per day generally during mid-day (1100-1300) and

early evening (1600-1800). Dead fish on the upstream side of the weir were enumerated, identified to species and the presence and extent of injuries were noted. The tail was cut off of each adipose-fin present mortality before they were tossed downstream of the weir so that they would not be double counted during surveys. Weir efficiency, a measure of the proportion of total spawning escapement encountered by the weir, was calculated by the equation;

$$X = \frac{W_T}{T}$$

where X was weir efficiency, W_T was the number of adult summer/fall Chinook encountered in the weir trap including released fish, and T was the total summer/fall Chinook spawning escapement for the Okanogan River Basin.

Weir effectiveness was a measure of the proportion of the adult hatchery Okanogan summer/fall Chinook run encountered in the weir trap, becoming available for removal from the population as a form of adult fish management. It was calculated by the equation;

$$Y = \frac{W_H}{W_H + HOS}$$

where Y is weir effectiveness, W_H is the number of adult hatchery origin fish encountered in the weir trap, and HOS is the total number of hatchery origin spawners.

Trapping operations were conducted under allowable temperature ($\leq 22.5^\circ \text{C}$) and head differential ($< 10 \text{ cm.}$) conditions for the season. Trapping operations began on August 11 and continued until September 23. When fish entered the trap during an active trapping session, fish were identified and either released or collected for brood. Ten natural-origin Chinook were collected from the weir trap from September 7 –September 22 and transported to a 600-gallon hatchery truck via a rubber boot. The fish were then transported approximately 32 km to Chief Joseph Hatchery where they were held in the brood stock raceways until spawning in October. The Whoooshh™ fish transport system was not deployed in 2021 staffing was limited to effectively operate the system during the season.

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 2). 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 an Apple iPhone™. 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 an Apple iPhone [™].

Table 2. Reach names and locations for the Okanogan and Similkameen for summer/fall Chinook Salmon spawning and carcass surveys.

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

All redds were classified as either a:

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

Redds per reach were calculated for each week as the combined number of new redds counted during aerial- and float-surveys for a given week. Post-season analysis consisted of summing the combined aerial- and float-survey weekly redd totals to calculate annual redd totals per reach, and per total survey area. Estimated total spawning escapement was then calculated by multiplying the total redd count by the expansion factor for the current year (2.31 for 2021).

The expansion factor = 1 + the number of males per female as randomly collected for broodstock at Wells Dam (1.31:1.00 in 2021). 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

In previous years, video systems operated by OBMEP and located in the fishways of Zosel Dam allowed 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 Okanagan Basin Monitoring and Evaluation Program (OBMEP) annual reports posted at (http://www.colvilletribes.com/obmep_publications.php). However, in 2021 no video monitoring occurred. Therefore, any information regarding Chinook passage at Zosel Dam and/or escapement into the Canadian portion of the Okanagan basin in 2021 is extremely limited and are based primarily on in-stream PIT array data and anecdotal observations.

Dead pitch surveys are routinely conducted in Okanagan summer Chinook spawning areas in the mainstem Okanagan River from late September to early November. Surveys have been conducted annually since 2006 and have been focused on Sockeye. Sampling efforts have focused on pre-, peak and post die-off of Sockeye as informed by enumeration surveys. In the past, surveys were directed primarily at Sockeye, and Chinook were sampled opportunistically. Surveys are conducted separately in the natural and semi-natural spawning reaches of the river, as well as in Penticton Channel. The section between McIntyre Dam and Okanagan Falls (“Skaha Section”) is currently covered by enumeration but not by dead pitch surveys and the current dead pitch program will be evaluated to determine whether the number of Chinook enumerated in this section warrants expansion of the surveys (McGrath, 2020).

During surveys, field crews walk survey sections and all encountered Chinook carcasses are sampled. The numbers of Chinook carcasses sampled during dead pitch surveys have ranged from 5 to 34 annually. The escapement of Okanagan Chinook to the “Index Section” of the Okanagan River is estimated using counts from enumeration surveys and the AUC method. As such, current escapement estimates represent an abundance index rather than a total abundance. The carcass sampling rate is generally high for years with low returns. In some years, the AUC estimate was lower than the number of carcasses sampled, in which case the

abundance estimate was changed to equal the number of carcasses sampled. In those years, the abundance estimate should be understood as a minimum abundance estimate (McGrath, 2020).

CARCASS SURVEYS

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

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

The target sample size for carcass recovery efforts is 20% of the spawning population within each reach (Hillman et al. 2014). Carcass recovery efforts occurred simultaneously with redd float surveys, although carcass efforts also occurred once a week during August and September on the Similkameen River as well. These surveys assessed potential pre-spawn mortality that occurred for those fish that held in the cooler waters of the Similkameen River before spawning began in October. Recovered carcasses were transported within inflatable rafts downstream until a suitable site was found for processing. If a carcass was too degraded to sample for biological data, it was returned to the river without sampling. All adipose absent carcasses were assumed to be of hatchery-origin, and all carcasses displaying an intact adipose fin were assumed to be of natural-origin³. Origin was later verified by results from the WDFW scale lab analyses. 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 estimated to be within a carcass were assumed to have been successfully deposited. Any female carcass containing an estimated 5,000 eggs were considered a pre-spawn mortality. Forceps were used to remove five scale samples from all natural-origin Chinook. Scales were adhered to desiccant scale cards for preservation and identified by sample number and sample date. At the conclusion of spawning season, scales were sent to WDFW for post-hoc age analysis. Age analysis data were used to assess age-at-return (run-reconstruction) and combined with biological data to assess length-at-age. All Chinook were scanned for passive integrated transponder (PIT) tags and all PIT

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

detections were recorded and later uploaded to PTAGIS. Carcasses were scanned with a T-wand (Northwest Marine Technology, Inc., Shaw Island, WA USA) for coded wire tags (CWT). If present, the snout portion was removed and individually bagged and labeled with species, origin, FL, river of recovery and date. After sampling each carcass, the caudal fin was removed before the carcass was returned to the river to avoid resampling on subsequent surveys. All data collected in the field were input directly into an Apple iPhone™. Weekly carcass recovery totals were summed post-season to calculate annual carcass recovery totals per reach and per survey area.

Some key assumptions for carcass surveys included:

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

pHOS and PNI

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

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

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

Relative reproductive success has not been estimated for summer/fall Chinook in the Okanogan. One of the key assumptions in the In-Season Implementation Tool was that first-generation hatchery fish are less effective natural spawners than natural-origin fish. Currently, the hatchery fish effectiveness assumption for the Okanogan population is that first-generation hatchery-origin spawners are 80% as effective as natural-origin fish as contributing genes to the

next generation⁴ This assumption is based on research conducted by Reisenbichler and McIntyre (1977) and Williamson et al. (2010). Therefore, the pHOS calculation was amended in 2013 to account for the reduction in hatchery spawner effectiveness, such that:

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

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

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

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

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

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

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

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

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

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

PNI was calculated as:

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

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

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

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

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

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

Origin of Hatchery Spawners

Snouts from adipose fin clipped fish were removed, individually labeled, frozen, and delivered to the Chief Joseph Hatchery coded wire tag lab for CWT extraction and reading. The Regional Mark Information System (RMIS; <http://www.rmis.org/rmis>) was queried in March 2022 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

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).

McNary Dam Juvenile bypass (MCN). Although some recaptures were obtained further downstream than McNary Dam, survival through the entire hydropower system to Bonneville Dam could not be generated because there were not enough recaptures downstream to estimate the recapture probability. Survival estimates and travel time for nearby hatcheries and the wild summer Chinook captured in the RST and beach seine were also analyzed for comparison purposes.

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

Migration timing from release to the lower Okanogan River was determined using a query of the PTAGIS database (<https://www.ptagis.org/data/quick-reports/small-scale-site-detections>) to determine the timing of PIT tag detections from releases of Summer Chinook at Omak Pond. No PIT tags were released from Similkameen Pond in 2021. 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 calculated using two different methods, PIT tags and coded-wire tags (CWT). For PIT tags, SAR was calculated for adult fish (age 4-6) from release, back to Bonneville and Wells dams using the formula:

$$SAR = \frac{\# \text{ PIT tags detected in adult ladders at dam } x}{\# \text{ PIT tags released}}$$

A correction was then applied to the SAR to account for adult fish harvested before reaching each dam. Standard harvest rates for each return year were applied based on harvest summaries for indicator stocks generated by the Technical Advisory Committee of US v Oregon.

The SAR for CWT was estimated as:

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

where expanded CWT recoveries included estimated expanded recoveries on the spawning grounds, at hatcheries and in fisheries. Two expansions were applied. First the number of recoveries was expanded to account for the proportion of the release group that wasn't tagged. For example, with a 99% CWT mark rate the recoveries would be increased by 1%. Second, the recoveries were expanded based on the proportion of the population that was sampled. For example, if carcass surveys recovered 20% of the estimated spawners, then the number of CWT

recoveries was expanded by 80%. The number of CWT fish released were simply the hatchery release data including all tag codes for CWT released fish (CWT + Ad Clip fish and CWT-only fish).

Coded Wire Tag Lab Analysis

Coded wire tags (CWT) from broodstock, ladder surplus, purse seine harvest, creel and spawning ground surveys were extracted, read, and reported in the Chief Joseph Hatchery Lab from December 2021 to February 2022. The snouts were then interrogated for the presence of a CWT by using a T-wand. After positive detection, the snout was cut bilaterally into symmetrical portions keeping the half that indicated detection and discarding the other half into the snout bag from which it came. This process was then repeated until only a small piece of tissue containing the CWT remains. The final piece of tissue was then smeared on a cutting mat exposing the CWT, then placed on its corresponding snout card and finally on to a cafeteria tray (groups of ~25 tags) to be read under a microscope.

Extracted tags were removed from the tray one-by-one to be cleaned, recorded, and read. The CWT was cleaned by wetting a lint free cloth and rolling the tag between a finger and cloth to remove all remaining tissue. The CWT was attached to a Northwest Marine Technologies (NMT) magnetic pencil and inserted into a jig to be read under a LCD microscope with the aid of an illuminator. Biological data was transcribed from the snout card to a final CWT datasheet. The CWT was attached to this datasheet with tape after the six-digit code was read. Information from the datasheet was transferred to an excel workbook which contains all applicable CWT code combinations.

CWTs were expanded based on their tag loss and sample rate to estimate total catch contribution for a specific fishery. For each fishery, every CWT recovered and decoded was grouped according to their tag code with the total number of CWTs recovered from that release group, (e.g., tag code 200108 was recovered 10 times for a fishery/location (tag group 1). (See formula 1 below). Tag group 1 is then divided by the sum of all recovered/decoded CWTs for that specific fishery. This value was multiplied by the sum of all lost and scratched tags with tag group 1 being added to the end of the calculation. This provides an adjustment factor for lost and scratched tags for every unique tag code by hatchery of origin. Mark rates are typically high (~99%) for most Upper Columbia River release groups, however it is important to account for missing tags or tags that were shed during the fish's lifecycle. (See formula 2 below). Taking the adjustment factor for lost and scratched tags and multiplying it by the tag loss rate (tag loss rate can be found at www.RMPC.ORG) provides an adjustment for missing tags. These adjustments (lost/scratched/missing) can be summed together to provide total catch contribution for a fishery that was sampled at 100 percent. (See formula 3 below). When sampling occurred at less than 100 percent the adjustment total is divided by the sample rate to calculate the expanded number of fish for each release group.

(1) Adjustment for Lost/scratched tags:

$$CWT_{Adjustment} = (Tag_{group1} / \sum Total\ tags) * (\sum Lost + scratched\ Tags) + Tag_{group1}$$

(2) Adjustment for tag loss:

$$CWT_{Adjustment} = \{ (Tag_{group1} / \sum Total\ tags) * (\sum Lost + scratched\ Tags) + Tag_{group1} \} * (Tag\ loss\ Rate)$$

(3) CWT expansion

$$CWT_{Adjustment} = \frac{\{ (Tag_{group1} / \sum Total\ tags) * (\sum Lost + scratched\ Tags) + Tag_{group1} \} * (Tag\ loss\ Rate)}{Sample\ Rate}$$

Finally, after accounting for the mark rate of each group, the remaining ad-clip, no-CWT fish were assigned to the CJH segregated group.

RESULTS

Rotary Screw Traps

The rotary screw traps captured 12,921 Chinook juvenile out migrants, including 1,490 hatchery- and 11,431 natural-origin. Highest catches were recorded when Okanogan River flow began to increase (Figure 8). The mean length of Chinook increased throughout the trapping season, and we were able to PIT tag 1,692 natural-origin smolts after capture at the screw traps (Figure 9). The 2021 rotary screw trap season was a great year for total catch and was our largest tagging effort to date. No natural-origin fish were captured that were likely yearling Chinook.

Following Chinook, the next most abundant species captured in the RST was mountain whitefish (Table 3). Notably, only 21 Sockeye were detected, which is far lower than in some previous years. Seventeen adipose fin present⁶ steelhead and 56 adipose fin absent (hatchery-origin) steelhead were removed from the trap and released immediately into the river. There was one juvenile steelhead mortality at the trap resulting in a 1% juvenile trapping and handling mortality rate for steelhead. The encounter of 57 adipose clipped and 17 adipose present (assumed natural-origin) and mortality of zero (1) assumed natural-origin steelhead

⁶ Not all hatchery steelhead released in the Okanogan receive an adipose fin clip. In 2021, 89,816 steelhead were released into the Okanogan River with an adipose clip, and 12,153 unclipped steelhead were released.

are within the take limits identified in the authorizing ESA Section 10(a)(1)(A) Permit for the rotary screw trap operation (Permit 16122).

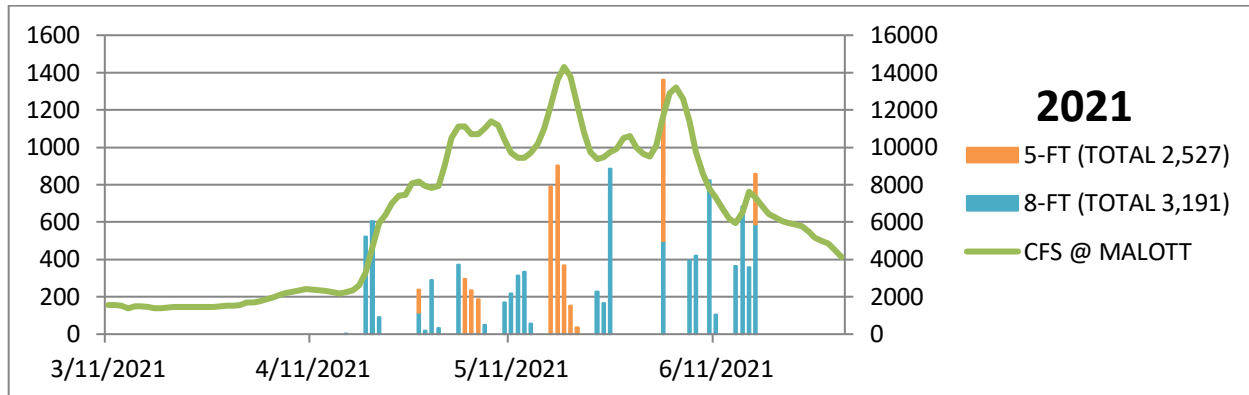


Figure 8. Daily natural-origin sub-yearling Chinook catch for the 8 foot and 5 foot trap within the Okanogan River in 2021.

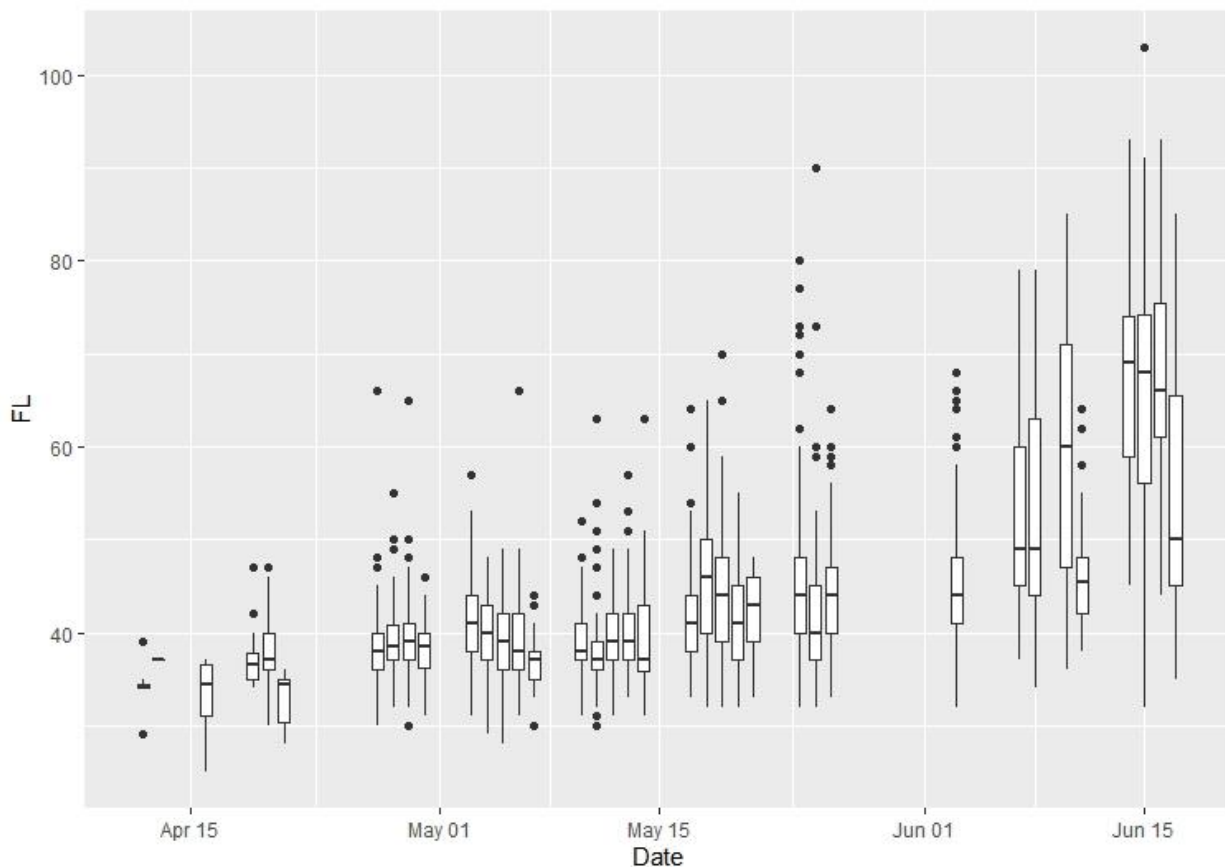


Figure 9. Natural-origin sub-yearling Chinook size distribution (n= 2,868) from the rotary screw traps on the Okanogan River in 2021. Boxes encompass the 25th to 75th percentiles of

measured fish, points represent statistical outliers, and the mid-line in the box is the median fish length. FL = fork length in millimeters (mm).

Table 3. Number of juvenile fish trapped at the Okanogan River rotary screw traps in 2021.

Species	Total Trapped
Bluegill	35
Bridgelip Sucker	13
Common Carp	34
Longnose Dace	7
Northern Pikeminnow	51
Largemouth Bass	36
Sculpin (<i>Cottus</i> spp.)	26
Smallmouth Bass	12
Three Spine Stickleback	53
Peamouth	1
Speckled Dace	5
Pacific Lamprey	16
Bullhead (<i>Ameiurus</i> spp.)	5
Yellow Perch	182
Non-salmonid total	460
Adipose Clipped steelhead	57
Adipose Present steelhead	17
Hatchery Chinook	1,490
Sockeye	21
Wild Chinook Subs	11,431
Wild Chinook Yearling	0
Eastern Brook Trout	0
Mountain Whitefish	2,832
Salmonid total	16,041

Four efficiency trials were conducted with juvenile Chinook (all with natural-origin subyearlings) at varying cfs (Table 4.). Since RST efficiency and Okanogan River flow have not been correlated in the past and the number of efficiency trials conducted in 2021 was not large enough to show correlation during this year, the WDFW smolt abundance calculator was not employed. Because of the inability to collect sufficient data to confidently estimate juvenile outmigration, abundance estimates were not produced for the 2021 outmigration.

Table 4. Efficiency trials conducted on natural-origin Chinook sub-yearlings at the Okanogan rotary screw traps in Ma7 and June, 2021.

Trap Date	River Flow @ USGS Malott	Total Chinook Marked and Released	Age Class / Origin	Total Chinook Recaptured	Trap Efficiency
5/5	10,700	602	0/Wild	2	0.33%
5/12	9,440	503	0/Wild	2	0.40%
5/17	12,200	1,000	0/Wild	5	0.50%
6/9	8,570	662		13	1.96%
Total		2,767		22	0.80%

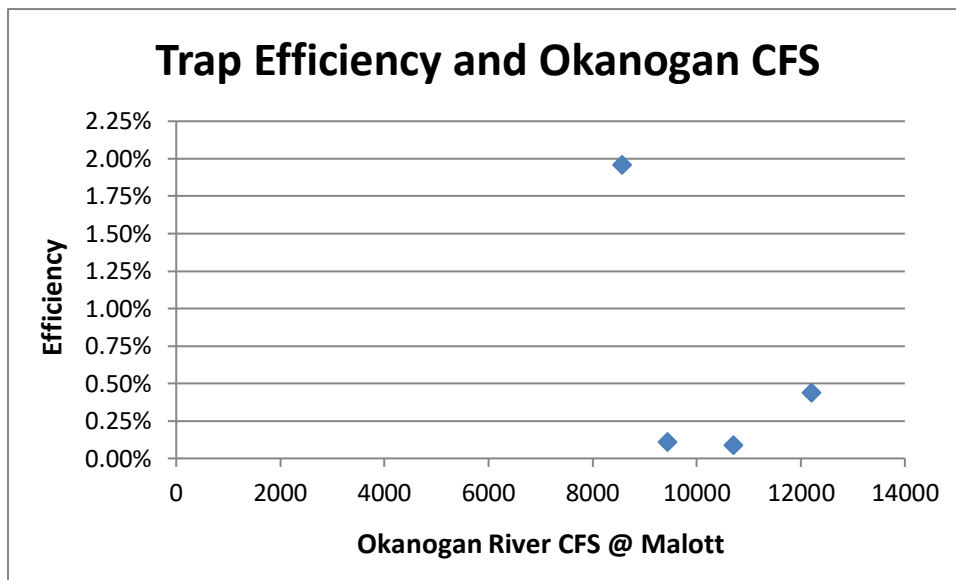


Figure 10. The efficiency trials conducted with dyed natural-origin Chinook sub-yearlings are marked in blue.

Since streamflow did not affect trapping efficiency, efficiency trials were pooled to calculate overall trap efficiency for natural origin fish only (Table 5). Only twenty-two natural-origin sub-yearlings out of 2,767 released were recaptured (0.80% efficiency). There were not enough hatchery origin fish to estimate efficiency. Overall efficiency estimates for natural origin

fish were low even as total catches improved, leading to a relatively imprecise estimate of total emigration (Table 6).

Table 5. Pooled efficiency trial results for all trap configurations. Whenever fish were released, each trap was operational. Efficiency was calculated based on recaptures for each individual trap, as well as the combined efficiency of both traps.

Trap	Stock	Mark-Released	Recaptured	Efficiency
2.4 m Trap	Natural Sub-yearling	2,767	15	0.54%
	Hatchery Yearling	N/A	0	0.00%
1.5 m Trap	Natural Sub-yearling	2,767	7	0.25%
	Hatchery Yearling	N/A	0	0.00%

Table 6. Population estimates for natural-origin juvenile Chinook salmon in the Okanogan River Basin.

Species	Population Estimate	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Hatchery-origin Chinook*	N/A	N/A	N/A
Natural-origin*** Chinook	1,343,321	807,615	1,879,028

* A total of 877,713 hatchery-origin Chinook were released into the Okanogan River system upriver from the screw trap site in 2021. 222,508 were released from the Riverside acclimation pond from April 19-21; 386,943 were released from the Similkameen hatchery from April 15 – April 30; 298,988 were released from the Omak acclimation pond on April 19-21; and 21,847 were released in Canada into the Okanogan River in April 2021.

** The lower confidence interval is bounded by the number of hatchery-origin Chinook captured in the RST in 2018

Juvenile Beach Seine and Pit Tagging

In 2021, 29,043 natural-origin juvenile salmonids were collected in over the course of 12 tagging days (Table 7). Out of the juvenile summer/fall Chinook collected, 20,213 (70%) sub-yearling Chinook were PIT tagged and released (Figure 11). Pre- and post-tag mortality was 11.5% and 5.2% respectively. All recovered tags were removed from the tagging file before upload to PTAGIS. Fish size increased through time (Figure 12), but after peaking in the week beginning on 29 June, the number of fish captured at Gebber's rapidly declined (Table 7). By late-June, Columbia River temperatures had risen to above 14° C. We suspect that sub-yearling Chinook may have migrated downstream, or to deeper, cooler water making it difficult to collect them via beach seine, as has presumably happened in past years. Fork length for tagged fish ranged from 45-108 mm, with an average of 69.7 mm (SD 8.7 mm) and a median of 70 mm (Figure 13). Bycatch included hatchery-origin juvenile Chinook, three-spine stickleback, mountain whitefish, smallmouth bass, and sculpin.

Table 7. Summary of juvenile Chinook beach seining effort at Gebber's Landing and Pharr Road in 2021. This table excludes Chinook salmon that were captured, PIT tagged, and then recaptured in the beach seine.

Week start	Gebber's Fish Collected	Gebber's Fish Tagged	Proportion Gebber's Fish Tagged	Pharr Rd. Fish Collected	Pharr Rd. Fish Tagged	Proportion Pharr Rd. Fish Tagged
6/9				119	20	20.2%
6/10	815	326	40%			
6/15	2,431	2,300	94.6%			
6/16	2,974	2,581	86.8%			
6/17	2,420	2,307	95.3%			
6/18	2,595	2,247	86.6%			
6/23	2,704	2,337	86.4%			
6/24	2,210	1,611	72.9%			
6/25	1,781	1,530	85.9%			
6/29	3,289	2,829	86.0%			
6/30	2,787	2,518	90.3%			
7/1	555	508	91.5%			
Total	24,561	21,094		119	20	
Mean	2,232	1,917		119	20	

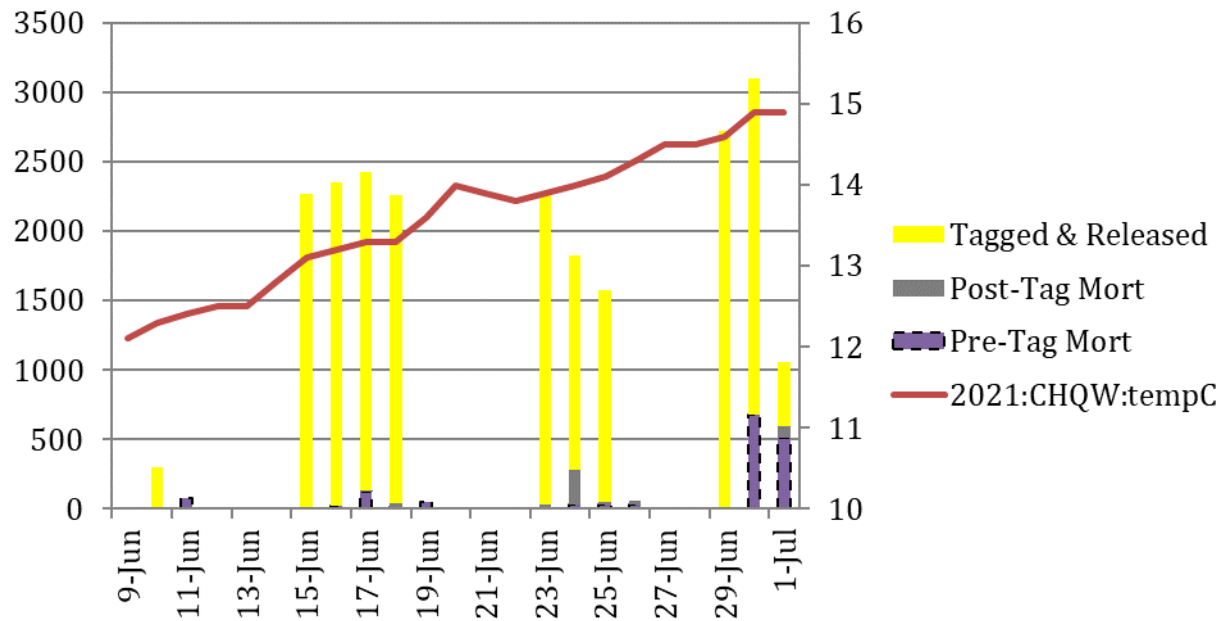


Figure 11. Total mortality and number of released natural-origin sub-yearling Chinook in 2021. Primary y-axis shows number of juvenile Chinook; secondary y-axis (right hand side) shows water temperature (degrees Celsius (C)).

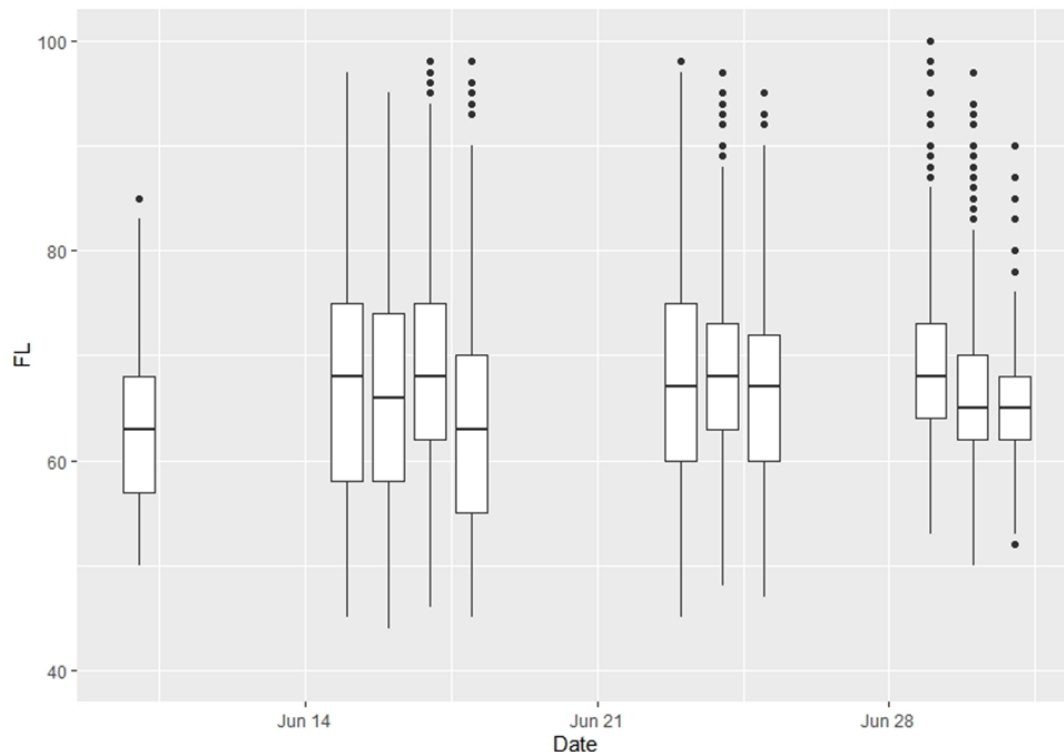


Figure 12. Size distribution of PIT tagged juvenile Chinook by release date from the beach seine effort in 2021. Boxes encompass the 25th to 75th percentiles of measured fish; the mid-line in the box is the median fish length. FL = fork length in millimeters (mm).

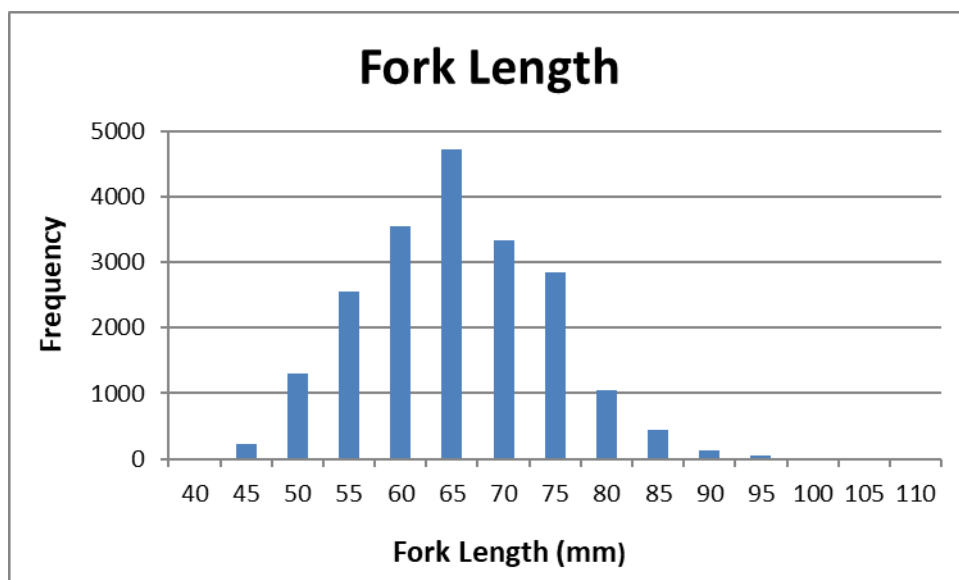
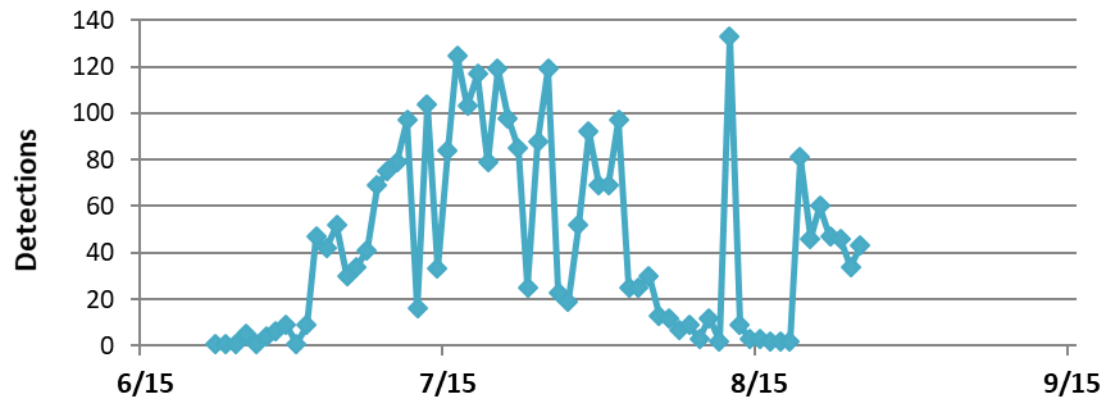


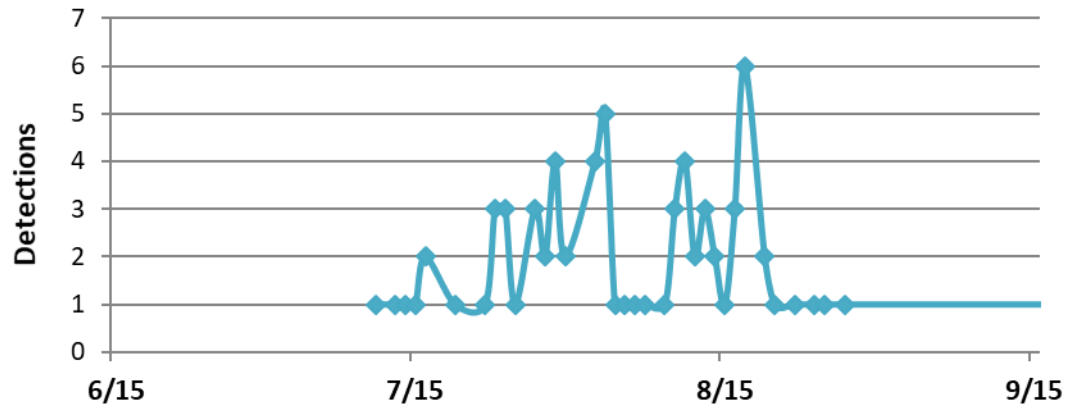
Figure 13. Size distribution of natural origin sub-yearling Chinook tagged during the beach seining effort in 2021.

The Rocky Reach juvenile bypass system detected 2,869 PIT tagged juvenile Chinook from the beach seining effort, which was 14.2% of total fish tagged and released. Seventy-two (0.36%), 35 (0.17%) and 16 (0.08%) were detected at the McNary, John Day and Bonneville Dams respectively. Detections for sub-yearlings occurred primarily from late-June to early-August at all downriver dams (Figure 14). Utilizing the mark-recapture model from DART, the apparent survival rate was 41% (SE 6%) to Rocky Reach. Survival estimates could not be calculated in DART from Rocky Reach down due to abnormal spillage events that resulted in low detection rates from McNary to Bonneville dams.

a) Rocky Reach



b) McNary



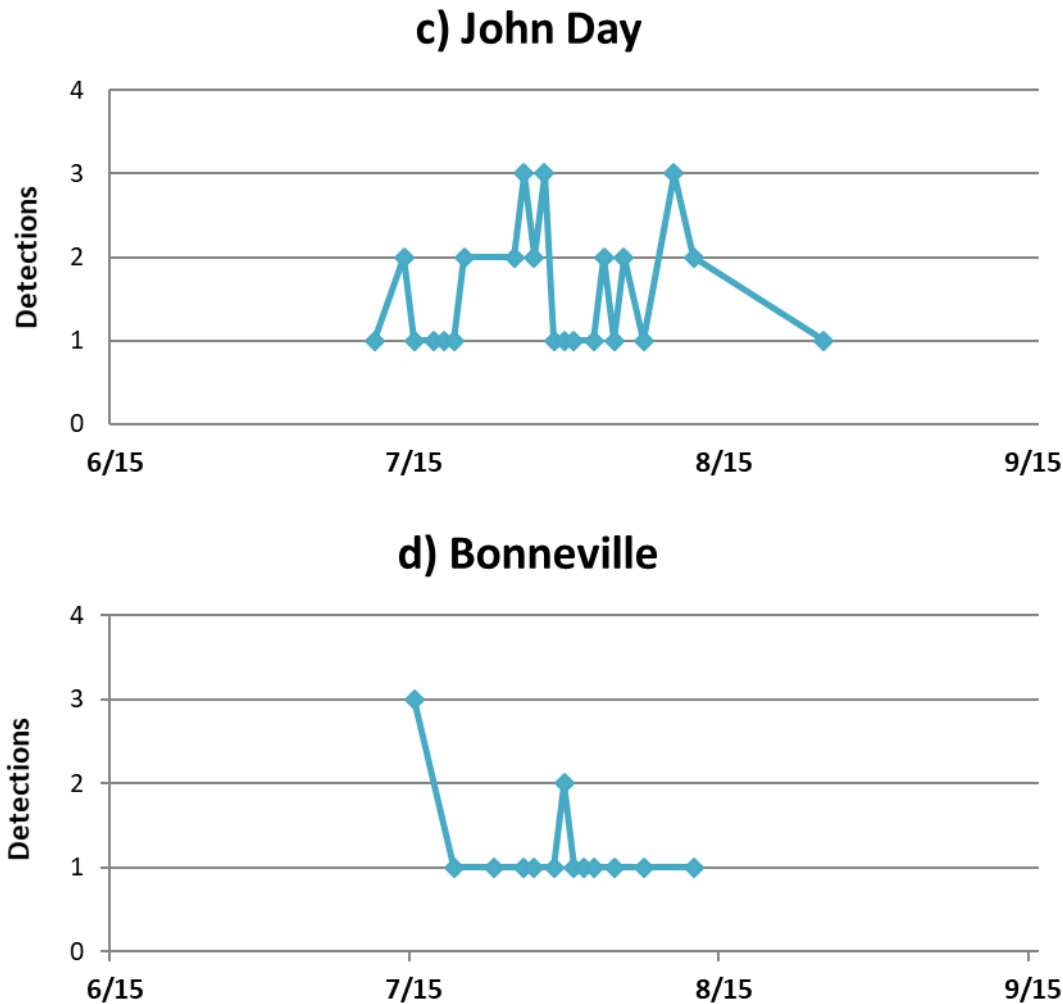


Figure 14. Daily distribution of detections of PIT-tagged sub-yearling Chinook at Rocky Reach, McNary, John Day, and Bonneville Dams in 2021. Note differences in scale on the y-axis. The y axes denote the numbers of PIT-tagged fish encountered daily at each of the mainstem project arrays.

Travel time from release to Rocky Reach Dam was the slowest compared to travel time from release to the other lower river dams – on average, fish moved downstream more quickly the further downstream they travelled (Table 8). Larger fish travelled faster to Rocky Reach Dam (Figure 15). This is similar to what was reported in 2011-2013 by Douglas County PUD and observed in previous years by CCT.

Table 8. Mean travel time (d) and rate (km/d) for PIT tagged sub-yearling Chinook released near Gebber's Landing and detected at Columbia River dam PIT arrays.

	Rocky Reach (762)		McNary (470)		John Day (347)		Bonneville (235)	
Location (River KM)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)
Release (856)	32.31 (Standard Deviation = 13.9; n=2,471)	2.9	45.38(Standard Deviation = 20.8; n=65)	8.5	38.31 (Standard Deviation = 39.4; n=31)	1	36.78 (Standard Deviation= 60.9; n=14)	13.3
Rocky Reach (762)			8.77 (Standard Deviation = 14.9; n=22)	33.3	13.12 (Standard Deviation = 15.2; n=6)	31.6	15.87 (Standard Deviation = 87.1; n=4)	33.2
McNary (470)					**** (Standard Deviation = *, n=0)	N/A	**** (Standard Deviation=*, n=0)	N/A
John Day (347)							2.03 (Standard Deviation = 0; n=1)	55.2

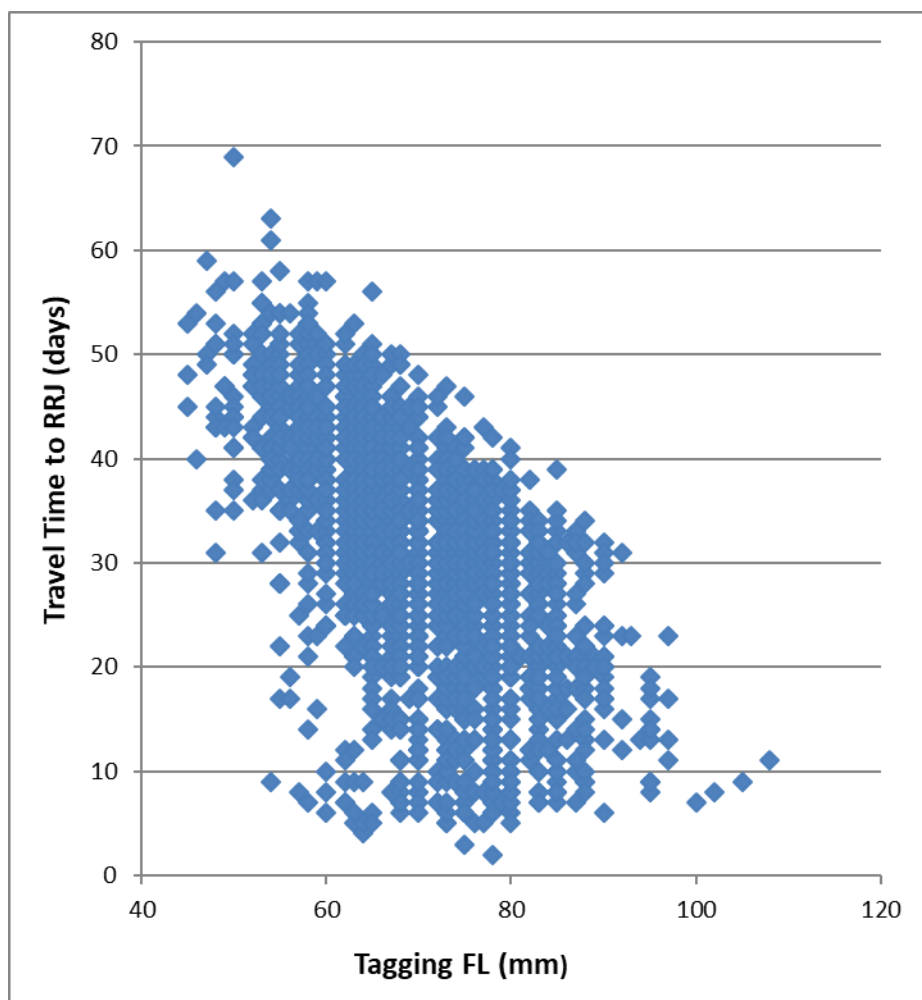


Figure 15. Fish size (fork length) and travel time of tagged Chinook to Rocky Reach Dam.

Lower Okanogan Adult Fish Pilot Weir

The Okanogan River (at Malott) discharge was below normal in 2021 which allowed for deployment of the weir to start on August 2nd with the river flow at 927 cfs (Figure 16). Discharge continued to drop throughout the season and was approximately 828 cfs by the time the weir was removed for the season on September 29.

Migration of sockeye and summer/fall Chinook is generally affected by a thermal barrier that is caused by warm water temperatures ($\geq \sim 22^{\circ}\text{C}$) in the lower Okanogan River. The thermal barrier is dynamic within and between years, but it generally sets up in mid-July and breaks down in late August. In some years, the Okanogan River will temporarily cool off due to a combination of interrelated weather factors including rainstorms, cool weather, cloud cover and/or wildfire smoke. This 'break' in the thermal barrier can allow a portion of the fish holding in the Columbia River to enter the Okanogan and migrate up to thermal refuge in the Similkameen River or Lake Osoyoos. In 2021, temperatures were similar to the

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

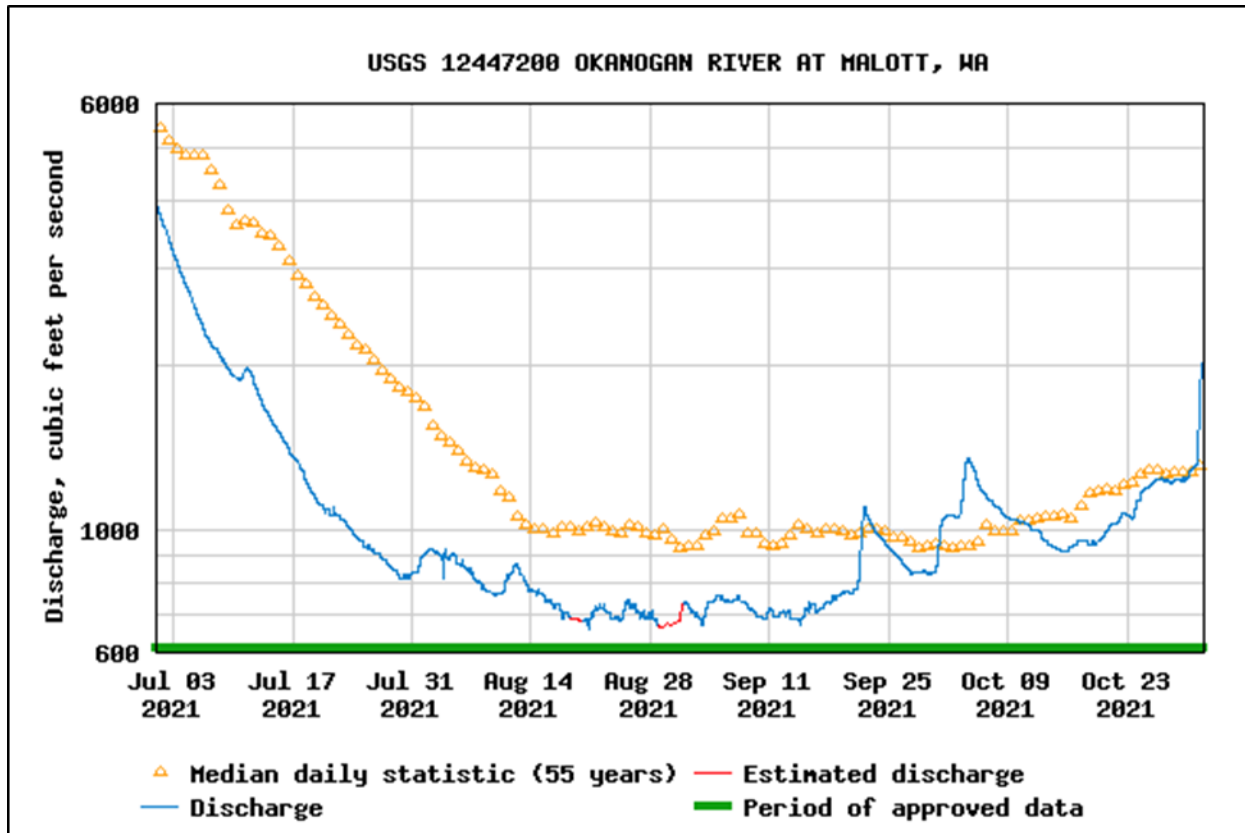


Figure 16. Discharge of the Okanogan River between July 1 and October 31, 2021. This figure was copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

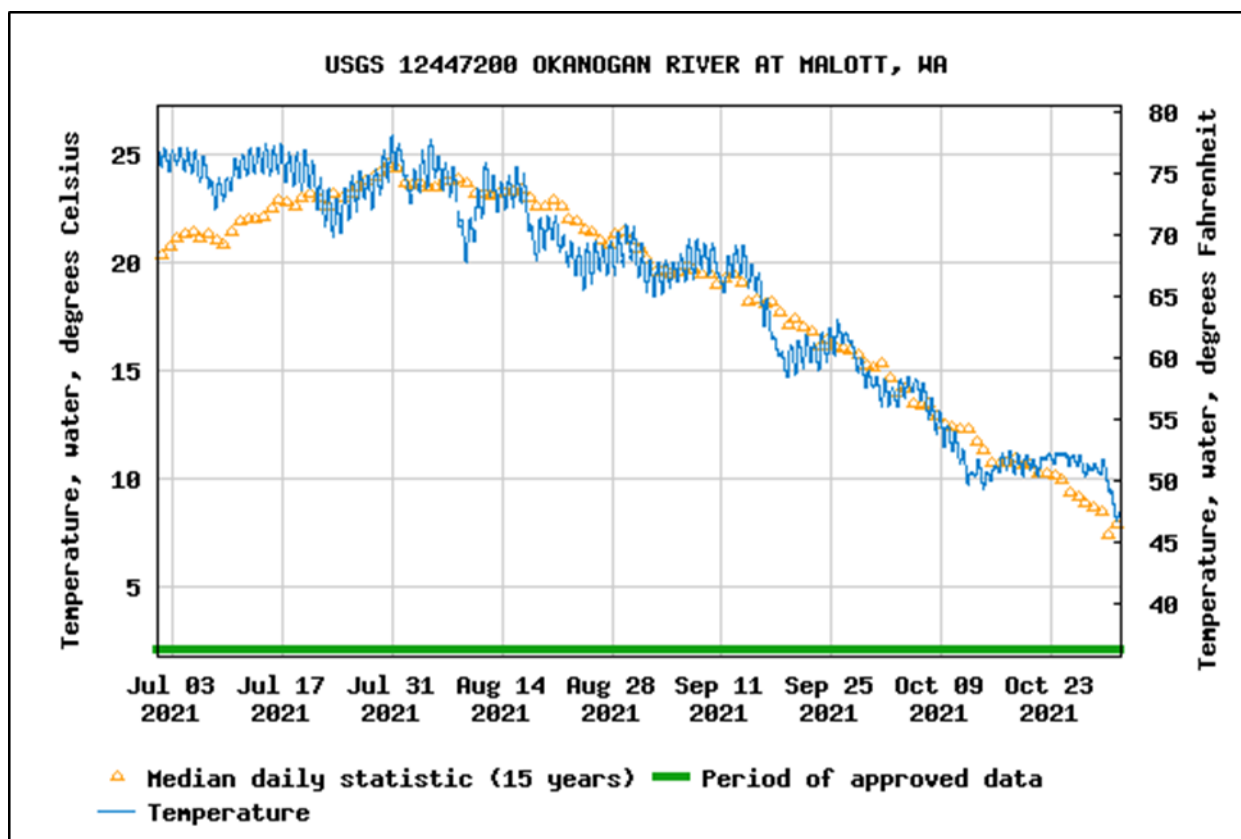


Figure 17. Temperature of the Okanogan River between July 1 and October 31, 2021. This figure was copied directly from the USGS website (<http://nwis.waterdata.usgs.gov/wa>).

Dissolved Oxygen varied from 6.5 to 9.5 mg. /L, total dissolved solids varied from 122-184 ppm and turbidity varied from 0.6 and 1.6 NTUs (Table 9). The head differential was measured only when pickets were down and ranged from 1.0-21.0 cm. The maximum water velocity measured was 4.4 ft. /sec. (Table 10).

Table 9. Water quality data at or near the lower Okanogan weir in 2021. Temperature and discharge were taken from the USGS gage at Malott. Minimum depth allowed for trap depth is 6 inches and optimal dissolved oxygen levels for adult Chinook should not drop below 6 mg/L.

Date	Trap Depth (ft.)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (ppm)	Turbidity (NTU)	Mean Temperature (°C)	Mean Discharge (cfs)
8/12	1.9	9.10	149	1.2	23.6	850
8/13	2.0	8.10	133	1.0	23.1	795
8/16	1.7	9.29	135	1.3	23.3	735
8/17	1.7	9.50	139	1.2	21.7	714
8/18	1.6	9.14	136	1.2	21.0	698
8/19	1.8	8.95	138	1.6	21.4	686
8/20	2.4	9.00	184	1.6	21.6	681
8/23	2.0	9.10	136	0.9	20.1	688
8/24	1.7	7.53	134	1.0	19.8	688
8/25	1.8	N/A	133	1.0	20.0	725
8/26	1.8	6.45	136	1.6	20.2	704
8/27	1.8	7.90	136	1.2	20.2	690
8/28	1.8	7.60	137	1.0	20.4	683
8/30	1.9	9.00	139	0.6	20.9	673
8/31	1.9	8.60	134	0.7	20.1	702
9/1	1.7	8.50	137	0.8	19.5	726
9/2	1.6	7.80	136	0.7	19.3	698
9/3	2.6	7.34	137	0.9	19.4	716
9/7	1.7	9.30	143	0.7	20.2	747
9/8	1.7	8.72	142	0.7	20.4	725
9/9	1.6	8.90	142	0.8	20.2	702
9/10	1.6	7.30	144	0.9	19.6	701
9/13	1.6	7.42	146	0.7	20.2	699

9/14	1.6	8.99	144	1.2	19.5	689
9/15	1.6	6.75	143	1.1	19.1	722
9/16	1.6	6.95	135	0.7	17.8	722
9/17	1.6	7.24	133	0.8	16.6	734
9/20	1.7	8.00	122	0.6	15.7	775
9/21	1.7	7.54	128	0.7	15.9	881
9/22	2.0	7.50	127	0.9	15.9	1060
9/23	1.9	7.87	122	1.2	15.9	992
Min	1.6	6.5	122.0	0.6	15.7	673
Max	2.6	9.5	184.0	1.6	23.6	1060

Table 10. Water velocity upstream (US) and downstream (DS) of the weir and in the trap. Velocity should not exceed 3.5 ft. /sec Measurements are in ft. /sec.

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

9/16	1.7	1.6	2.4	2.9	2.8	2.6	0.6
9/17	1.7	1.5	2.4	2.8	2.7	3.0	1.0
9/20	1.8	1.6	2.4	2.6	3.0	3.0	0.6
9/21	1.9	1.6	2.4	2.9	3.1	2.7	0.8
9/22	2.2	1.6	2.5	3.1	4.4	3.1	0.7
9/23	2.2	1.7	2.6	3.0	3.5	3.1	0.7
Min	0.2	0.8	1.3	1.2	2.0	1.3	0.0
Max	2.2	1.9	2.6	3.1	4.4	3.1	2.0

Thirty-two dead fish were removed from the weir between August 13 and September 11. The majority of the mortalities (22) were sockeye and 7 of the mortalities were mountain whitefish. There were no Chinook mortalities removed from the weir in 2021. All mortalities were impinged on the upstream side of weir indicating that they had most likely died upstream and floated down onto the weir.

Tower observations showed the fish that were milling below the weir were equally distributed in the left, center, and right (looking downstream) sections of the river. Estimates were highest for a couple days in mid-August, about a week after trapping began, when mean daily river temperatures dropped below 22.5 °C. Bank observations showed that the number fish observed holding in the lower pool, 0.8 km below the weir, increased after temperatures decreased below 18 °C in mid-September (Figure 18). Trapping was suspended for the first week of the season because of high temperatures but operations began on August 18 and continued till September 23 after river temperatures dropped below 22.5 °C. Similar to 2019, the program experienced a higher-than-normal density of algae in the Okanogan River during weir operations. From August 18-22, trapping only occurred during morning hours so that available staff could keep panels clear of algae. Pickets were pulled up during non-trapping, afternoon, and night-time hours during this five-day period. After August 23rd, the program was able to maintain cleanings on the weir panels through the rest of the season. The total fish trapped at the weir in 2021 was 99 with 57% of them being Chinook salmon (Figure 19). Fifty-seven percent of the Chinook trapped were released back into the river (Figure 20). Ten steelhead were trapped in 2021.

Ten natural-origin Chinook were transported to the hatchery and held in the brood stock ponds concurrently with the fish taken for brood stock from the purse seine. Adult Chinook were transported from the weir trap to the hatchery brood truck via a rubber boot. We were unable to assess the pre-spawn mortality of the weir brood

because they were mixed with the rest of the integrated brood when they were transported to the hatchery. Past efforts have not indicated a problem with survival of brood fish collected at the weir. If we need to assess pre-spawn mortality in future years, we will need to mark these fish before they are transported to the hatchery or before they are mixed with the other brood at the hatchery.

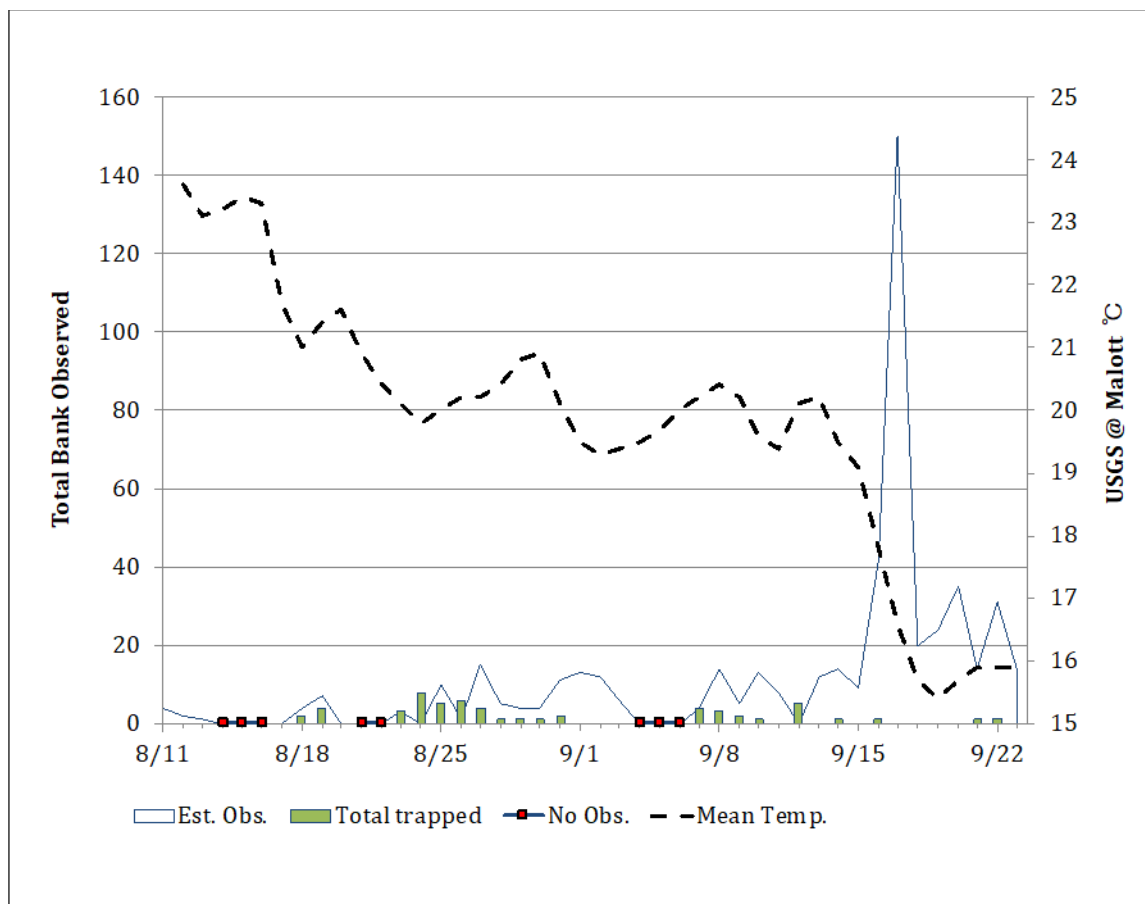


Figure 18. Estimate of Chinook observed from the bank at the lower pool, 0.8 km downstream of the weir. Primary y-axis indicates number of Chinook observed; secondary y-axis (right hand side) indicates the mean stream temperature in degrees Celsius (C).

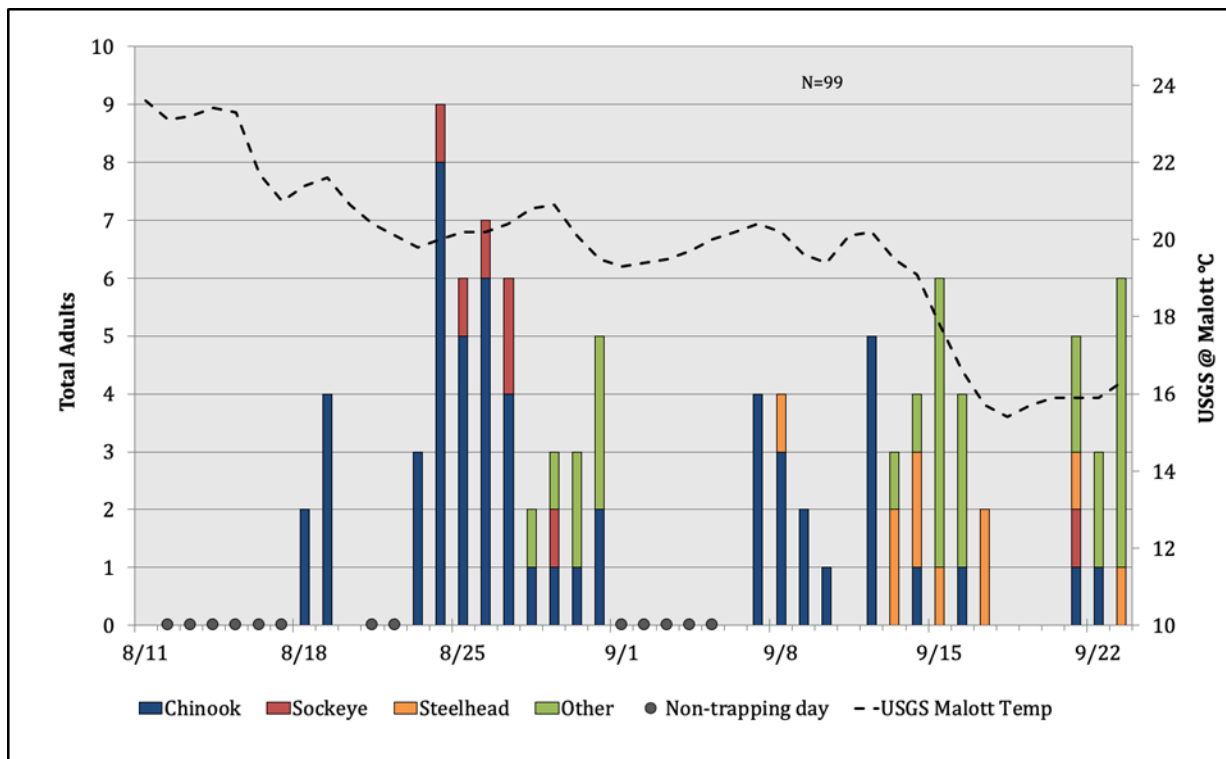


Figure 19. Total number of fish trapped at the Okanogan weir in 2021.

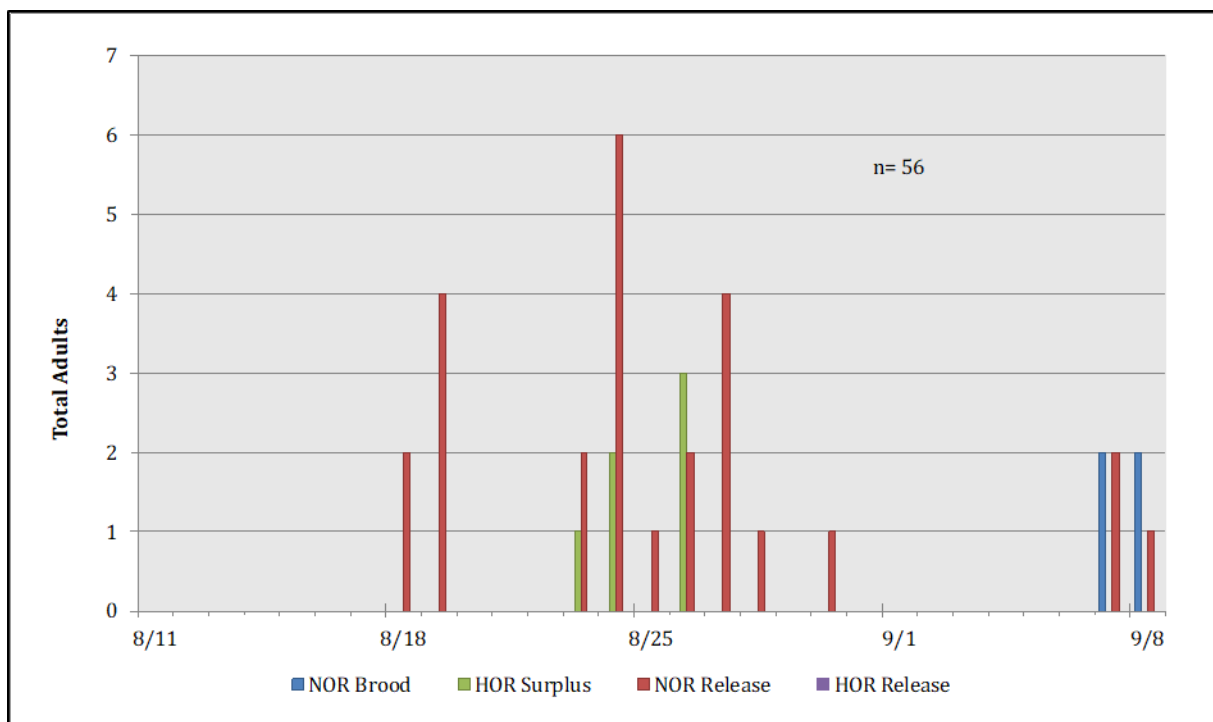


Figure 20. Final destination of Chinook adults captured in the weir trap during trapping operations in 2021.

In 2021, 0.006 (0.6%) of total spawning escapement was detected in the trap (i.e., weir efficiency) (Table 11). The potential weir effectiveness (if we had been removing all of the HOR encountered) was 0.003 (0.3%).

Table 11. The number of hatchery and natural origin Chinook Salmon encountered at the lower Okanogan weir in 2021. Weir efficiency and effectiveness were metrics for evaluating the potential for the weir to contribute to the CJHP population management goals in the future.

Survey Year	Number of Days Trapped	Chinook Adults Encountered in the Weir Trap		Chinook Spawning Escapement Estimates ^{c,d}		Weir Metrics	
		Natural Origin (NOR)	Hatchery Origin (HOR)	Natural Origin (NOS)	Hatchery Origin (HOS)	Weir Efficiency ^a	Weir Effectiveness ^b
2013	23	73	18	5,627	2,567	0.010	0.007
2014	34	2,006	318	10,407	1,756	0.147	0.140
2015	34	36	19	10,439	3,297	0.004	0.005
2016	30	135	34	8,700	1,905	0.014	0.016
2017	24	344	103	5,429	1,139	0.058	0.075
2018	38	32	16	3,266	1,594	0.009	0.009
2019	5	119	24	2,604	2,849	0.023	0.008
2020	27	709	161	7,957	3,062	0.066	0.045
2021	30	37	9	4,525	2,521	0.006	0.003

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

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

^c Estimates do not include Chinook Zosel Dam counts.

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

Redd Surveys

In 2021, 3,050 summer/fall Chinook redds were counted in the Okanogan and Similkameen rivers using a combination of ground and aerial surveys. The number of redds counted in 2021 was lower than the previous year (2020) – higher than the long-term average and 5-year average (Table 12). Consistent with previous years, the majority of Chinook redds were located in reaches S1 (31%), O6 (38%), and O5 (18%; Figure 22). These three reaches accounted for 87% of the total Chinook spawning in the basin. The overall redd distribution across reaches was similar to previous years with the majority of spawning taking place in the upper Okanogan reaches (O5 and O6) and lower Similkameen (S1) (Figure 22).

Estimated spawning escapement was 7,046 ($3,050 \text{ redds} \times 2.31 \text{ fish per redd}$) (Table 14). Since 1989, the summer/fall Chinook spawning escapement within the U.S. portion of the Okanogan River Basin has averaged 5,861 and ranged from 473 to 13,857 (Table 14).

Summer/fall Chinook redds were counted during spawning ground surveys between October 6- Nov 5 (Table 15).

Table 12. Total number of redds counted in the Okanogan River Basin, 1989-2021 and the averages for the total time series and the most recent 5-year period.

Survey Year	Number of summer Chinook redds		
	Okanogan River	Similkameen River	Total Count
1989	151	370	521
1990	99	147	246
1991	64	91	155
1992	53	57	110
1993	162	288	450
1994	375*	777	1,152
1995	267*	616	883
1996	116	419	535
1997	158	486	644
1998	88	276	364
1999	369	1,275	1,644
2000	549	993	1,542
2001	1,108	1,540	2,648
2002	2,667	3,358	6,025
2003	1,035	378	1,413
2004	1,327	1,660	2,987
2005	1,611	1,423	3,034
2006	2,592	1,666	4,258
2007	1,301	707	2,008
2008	1,146	1,000	2,146
2009	1,672	1,298	2,970
2010	1,011	1,107	2,118
2011	1,714	1,409	3,123
2012	1,613	1,066	2,679
2013	2,267	1,280	3,547
2014	2,231	2,022	4,253
2015	2,379	1,897	4,276
2016	3,486	1,790	5,276
2017	2,434	787	3,221
2018	1,554	558	2,112
2019	1,638	733	2,371
2020	2,386	1,741	4,127
2021	2,067	983	3,050
Average	1,324	1,036	2,300
5-yr Avg.	2,016	960	2,976

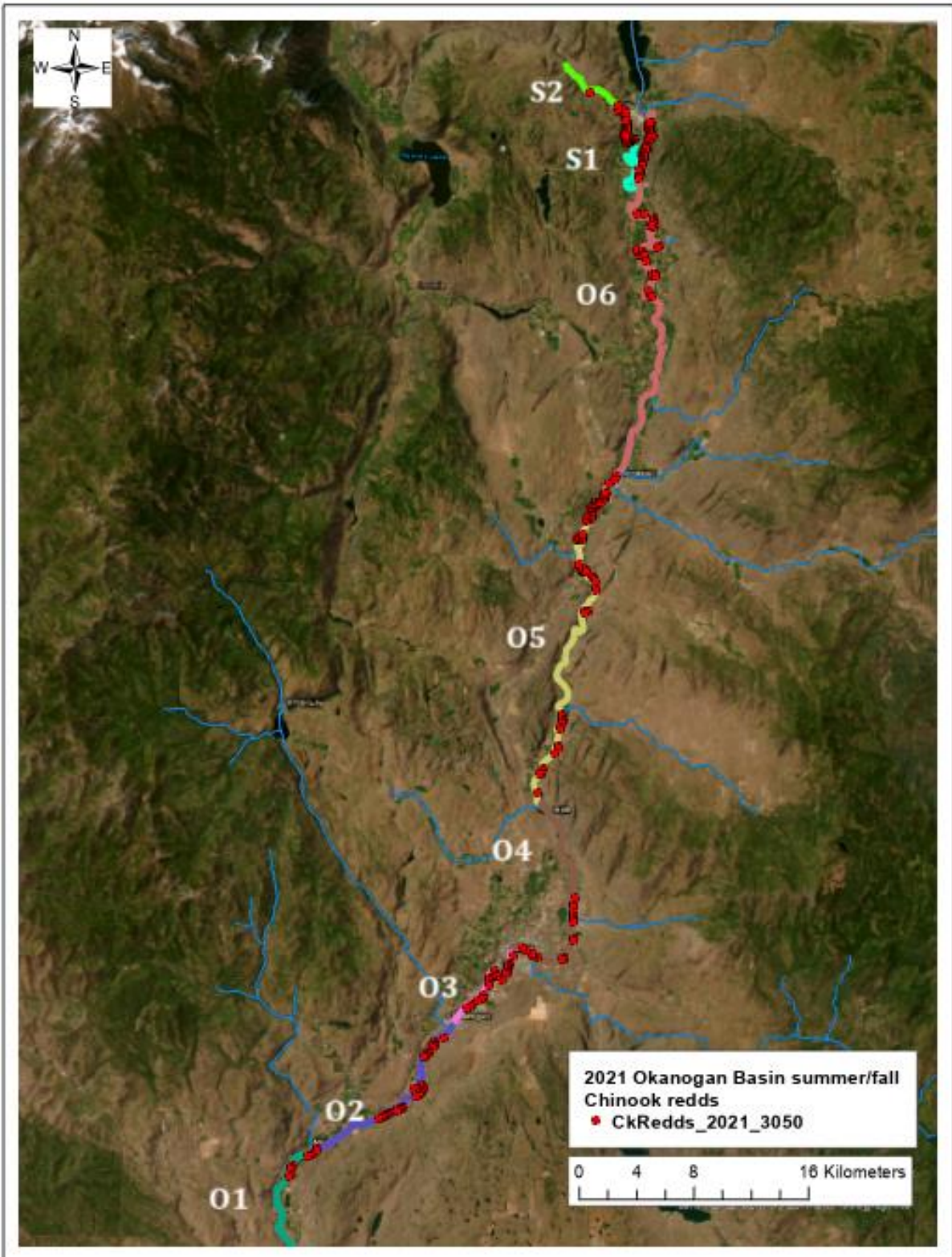


Figure 21. Distribution of summer/fall Chinook redds in 2021. Individual redds are identified by red circles. Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Table 13. Annual and average abundance of summer/fall Chinook redds in each reach of the Okanogan (O1-O6) and Similkameen (S1-S2) Rivers from 2006-2021.

Return Year	Number of Summer Chinook Redds								
	Okanogan						Similkameen		Total
	O1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
2006	10	56	175	145	840	1,366	1,277	405	4,274
2007	3	16	116	63	549	554	624	86	2,011
2008	4	51	59	96	374	561	801	199	2,145
2009	3	32	91	138	619	787	1,091	207	2,968
2010	9	58	67	89	357	431	895	212	2,118
2011	3	20	101	55	593	942	1,217	192	3,123
2012	12	54	159	68	555	765	914	152	2,679
2013	3	2	158	46	397	1,661	1,254	26	3,547
2014	11	57	191	111	851	1,010	1,737	285	4,253
2015	36	113	284	79	1,008	859	1,611	286	4,276
2016	2	57	52	130	907	2,338	1,645	145	5,276
2017	2	62	192	111	830	1,237	710	77	3,221
2018	11	74	211	133	618	507	501	57	2,112
2019	12	154	275	92	600	505	694	39	2,371
2020	25	51	270	103	683	1,254	1,445	296	4,127
2021	39	167	108	52	542	1,159	945	38	3,050
Average	12	64	157	94	645	996	1,085	169	3,222

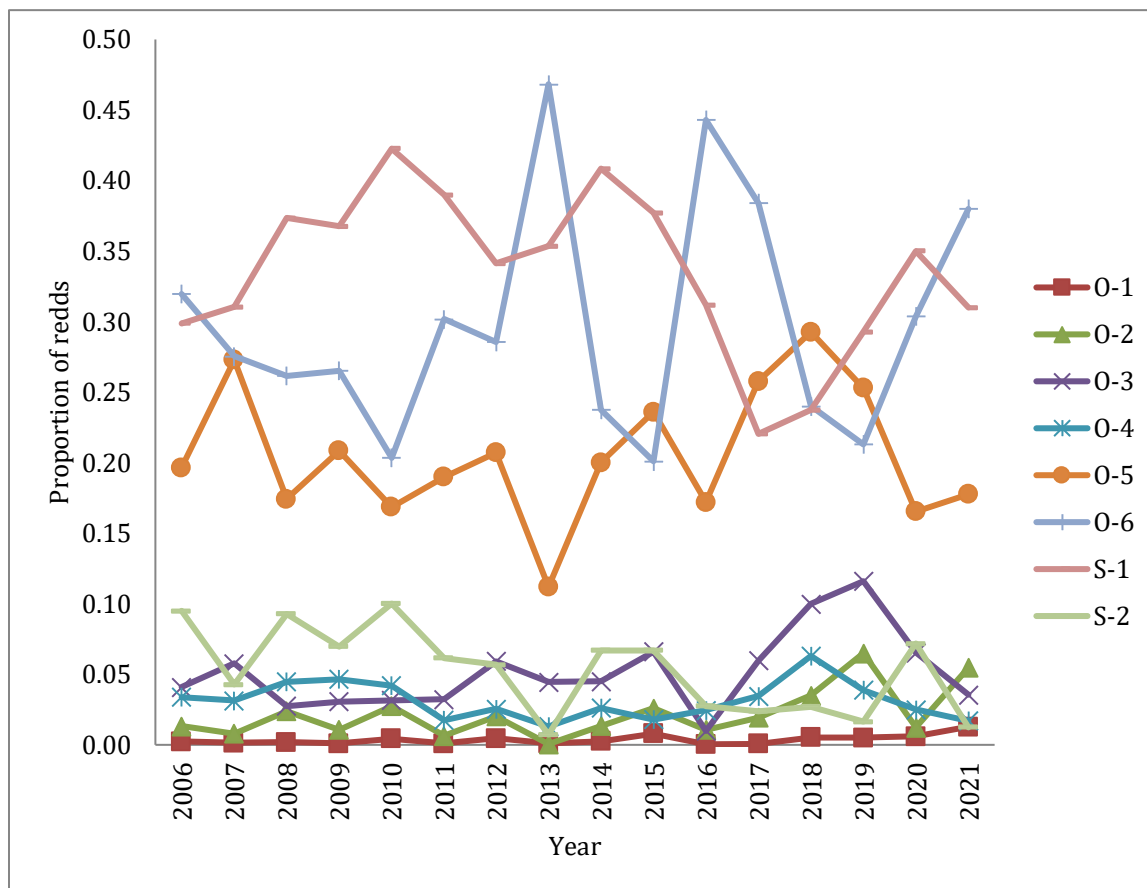


Figure 22. Proportion of redds in each reach of the Okanogan and Similkameen Rivers from 2006 to 2021.

Table 14. Spawning escapements for summer/fall Chinook in the Okanogan and Similkameen Rivers for return years 1989-2021.

Return Year	Fish/Redd Ratio	Spawning Escapement		
		Okanogan	Similkameen	Total
1989*	3.300	498	1,221	1,719
1990*	3.400	337	500	837
1991*	3.700	237	337	574
1992*	4.300	228	245	473
1993*	3.300	535	950	1,485
1994*	3.500	1,313	2,720	4,033
1995*	3.400	908	2,094	3,002
1996*	3.400	394	1,425	1,819
1997*	3.400	537	1,652	2,189
1998	3.000	264	828	1,092
1999	2.200	812	2,805	3,617
2000	2.400	1,318	2,383	3,701
2001	4.100	4,543	6,314	10,857
2002	2.300	6,134	7,723	13,857
2003	2.400	2,505	915	3,420
2004	2.300	2,986	3,735	6,721
2005	2.900	4,720	4,169	8,889
2006	2.020	5,236	3,365	8,601
2007	2.200	2,862	1,555	4,418
2008	3.250	3,725	3,250	6,975
2009	2.540	4,247	3,297	7,544
2010	2.810	2,841	3,111	5,952
2011	3.100	5,313	4,368	9,681
2012	3.070	4,952	3,273	8,225
2013	2.310	5,237	2,957	8,194
2014	2.860	6,381	5,783	12,164
2015	3.215	7,648	6,099	13,747
2016	2.010	7,007	3,598	10,605
2017	2.039	4,963	1,605	6,568
2018	2.301	3,576	1,284	4,860
2019	2.300	3,767	1,686	5,453
2020	2.670	6,371	4,648	11,019

2021	2,310	4,775	2,271	7,046
Average	2,858	3,248	2,793	6,041
5-Year Avg.	2,324	4,690	2,299	6,989

* Spawning escapement was calculated using the “Modified Meekin Method” (i.e., $3.1 \times$ jack multiplier).

Note: All values have been updated from previous reports to account for low sample rates (i.e., carcass recoveries). For any reach with carcass recoveries <5%, the annual basin composition (i.e., HOS:NOS) was used to determine the number of HOS and NOS.

Table 15. Number and timing of summer Chinook redd counts in reaches of the Okanogan and Similkameen Rivers in 2021.

Reach	River mile	Oct. 11-15	Oct. 18-22	Oct. 25-29	Nov. 1-4	Nov. 7-10	Redd Count	Percent
Okanogan River								
01	0.0-16.9	0	26	7	4	2	39	2%
02	16.9-26.1	0	106	61	0	0	167	8%
03	26.1-30.7	0	108	0	0	0	108	5%
04	30.7-40.7	0	52	0	0	0	52	3%
05	40.7-56.8	258	279	5	0	0	542	26%
06	56.8-77.4	1037	122	0	0	0	1159	56%
Total		1295	693	73	4	2	2067	100%
Similkameen River								
S1	0.0-1.8	0	921	24	0	0	945	96%
S2	1.8-5.7	0	33	5	0	0	38	4%
Total		0	954	29	0	0	983	100%

Escapement into Canada

Methodological uncertainties have limited our confidence in Chinook escapement estimates into the Canadian portion of the Okanogan basin. Prior to 2018, insights into escapement into Canada had been based primarily on video counts of fish ascending the passageway at Zosel Dam, with the important caveat being that due to the variations in dam operations, there was uncertainty regarding the proportion of fish that are passing within range of the video system, and thus, available for counting. Additionally, fish fallback and re-ascension is known to occur (as indicated by limited PIT tag data), though the frequency of occurrence is poorly understood. With these uncertainties in mind, we present Canadian escapement information for years prior to 2018 (Table 16). No video count data exists for Chinook from 2018-2021. Average Chinook passage at Zosel Dam for years 2010 thru 2017 was 1,315, with a minimum of 263 (2010) and a maximum of 2,276 (2013).

Table 16. Chinook escapement to Canada as estimated by Zosel Dam counts and Okanogan Nation Alliance area-under-the-curve (AUC) methods.

Year	Zosel Dam Video Count	Zosel Dam % Hatchery	ONA AUC Spawner Estimate	ONA AUC % Hatchery
2006 ^a	481	1%	34	3%
2007	455	40%	7	0%
2008	267	29%	14	23%
2009 ^a	256	17%	6	0%
2010	359	29%	5	0%
2011 ^a	1415	36%	21	21%
2012 ^a	826	24%	11	10%
2013	2275	14%	40	13%
2014 ^b	1188	10%	52	13%
2015	1206	7%	61	8%
2016	1823	13%	40	5%
2017	737	14%	55	6%
2018	No Data	No Data	10	20%
2019	No Data	No Data	15	18%
2020	No Data	No Data	79	7%
2021	No Data	No Data	73	0%
Average	941	19%	47	4%

^aAUC spawner estimates is based on the number of carcasses sampled so this is the minimum estimate.

^b2014 data were adjusted for fallback/re ascension, down camera time, and differentiation of spring Chinook from summer/fall Chinook.

More recently, Okanagan Nation Alliance (ONA) has provided information on escapement estimates in Canada based on live counts of summer Chinook adjusted by the residency estimate for the area-under-the-curve (AUC). Using AUC estimation methods, the largest spawner estimate occurred more recently in 2020 with 79 spawners (Table 16).

Carcass Surveys

In 2021, 1,273 carcasses were recovered on the spawning grounds, including 830 natural-origin and 443 hatchery-origin⁷. An additional 8 carcasses were recovered during pre-spawn surveys (2 ad-clipped, 6 ad-present). The spawning ground carcass recovery rate was 18.1% of the total spawning escapement. Similar to previous years, the majority of carcasses ($n = 1,143$; 90%) were collected from reaches O5, O6 and S1 (Figure 23, also see Appendix C). Regarding the distribution of carcasses throughout the basin, the proportions of natural-origin carcasses recovered in 2020 were similar in all reaches, compared to the average of the 10 years preceding Chief Joseph Hatchery (Figure 23, panel A). The proportions of hatchery-origin carcasses recovered in 2020 were significantly higher in reaches O1-O4 and lower in reaches O5, O6, S1 and S2 compared to the average of the 10 years preceding Chief Joseph Hatchery (Figure 23, panel B).

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

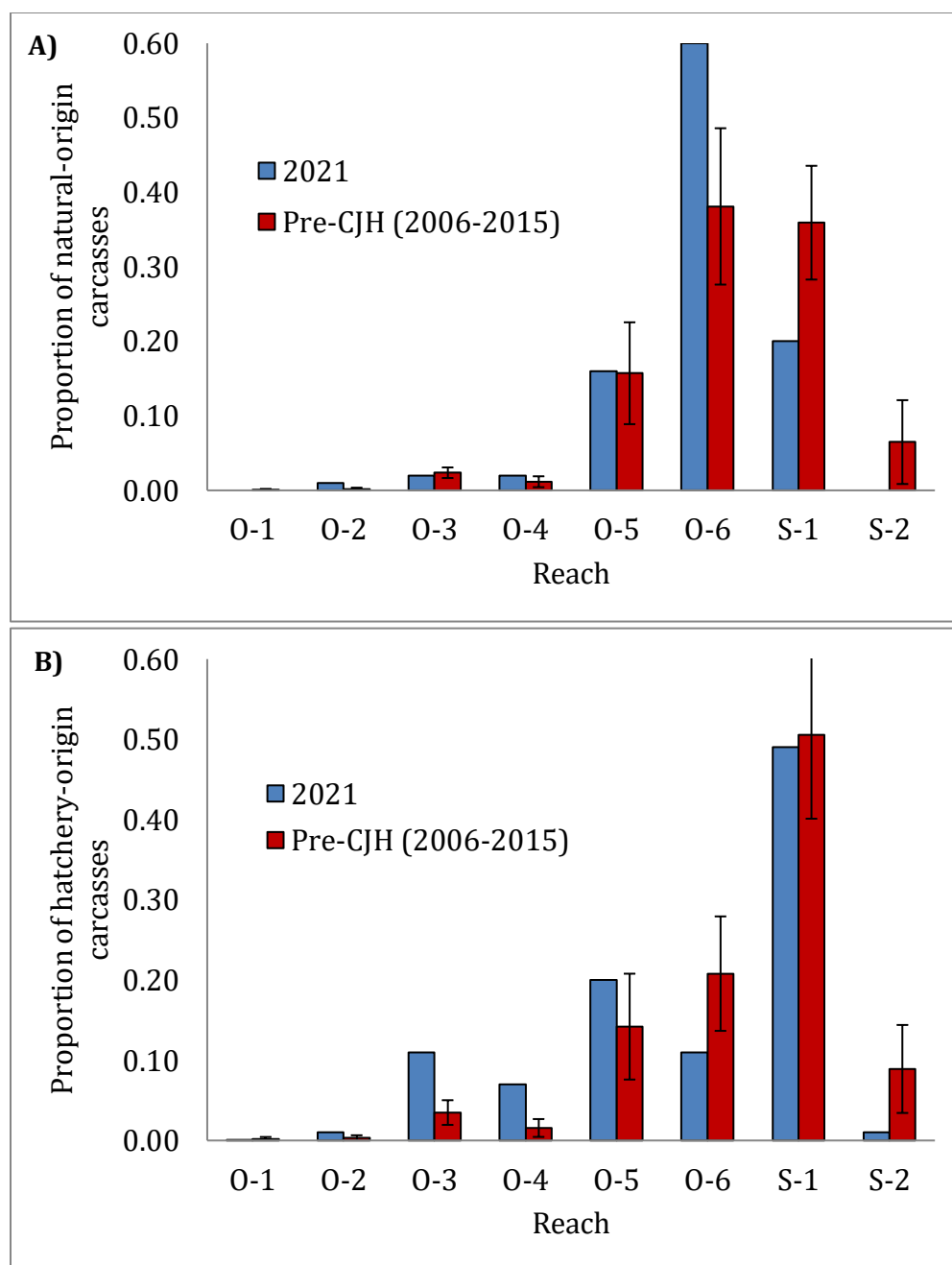


Figure 23. Distribution of (A) natural-origin and (B) hatchery-origin summer/fall Chinook carcasses recovered in the Okanogan (reaches O1-O6) and Similkameen (reaches S1-S2) Rivers in 2021 compared to the average of the 10 years preceding Chief Joseph Hatchery (2006-2015). Error bars represent standard deviation (SD).

In the Okanogan basin, just 10 of the 720 sampled female carcasses were estimated to have retained all their eggs. Therefore, pre-spawn mortality, (for fish that survived to the spawn period) was estimated to be 0.00% for natural-origin females and 1.40% for

hatchery-origin females (Table 17). Overall egg retention of all fish sampled (including fish that had expelled a portion of their eggs) was 1.83%.

Table 17. Egg retention and pre-spawn mortality of sampled summer/fall Chinook carcasses in the Okanogan Basin.

Year	Origin	Total carcass sampled	Female carcasses sampled	Potential egg deposition	Eggs retained	^a Egg retention rate	^b Pre-spawn mortality rate
2013	Natural-origin	613	326	1,630,000	6,152	0.40%	0.00%
	Hatchery-origin	297	237	1,185,000	10,970	0.90%	0.00%
	Total	910	563	2,815,000	17,122	0.60%	0.00%
2014	Natural-origin	2123	1136	5,680,000	373,708	6.60%	1.40%
	Hatchery-origin	329	166	830,000	81,105	9.80%	1.80%
	Total	2452	1302	6,510,000	454,813	7.00%	1.50%
2015	Natural-origin	2554	981	4,905,000	609,869	12.40%	10.90%
	Hatchery-origin	738	340	1,700,000	96,354	5.70%	5.00%
	Total	3292	1321	6,605,000	706,223	10.70%	9.40%
2016	Natural-origin	2171	1370	6,850,000	300,046	4.38%	3.43%
	Hatchery-origin	584	434	2,170,000	66,254	3.05%	2.76%
	Total	2755	1804	9,020,000	366300	4.06%	3.27%
2017	Natural-origin	997	592	2,960,000	17,345	0.59%	0.00%
	Hatchery-origin	204	129	645,000	24,997	3.88%	3.10%
	Total	1201	721	3,605,000	42342	1.17%	0.55%
2018	Natural-origin	374	251	1,255,000	3,075	0.25%	0.00%
	Hatchery-origin	173	123	615,000	16,024	2.61%	3.25%
	Total	547	374	1,870,000	19,099	1.02%	1.07%
2019	Natural-origin	229	122	610,000	5,680	0.93%	0.82%
	Hatchery-origin	244	161	805,000	22,149	2.75%	2.48%
	Total	473	283	1,415,000	27,829	1.97%	1.77%
2020	Natural-origin	1,908	826	4,045,568	84,432	2.09%	0.61%
	Hatchery-origin	696	252	1,260,000	53,552	4.25%	1.98%
	Total	2604	1078	5,305,568	137,984	2.60%	0.46%
2021	Natural-origin	830	434	2,170,000	37,888	1.75%	0.00%
	Hatchery-origin	443	286	1,430,000	28,088	1.96%	1.40%
	Total	1273	720	3,600,000	65,976	1.83%	0.69%

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

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

PHOS AND PNI

There was an increase in the proportion of hatchery-origin spawners (pHOS) across all lower reaches (O1-O4) in 2021 compared to the 10 years preceding Chief Joseph Hatchery (Figure 24). Hatchery-origin spawners comprised 36% of the spawn escapement estimate in the U.S. portion of the Okanogan, which was higher than the pHOS observed in 2020 (.28). After corrections for hatchery fish effectiveness assumptions (0.80 relative reproductive success rate for hatchery-origin spawners) the effective pHOS for 2020 was 0.31, which was just above the five-year average (0.29) (Table 19). The five-year average is currently meeting the biological objective for pHOS (<0.3) (Figure 25).

The proportion of natural-origin broodstock (pNOB) in 2021 was 0.97 and the pNOB for Okanogan origin fish was 0.87 (Table 19). The resulting PNI for 2021 was 0.76, with a 5-year average PNI of 0.73. The 5-year average is still meeting the Biological Objective (>0.67) (Figure 26).

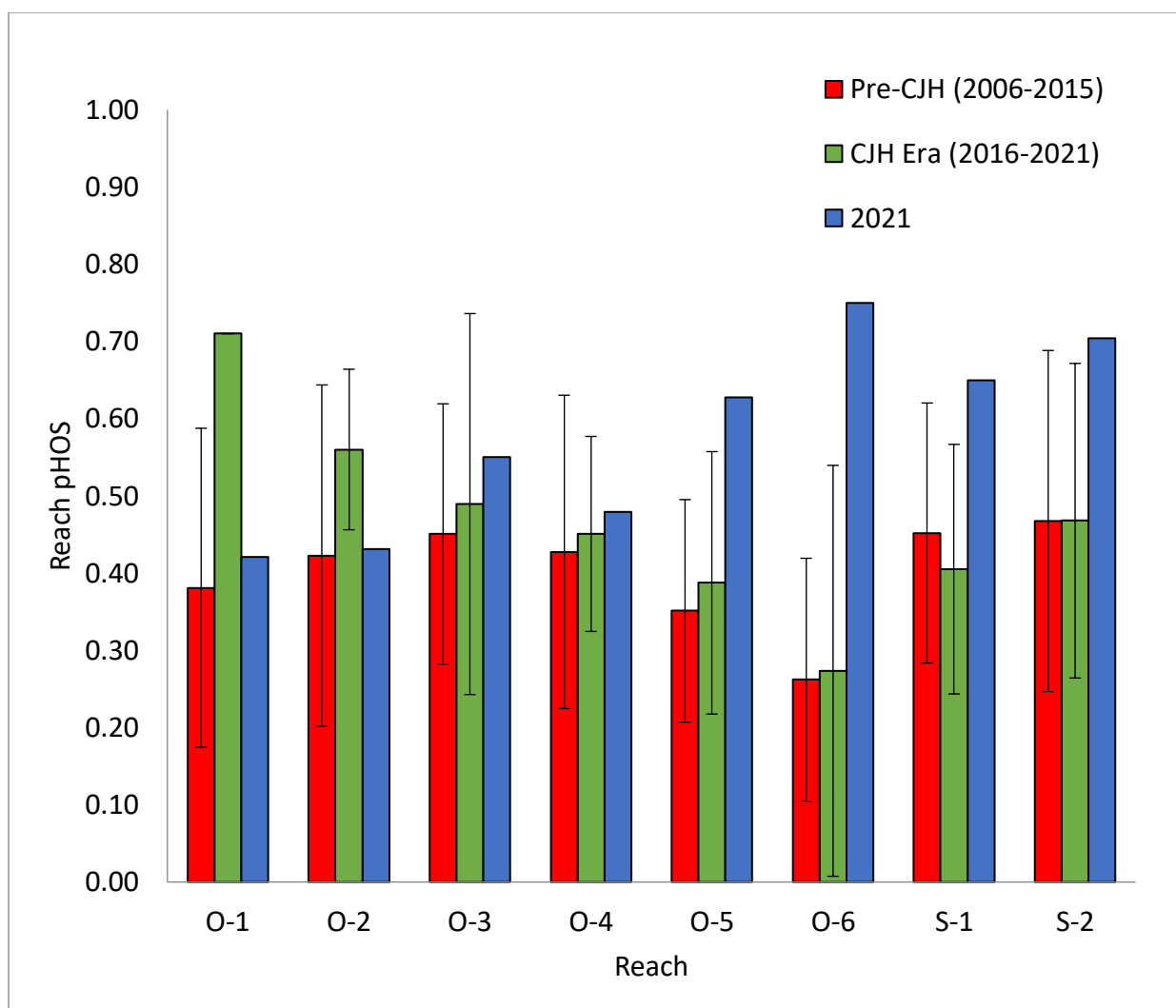


Figure 24. Okanogan (O1-O6) and Similkameen (S1-S2) river summer/fall Chinook pHOS (unadjusted for RSS) by reach. Red bars represent the average of the 10 years preceding Chief Joseph Hatchery (2006-2015), green bars represent the average of the years since Chief Joseph Hatchery operation (2016-2021), and blue bars represent the current year (2021). Reaches with <5% carcasses recoveries were omitted. Error bars represent standard deviation.

Table 18. Natural- (NOS) and hatchery- (HOS) origin spawner abundance and composition for the Okanogan River Basin, brood years 1989-2021.

Brood Year	Spawners			
	NOS	HOS	pHOS	Effective pHOS^
1989	1,719	0	0	0
1990	837	0	0	0
1991	574	0	0	0
1992	473	0	0	0
1993	915	570	0.38	0.33
1994	1,323	2,710	0.67	0.62
1995	979	2,023	0.67	0.62
1996	568	1,251	0.69	0.64
1997	862	1,327	0.61	0.55
1998	600	492	0.45	0.4
1999	1,274	2,343	0.65	0.6
2000	1,174	2,527	0.68	0.63
2001	4,306	6,551	0.6	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	6,787	1,814	0.21	0.18
2007	2,730	1,688	0.38	0.33
2008	2,820	4,155	0.60	0.54
2009	4,100	3,443	0.46	0.40
2010	3,178	2,773	0.47	0.41
2011	4,618	5,063	0.52	0.47
2012	4,521	3,704	0.45	0.40
2013 ^a	5,627	2,567	0.31	0.27
2014	10,407	1,756	0.14	0.12
2015	10,439	3,308	0.24	0.20
2016	8,700	1,905	0.18	0.15
2017	5,429	1,139	0.17	0.14
2018	3,266	1,594	0.33	0.28
2019	2,604	2,849	0.52	0.47
2020	7,957	3,062	0.28	0.24
2021	4,525	2,521	0.36	0.31
Average	3,677	2,363	0.38	0.34
5-year Average	4,756	2,233	0.33	0.29

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

[^] Effective pHOS assumes 0.80 HOS effectiveness

Note: All values have been updated from previous reports to account for low sample rates (*i.e.*, carcass recoveries). For any reach with carcass recoveries <5%, the annual basin composition (*i.e.*, HOS: NOS) was used to determine the number of HOS and NOS.

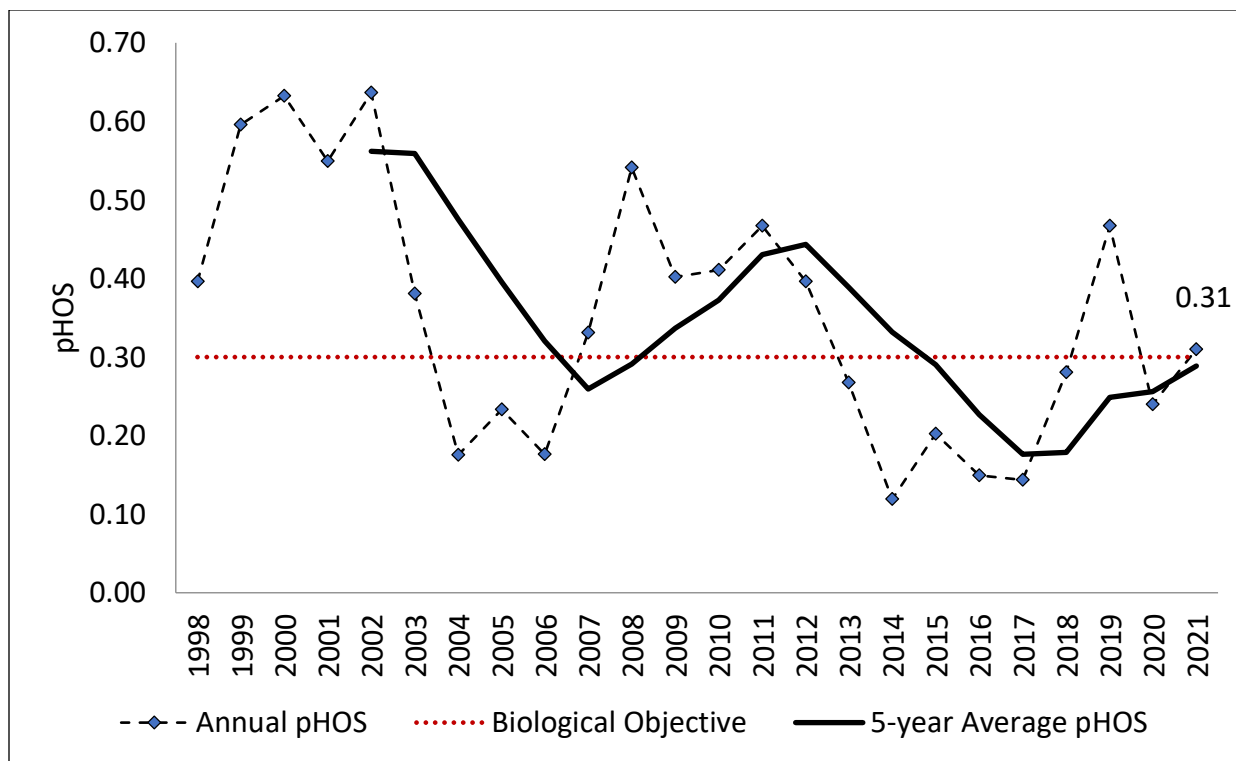


Figure 25. Annual and 5-year average proportion of hatchery-origin spawners (pHOS) in the Okanogan and Similkameen River (combined) from 1998-2021. pHOS values represent the effective pHOS (adjusted for RRS).

Table 19. Okanogan basin summer/fall Chinook spawn escapement, broodstock composition, pHOS, and PNI for Brood Years 1989-2021.

Brood Year	Spawners			Broodstock					PNI	Okan. PNI
	NOS	HOS	Effective pHOS	NOB	Okan NOB	HOB	pNOB	Okan pNOB		
1989	1,719	0	0.00	1,297		312	0.81		1.00	
1990	837	0	0.00	828		206	0.80		1.00	
1991	574	0	0.00	924		314	0.75		1.00	
1992	473	0	0.00	297		406	0.42		1.00	
1993	915	570	0.33	681		388	0.64		0.66	
1994	1,323	2,710	0.62	341		244	0.58		0.48	
1995	979	2,023	0.62	173		240	0.42		0.40	
1996	568	1,251	0.64	287		155	0.65		0.50	
1997	862	1,327	0.55	197		265	0.43		0.44	
1998	600	492	0.40	153	77	211	0.42	0.21	0.51	0.34
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	339	0.33	0.16	0.34	0.21
2001	4,306	6,551	0.55	91	46	266	0.25	0.13	0.05	0.19
2002	4,346	9,511	0.64	247	124	241	0.51	0.25	0.44	0.28
2003	1,933	1,487	0.38	381	191	101	0.79	0.40	0.68	0.51
2004	5,309	1,412	0.18	506	253	16	0.97	0.48	0.84	0.73
2005	6,441	2,448	0.23	391	196	9	0.98	0.49	0.81	0.68
2006	6,787	1,814	0.18	500	250	10	0.98	0.49	0.85	0.74
2007	2,730	1,688	0.33	456	228	17	0.96	0.48	0.74	0.59
2008	2,820	4,155	0.54	404	202	41	0.91	0.45	0.60	0.46
2009	4,100	3,443	0.40	507	254	0	1.00	0.50	0.71	0.55
2010	3,178	2,773	0.41	484	242	8	0.98	0.49	0.70	0.54
2011	4,618	5,063	0.47	467	332	26	0.95	0.67	0.67	0.59
2012	4,521	3,704	0.40	107	96	0	1.00	0.90	0.72	0.69
2013	5,627	2,567	0.27	366	329	1	1.00	0.90	0.79	0.77
2014	10,407	1,756	0.12	499	449	5	0.99	0.89	0.89	0.88
2015	10,439	3,308	0.20	421	379	9	0.98	0.88	0.83	0.81
2016	8,700	1,905	0.15	584	526	0	1.00	0.90	0.87	0.86
2017	5,429	1,139	0.14	350	315	17	0.95	0.86	0.87	0.86
2018	3,266	1,594	0.28	193	174	212	0.48	0.43	0.63	0.60
2019	2,604	2,849	0.47	381	343	205	0.65	0.59	0.57	0.55
2020	7,957	3,062	0.24	530	477	5	0.99	0.89	0.80	0.79
2021	4,525	2,521	0.31	426	383	14	0.97	0.87	0.76	0.74
Average	3,677	2,363	0.34	420	252	139	0.76	0.56	0.68	0.59
5-Year Average	4,756	2,233	0.29	376	338	91	0.81	0.73	0.73	0.71

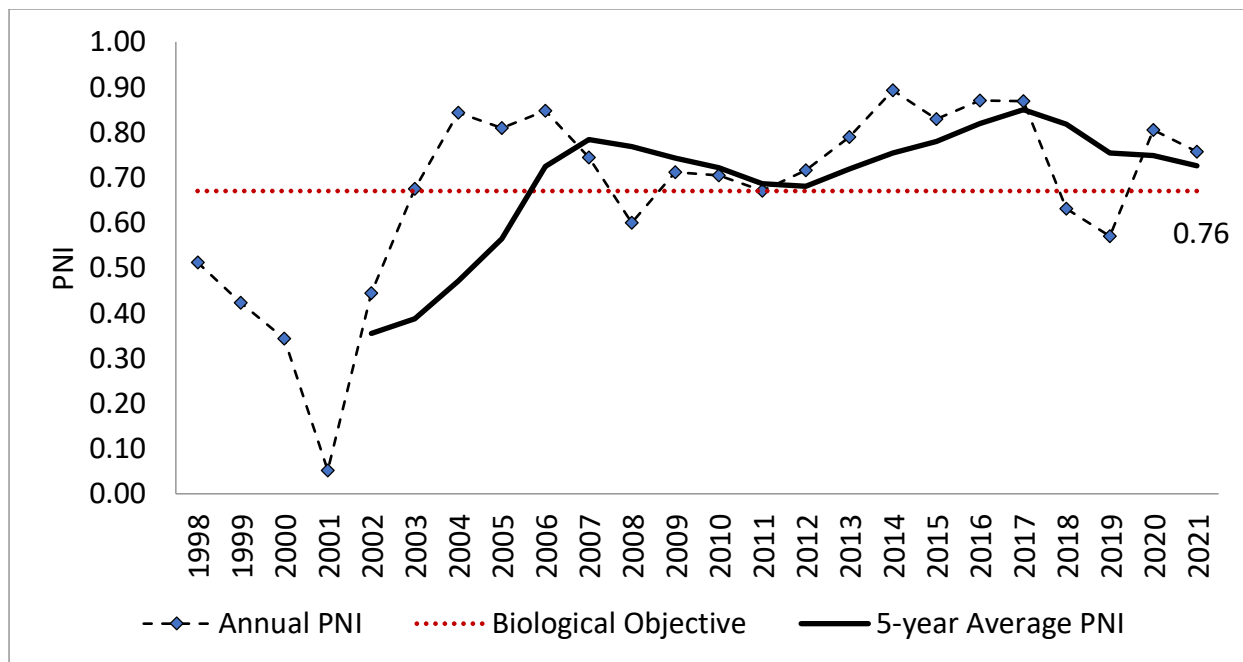


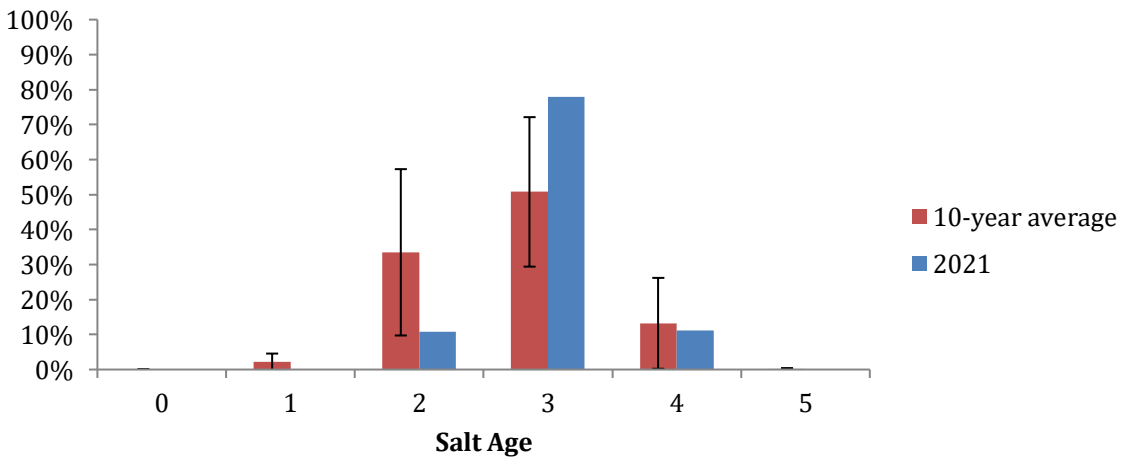
Figure 26. Annual and 5-year average proportionate natural influence (PNI) in the Okanogan basin from 1998 to 2021.

AGE STRUCTURE

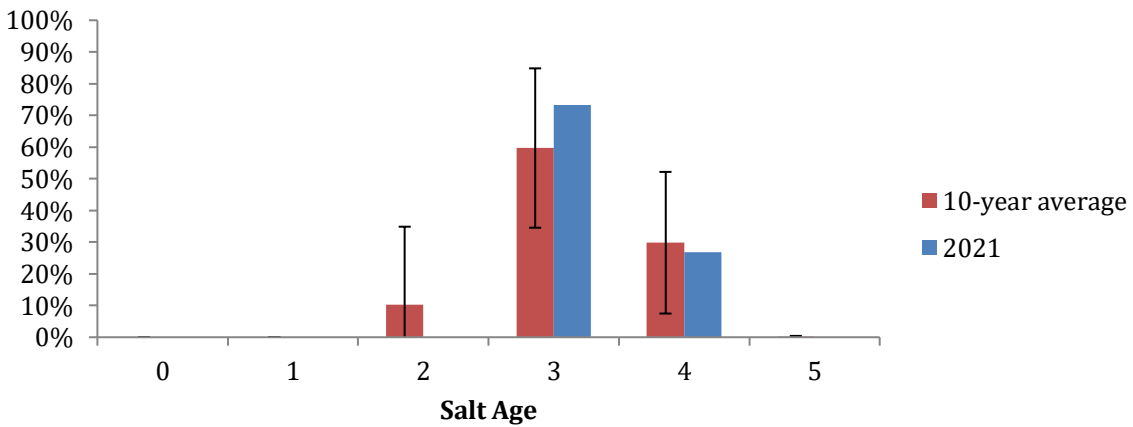
Attempts were made to age all carcasses recovered on the spawning grounds, either by microscopy of scale annuli for natural-origin fish or by extracting and reading coded wire tag information for hatchery-origin fish. Historically, most natural-origin summer Chinook out migrate as sub-yearlings, while 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 2021, male natural-origin spawners were comprised predominantly 3-year salt age fish, which is different than previous years (Figure 27-a). Natural-origin female spawner age structures were skewed towards 3-year salt age fish similar to previous years (Figure 27-b). With 434 natural-origin female Chinook collected on the spawning grounds in 2021, 97 were determined to be 4-year salt age. Hatchery-origin males were comprised by 2- and 3-year salt age fish. No 4-year hatchery-origin males were recovered. Hatchery-origin females were also mostly comprised of 2- and 3-year fish, and no 4-year fish were recovered.

a) Natural-origin Male Age Structure



b) Natural-origin Female Age Structure



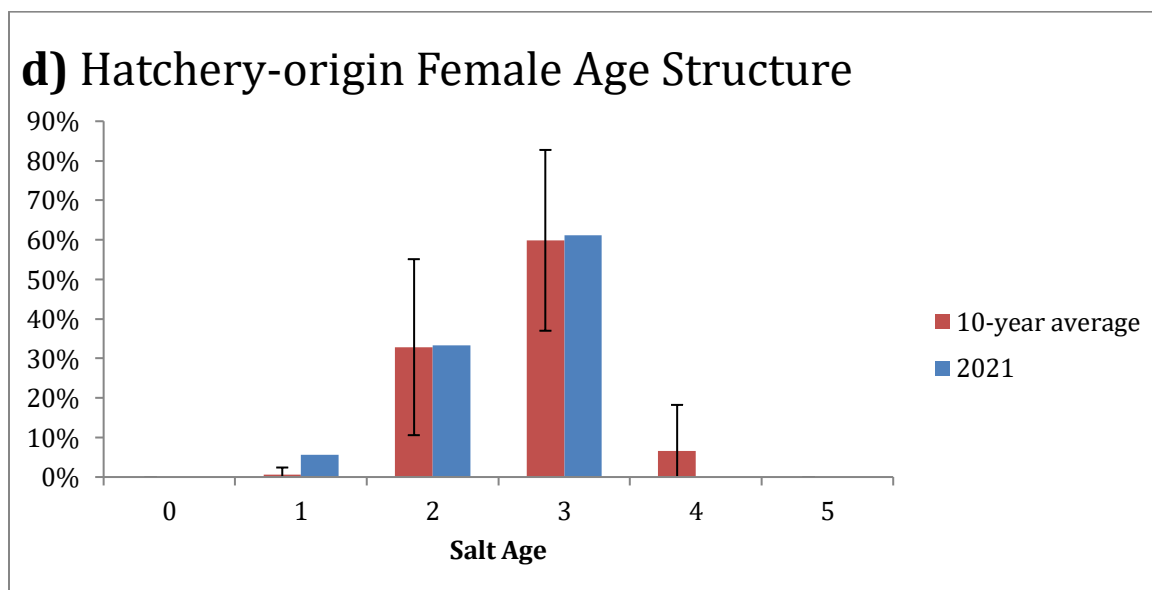
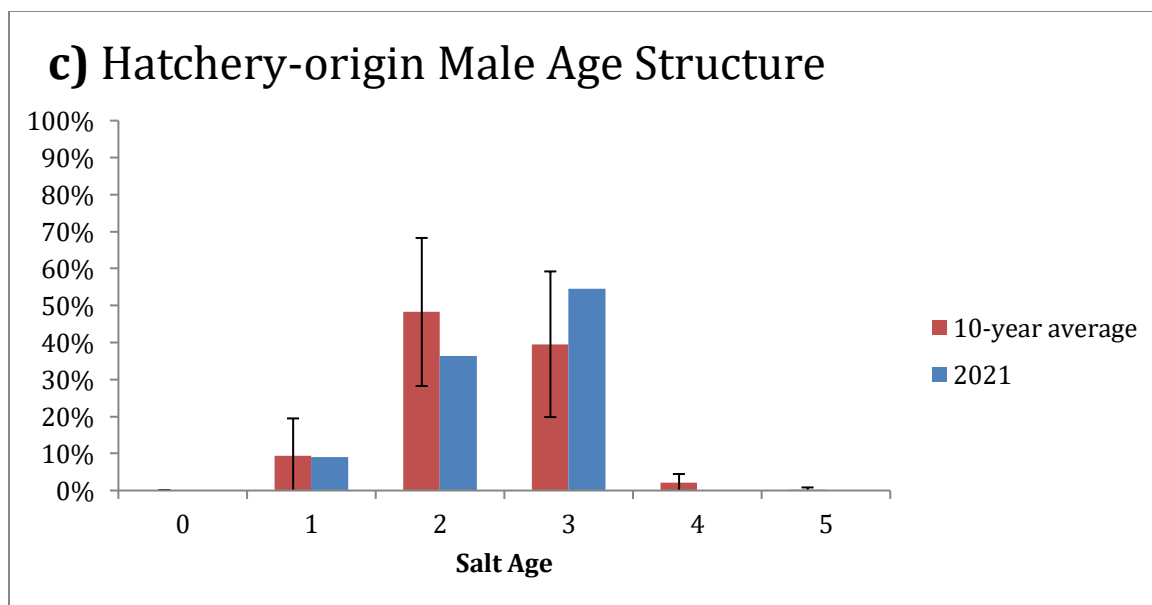


Figure 27. The salt ages of carcasses collected on the spawning grounds of the Okanogan and Similkameen rivers in 2021 along with 10-year averages (2011-2021) for a) Natural-origin males; b) Natural-origin females; c) Hatchery-origin males; and d) Hatchery-origin females.

HATCHERY-ORIGIN STRAY RATES

Strays to the Okanogan— The majority (79%) of hatchery-origin spawners recovered on the spawning grounds in 2021 were from the integrated CJH program Similkameen (61%) and Okanogan acclimated (18%) releases (Table 20). The majority of strays from outside the Okanogan were from the Chief Joseph Hatchery segregated program (13%), whereas strays from other hatchery programs in the Methow River, Entiat River, Chelan River, and mainstem Columbia River releases comprised 7% (Table 20). The contribution of stray hatchery fish to total spawn escapement was 7% (i.e., stray pHOS) (Table 21). This was above the recent (2006-2020) average of 4% and also above the biological target of < 5%. Note that this includes those fish released from the Chief Joseph Hatchery segregated program which comprised 0.7% of the spawner composition.

Strays outside the Okanogan— With the caveat that data are likely to continue to be updated in future reports as more data becomes available through the RMIS database, 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 2016. The 2016 brood year had a stray rate of 1.1% (includes straying to out of basin spawning grounds and hatcheries), which was slightly below the long term (1989-2016; 1.3%) and recent five-year (2012-2016; 1.4%) averages (Table 22). For return year 2021, RMIS queries revealed an estimate of 8 Okanogan hatchery-origin Chinook recovered on spawning grounds in non-target spawning areas in 2021 (Table 22). Okanogan basin hatchery program strays comprised 0.49% to Methow spawner composition in 2021 (Table 22). 5-year averages to Wenatchee, Methow, Chelan, and Entiat basins are all below 1%.

Table 20. 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 2006-2021.

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	Similkamee n River ^b	Methow River ^c	Wenatchee River ^d	Entiat River ^e	Chelan River ^f	Chief Joseph Hatchery (Seg.)	Mainstem Columbia River ^g	Mainstem Columbia River ^h	Snake River ⁱ	Other ⁱ
2006	0 (0%)	709 (87%)	12 (2%)	12 (2%)	0 (0%)	0 (0%)		81 (10%)	0 (0%)	0 (0%)	0 (0%)
2007	0 (0%)	1121 (95%)	17 (1%)	5 (0%)	0 (0%)	0 (0%)		42 (4%)	0 (0%)	0 (0%)	0 (0%)
2008	0 (0%)	3224 (95%)	11 (0%)	24 (1%)	0 (0%)	4 (0%)		133 (4%)	3 (0%)	0 (0%)	0 (0%)
2009	0 (0%)	2733 (95%)	14 (0%)	14 (0%)	0 (0%)	9 (0%)		99 (3%)	0 (0%)	5 (0%)	4 (0%)
2010	4 (0%)	2165 (89%)	44 (2%)	35 (1%)	0 (0%)	110 (5%)		75 (3%)	0 (0%)	4 (0%)	0 (0%)
2011	219 (5%)	4196 (93%)	44 (1%)	5 (0%)	0 (0%)	34 (1%)		22 (0%)	0 (0%)	6 (0%)	0 (0%)
2012	379 (13%)	2397 (83%)	29 (1%)	23 (1%)	0 (0%)	17 (1%)		52 (2%)	0 (0%)	0 (0%)	0 (0%)
2013	254 (14%)	1437 (81%)	10 (1%)	54 (3%)	0 (0%)	0 (0%)		10 (1%)	0 (0%)	0 (0%)	0 (0%)
2014	55 (5%)	1023 (90%)	16 (1%)	0 (0%)	6 (1%)	12 (1%)		29 (3%)	0 (0%)	0 (0%)	0 (0%)
2015	38 (1%)	2562 (91%)	70 (3%)	17 (1%)	19 (1%)	33(1%)		33 (1%)	4 (0%)	4 (0%)	21 (1%)
2016	81(4%)	1963 (91%)	42 (2%)	7 (0%)	3 (0%)	31 (1%)		14 (1%)	0 (0%)	0 (0%)	17(1%)

2017	249 (20%)	590 (46%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	428 (33%)	9 (1%)	0 (0%)	3 (0%)	0 (0%)
2018	357 (24%)	628 (43%)	27 (2%)	0 (0%)	0 (0%)	6 (0%)	396 (27%)	28 (2%)	0 (0%)	0 (0%)	36 (2%)
2019	403 (24%)	1250 (44%)	68 (2%)	0 (0%)	9 (0%)	37 (1%)	1021 (36%)	25 (1%)	0 (0%)	7 (0%)	0 (0%)
2020	813 (27%)	1,470 (48%)	65 (2%)	5 (0%)	17 (1%)	18 (1%)	589 (19%)	78 (3%)	0 (0%)	0 (0%)	0 (0%)
2021	455 (18%)	1,513 (61%)	24 (1%)	44 (2%)	0 (0%)	47 (2%)	328 (13%)	52 (2%)	0 (0%)	7 (0%)	4 (0%)
Avg.	196(7%)	1818 (67%)	31 (1%)	15 (1%)	3 (0%)	22 (1%)	584(21%)	49 (2%)	0 (0%)	2 (0%)	5 (0%)

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

^b Includes releases from Similkameen Pond

^c Includes releases from Carlton Acclimation Pond and Goat Wall 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 Falls Hatchery

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

^h Includes releases of fall Chinook from Hanford Reach

ⁱ Includes Releases from NPT Hatchery

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

Table 21. Percent of the total Okanogan spawning escapement comprised of various hatchery release groups, based on CWT recoveries and expansions for return years 2006-2021.

Return Year			Release Site									HOS Stray Contribution to Total Spawning Escapement	Effective 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	Chief Joseph Hatchery (Seg.)	Mainstem Columbia River ^g	Mainstem Columbia River ^h	SNAKE River ⁱ	Other ⁱ		
2006	0.00%	8.24%	0.14%	0.14%	0.00%	0.00%		0.94%	0.00%	0.00%	0.00%	1.22%	0.18
2007	0.00%	25.38%	0.38%	0.11%	0.00%	0.00%		0.95%	0.00%	0.00%	0.00%	1.45%	0.33
2008	0.00%	46.23%	0.16%	0.34%	0.00%	0.06%		1.91%	0.04%	0.00%	0.00%	2.51%	0.54
2009	0.00%	36.23%	0.19%	0.19%	0.00%	0.12%		1.31%	0.00%	0.07%	0.05%	1.92%	0.40
2010	0.07%	36.38%	0.74%	0.59%	0.00%	1.85%		1.26%	0.00%	0.07%	0.00%	4.50%	0.41
2011	2.26%	43.34%	0.45%	0.05%	0.00%	0.35%		0.23%	0.00%	0.06%	0.00%	1.15%	0.47
2012	4.61%	29.14%	0.35%	0.28%	0.00%	0.21%		0.63%	0.00%	0.00%	0.00%	1.47%	0.40
2013	3.10%	17.54%	0.12%	0.66%	0.00%	0.00%		0.12%	0.00%	0.00%	0.00%	0.90%	0.27
2014	0.45%	8.41%	0.13%	0.00%	0.05%	0.10%		0.24%	0.00%	0.00%	0.00%	0.52%	0.12
2015	0.28%	18.64%	0.51%	0.12%	0.14%	0.24%		0.24%	0.03%	0.03%	0.15%	1.46%	0.20
2016	0.08%	18.51%	0.40%	0.07%	0.03%	0.29%		0.13%	0.00%	0.00%	0.16%	1.07%	0.15
2017	2.33%	10.55%	0.00%	0.00%	0.00%	0.00%		0.14%	0.00%	0.06%	0.00%	0.20%	0.14
2018	7.35%	12.92%	0.56%	0.00%	0.00%	0.12%	8.15%	0.58%	0.00%	0.00%	0.74%	10.14%	0.28
2019	7.39%	22.92%	1.25%	0.00%	0.17%	0.68%	18.72%	0.46%	0.00%	0.13%	0.00%	21.40%	0.47
2020	7.38%	13.34%	0.59%	0.05%	0.00%	0.15%	0.16%	5.35%	0.00%	0.00%	0.00%	7.01%	0.24
2021	6.46%	21.47%	0.34%	0.62%	0.00%	0.00%	0.67%	4.66%	0.00%	0.10%	0.00%	7.18%	0.31
Avg.	2.61%	23.08%	0.39%	0.20%	0.02%	0.26%	6.93%	1.20%	0.00%	0.03%	0.07%	4.01%	0.31

Table 22. 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 1989-2016. 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	1,699	92.7%	96	5.3%	37	2.0%	0	0.0%
2006	5,162	97.6%	60	1.1%	67	1.3%	0	0.0%
2007	1,384	97.7%	23	1.6%	9	0.7%	0	0.0%
2008	3,577	96.8%	95	2.6%	20	0.6%	4	0.1%
2009	1,102	79.9%	260	18.9%	14	1.1%	2	0.2%
2010	927	43.4%	648	54.1%	9	0.4%	10	2.1%
2011	3,028	76.7%	881	22.3%	16	0.4%	26	0.7%
2012	478	72.8%	174	26.5%	4	0.6%	1	0.2%
2013	1,111	62.0%	666	37.1%	7	0.4%	9	0.5%
2014	562	65.7%	274	32.0%	8	0.9%	11	1.3%
2015	1,097	92.2%	70	5.9%	4	0.3%	19	1.6%
2016	2,353	94.4%	113	4.5%	8	0.3%	19	0.8%
Total	56,314	83.9%	7,240	14.9%	563	0.9%	157	0.4%

Average	2,011	83.9%	259	14.9%	20	0.9%	6	0.4%
5-yr average	1,120	77.4%	259	21.2%	6	0.5%	12	0.9%

Table 23. Number of estimated spawners and percent (%) of spawning escapements comprised of hatchery-origin Okanogan summer/fall Chinook within non-target basins, return years 1994-2021.

Return Year	Wenatchee		Methow		Chelan		Entiat	
	Number	%	Number	%	Number	%	Number	%
1994	0	0.00%	0	0.00%	-	-	-	-
1995	0	0.00%	0	0.00%	-	-	-	-
1996	0	0.00%	0	0.00%	-	-	-	-
1997	0	0.00%	0	0.00%	-	-	-	-
1998	0	0.00%	0	0.00%	0	0.00%	0	0.00%
1999	0	0.00%	0	0.00%	0	0.00%	0	0.00%
2000	0	0.00%	6	0.50%	30	6.40%	0	0.00%
2001	12	0.10%	0	0.00%	10	1.00%	0	0.00%
2002	0	0.00%	3	0.10%	4	0.70%	5	1.00%
2003	0	0.00%	8	0.20%	22	5.30%	14	2.00%
2004	0	0.00%	0	0.00%	5	1.20%	0	0.00%
2005	5	0.10%	27	1.10%	36	6.90%	7	1.90%
2006	0	0.00%	5	0.20%	4	1.00%	7	1.80%
2007	0	0.00%	3	0.20%	4	2.10%	0	0.00%
2008	0	0.00%	9	0.50%	46	9.30%	4	1.90%
2009	15	0.20%	3	0.20%	11	1.80%	18	9.90%
2010	5	0.06%	0	0.00%	32	2.48%	0	0.00%
2011	0	0.00%	0	0.00%	77	4.79%	0	0.00%
2012	7	0.09%	5	0.22%	19	0.36%	0	0.00%
2013	0	0.00%	0	0.00%	0	0.00%	0	0.00%
2014	0	0.00%	0	0.00%	0	0.00%	0	0.00%
2015	0	0.00%	0	0.00%	5	0.38%	0	0.00%
2016	0	0.00%	4	0.20%	4	0.38%	0	0.00%
2017	0	0.00%	0	0.00%	13	1.20%	0	0.00%
2018	0	0.00%	5	0.35%	6	0.53%	0	0.00%
2019	0	0.00%	0	0.00%	11	0.23%	0	0.00%
2020	0	0.00%	5	0.24%	0	0.00%	0	0.00%
2021	0	0.00%	10	0.49%	5	0.22%	0	0.00%

<i>Total</i>	<i>44</i>	<i>0.02%</i>	<i>93</i>	<i>0.16%</i>	<i>344</i>	<i>1.93%</i>	<i>55</i>	<i>0.77%</i>
<i>5-year Total</i>	<i>0</i>	<i>0.00%</i>	<i>20</i>	<i>0.22%</i>	<i>35</i>	<i>0.44%</i>	<i>0</i>	<i>0.00%</i>

Homing Fidelity within the Okanogan Basin

The 469 coded-wire tags recovered during spawning grounds surveys in fall of 2020 expanded to 814 and 1,471 spawners originated from Omak Pond and Similkameen Pond acclimation sites, respectively. The majority (83%) of the spawners originating from the Omak Pond acclimation site spawned in the Okanogan River and 16% in the Similkameen River (Table 24). The Omak Pond fish tended to spawn in habitat downstream and upstream of the Omak Pond site, with the majority in reaches O3 (24%) and O5 (32%). Only Omak Pond CWT's were recovered below reach O3 (Figure 28). . Most fish acclimated at Similkameen Pond spawned in the Similkameen River (65%) (Table 24). Of the Similkameen-origin fish that spawned in the Okanogan River, most used reaches O5 and O6 (32% combined; Figure 28). However, some of the CWT recoveries in reach O5 could have been fish that spawned upstream in S1 and swam or drifted downstream after spawning.

Table 24. Spawning distribution by river, for fish acclimated at Omak Pond and Similkameen Pond acclimation sites for 2018-2021

2018	Acclimation site (origin)	
Spawning location	Omak Pond	Similkameen Pond
Okanogan River	92%	60%
Similkameen River	8%	40%

2019	Acclimation site (origin)	
Spawning location	Omak Pond	Similkameen Pond
Okanogan River	90%	49%
Similkameen River	10%	51%

2020	Acclimation site (origin)	
Spawning location	Omak Pond	Similkameen Pond
Okanogan River	83%	35%
Similkameen River	17%	65%

2021	Acclimation site (origin)	
Spawning location	Omak Pond	Similkameen Pond
Okanogan River	86%	30%
Similkameen River	14%	70%

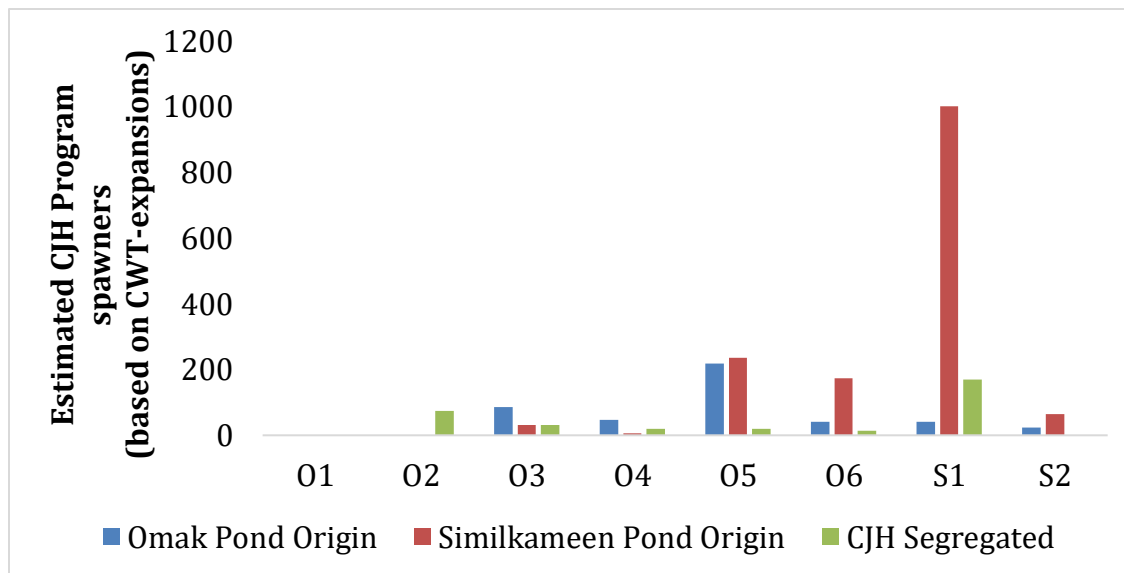


Figure 28. 2021 spatial distribution of CJHP integrated program summer/fall Chinook spawners originally reared at the Similkameen Pond and Omak Pond acclimation sites and CJHP segregated program strays to Okanogan spawning grounds.

Smolt Survival and Travel Time

Apparent survival of yearlings to RRJ in 2021 was 83% (SE 5%) for the segregated program released from CJH but survival could not be calculated for integrated fish released from Omak Pond due to only 22 detections of PIT tags leaving Omak Pond and only 5 detections at RRJ (Table 25). PIT tagged fish were not released from Similkameen pond in 2021. Once again, the values for apparent survival of yearlings to MCN was erroneous (139%) due to low capture probability and high standard errors resulting from the variable spill operations (Table 25). The yearling segregated program survival of 83% was higher than the average of the seven previous years (75%) and was similar to the nearest yearling summer Chinook program at Carlton Pond (80%)(Table 26).

Apparent survival of subyearlings to RRJ in 2021 was 39% (SE 12%) for the segregated program released from CJH and 43% (SE 8%) for integrated fish released from Omak Pond (Table 25). Apparent survival of subyearlings to MCN could not be calculated due to low capture probability and high standard errors resulting from the variable spill operations. Both programs had very similar survival compared to their recent averages and lower survival than Wells Hatchery subyearlings (Table 26). The reduced survival compared to Wells Hatchery is to be expected considering the shorter migration distance; however Wells is the only other subyearling program in the area.

Wild subyearlings had a survival to RRJ of 42% (SE 6%) (Table 25). The survival of wild summer Chinook from release to RRJ was slightly higher than the recent average (Table 26).

Table 25. Apparent survival estimates for PIT tagged summer/fall Chinook released in 2021 from Chief Joseph Hatchery (CJH), Omak Pond and other nearby hatcheries.

Summer Chinook Release Group	# PIT tags		Reach	Survival	Survival Standard Error (SE)	Capture Prob.	Capture Prob. (SE)
	Released	Recap.					
Yearlings released at CJH	4972	1684	Release to RRJ	0.83	0.05	0.41	0.02
		58	Release to MCN	1.39	0.78	0.01	0.00
Yearlings released at Omak Pond	4715	5	Release to RRJ	NA	NA	NA	NA
		0	Release to MCN	NA	NA	NA	NA
Yearlings released at Similkameen Pond	0	0	Release to RRJ	NA	NA	NA	NA
		0	Release to MCN	NA	NA	NA	NA
Yearlings released at Carlton Pond	5235	2346	Release to RRJ	0.80	0.03	0.56	0.02
		64	Release to MCN	0.75	0.25	0.02	0.01
Yearlings released at Dryden Pond	20363						
		394	Release to MCN	0.89	0.14	0.02	0.00
Yearlings Released at Wells Hatchery	4973	2305	Release to RRJ	0.88	0.04	0.53	0.02
		76	Release to MCN	0.72	0.22	0.02	0.01
Summer Chinook Release Group	# PIT tags		Reach	Survival	Survival Standard Error (SE)	Capture Prob.	Capture Prob. (SE)
	Released	Recap.					
Subyearlings released at CJH	4971	439	Release to RRJ	0.39	0.12	0.23	0.07
		19	Release to MCN	NA	NA	NA	NA
Subyearlings released at Omak	4694	559	Release to RRJ	0.43	0.08	0.28	0.05
		28	Release to MCN	0.32	0.31	0.02	0.02
Wells Fish Hatchery Subyearlings	5993	1022	Release to RRJ	0.62	0.07	0.28	0.03
		38	Release to MCN	0.98	0.97	0.01	0.01
Wild subyearlings from Col. R.	20200	2470	Release to RRJ	0.42	0.06	0.29	0.04
		60	Release to MCN	NA	NA	NA	NA

Table 26. PIT tag survival estimates for juvenile summer/fall Chinook from release to Rocky Reach and McNary dams from 2015 to 2021.

Summer Chinook Yearling Release Group																		
Release Year	Survival to Rocky Reach Dam									Survival to McNary Dam								
	CJH segr.		Omak Pond			Similk.		Carlton Pond		CJH segr.		Omak Pond		Similk.		Carlton Pond		
	Surv.	StdEr	Surv.	StdEr		Surv.	StdEr	Surv.	StdEr	Surv.	StdEr	Surv.	StdEr	Surv.	StdEr	Surv.	StdEr	
2015	0.71	0.04	NA	NA		NA	NA	0.63	0.02		0.68	0.14	NA	NA	NA	NA	0.55	0.10
2016	0.78	0.04	0.57	0.04		NA	NA	0.81	0.04		0.53	0.04	0.44	0.05	NA	NA	0.63	0.06
2017	0.77	0.06	0.80	0.06		NA	NA	NA	NA		0.82	0.14	0.63	0.10	NA	NA	NA	NA
2018	0.83	0.04	0.54	0.04		NA	NA	0.76	0.04		0.60	0.06	0.42	0.06	NA	NA	0.59	0.07
2019	0.67	0.04	0.69	0.03		0.63	0.03	0.79	0.04		0.45	0.10	0.50	0.08	0.53	0.10	0.56	0.11
2020	0.66	0.06	0.56	0.04		NA	NA	0.82	0.03		0.22	0.05	0.37	0.08	NA	NA	0.60	0.04
2021	0.83	0.05	NA	NA		NA	NA	0.80	0.03		1.39*	0.78	NA	NA	NA	NA	0.75*	0.25
Average	0.75		0.63			0.63		0.77			0.55		0.47		0.53		0.59	
*Value not used in the average due to high standard error																		

Summer Chinook Sub-Yearling Release Group																														
Release Year	Survival to Rocky Reach Dam									Survival to McNary Dam																				
	CJH segr.		Omak Pond		Wells Hatchery		Wild			CJH segr.		Omak Pond		Wells Hatchery		Wild														
	Surv.	StdEr	Surv.	StdEr	Surv.	StdEr	Surv.	StdEr		Surv.	StdEr	Surv.	StdEr	Surv.	StdEr	Surv.	StdEr													
2015	0.28	0.08			0.37	0.09			0.43	0.06			0.26	0.06			0.20	0.20			0.23	0.15			0.77	0.76			NA	NA
2016	0.44	0.08			0.35	0.05			0.51	0.05			0.24	0.03			0.14	0.05			0.14	0.06			0.25	0.05			NA	NA
2017	0.65	0.05			0.70	0.05			0.48	0.06			0.46	0.02			0.34	0.06			0.48	0.07			0.22	0.05			0.18	0.02
2018	0.65	0.06			NA	NA			0.79	0.07			0.44	0.04			0.53	0.09			NA	NA			0.53	0.11			0.12	0.03
2019	NA	NA			NA	NA			0.59	0.03			0.36	0.02			NA	NA			NA	NA			0.29	0.20			0.18	0.05
2020	0.49	0.08			0.45	0.05			0.59	0.05			0.43	0.03			0.23	0.08			0.27	0.08			0.39	0.12			0.37	0.15
2021	0.39	0.12			0.43	0.08			0.62	0.07			0.42	0.06			NA	NA			0.32*	0.31			0.98*	0.97			NA	NA
Average	0.48				0.46				0.57				0.37				0.29			0.28				0.41				0.21		
*Value not used in the average due to high standard error																														

Releases of yearling Summer Chinook smolts began on April 15, 2021. There is considerable uncertainty regarding the PIT tagged yearlings that were released from Omak Pond. The tag file suggests that 4,715 PIT tagged yearling summer Chinook released from Omak Pond (rkm 52), but only 4 were detected at the Lower Okanogan PIT detection array and only 5 were detected at RRJ; therefore, we could not assess the outmigration timing or travel time for integrated yearlings. Additionally, there are only 22 detections of summer Chinook yearlings leaving Omak Pond, suggesting that either the antennae array was malfunctioning or PIT tagged fish died or escaped the pond before the release. It's unlikely that the antennae array was malfunctioning because so few fish were detected at OKL and RRJ and it was working fine when the subyearlings were released a month later. It is not likely that a large percentage of them escaped the pond before release or there would be more detections and early detections at OKL. Hatchery staff and records did not reveal an issue related to the mortality in Omak Pond prior to release.

Travel time data for subyearlings revealed that 12.5% had negative travel times (arriving at OKL 12 to 15 days before the release date), indicating that at least some fish were released earlier than the reported release date or some other issues were present in the data set (as per reported on DART and PTAGIS). The 90th percentile for travel time from Omak Pond to OKL was 7.9 days, but that estimate is skewed by an unknown portion of fish that left the pond early.

The mean travel time of yearling summer Chinook released from CJH facilities to RRJ in 2021 was 24 days (4.9 km/day) for CJH segregated yearlings, 37 days (3.1 km/day) for segregated subyearlings and 33 days (4.6 km/day) for Omak Pond subyearlings (Table 27). Travel time could not be calculated for Omak yearlings due to too few detections at downstream interrogation sites.

Travel time and 90% passage dates were higher (slower) than the seven year average for subyearlings to RRJ and MCN (by 7-12 days) (Table 28). Travel times for yearlings to RRJ and MCN were 3-4 days slower than average for CJH segregated yearlings but only one day slower to BON (Table 29). The majority of yearling Summer Chinook from CJH arrived at RRJ from early May to early June, with a 90% passage date of June 1 (Figure 29). Travel time and temporal distribution could not be evaluated for Omak yearlings because only five fish were detected at RRJ from that release group (all 5 were detected between May 12-30). Subyearlings from the integrated program at Omak Pond and segregated program at CJH had 90% passage dates of July 8 and 19, respectively (Figure 29). The programs appeared to be successfully releasing actively migrating smolts and the migration speed increased substantially in reaches downstream of Rocky Reach Dam for all release groups (Table 27).

Table 27. Travel time (days), migration speed (km/day) and the number of days to 90% passage for summer/fall Chinook release groups in 2021.

Release Group	Release timing	Release Strategy	Mean Travel Time (days)			90% Passage (days)			Travel Rate (km/day)		
			Release to RRJ	Release to MCN	Release to BON	RRJ	MCN	BON	Release to RRJ	RRJ to MCN	MCN to BON
CJH Summer subs	June 3	Volitional	37	44	a	46	53	a	3.1	a	a
Omak Pond subs ^c	May 27	Forced	33	42	41	41	47	47	4.6	39.1	a
Wells FH subs	May 26	Forced	26	36	38	39	43	48	2.6	28.4	a
Wild subs	Jun 16-Jul 1	NA	32	45	37	44	56	46	3.0	33.3	a
CJH Summer yearlings	Apr 20	Volitional	24	34	33	41	48	49	4.9	30.9	a
Omak Pond yearlings	Apr 15	Volitional	a	a	a	a	a	a	a	a	a
Carlton yearlings	Apr 18	Forced	20	31	36	41	47	52	6.4	25.2	a
Dryden yearling	Apr 19	Volitional	NA	21	26	NA	35	35	NA	14.7 b	48.4
^a sample size too small (<10) to calculate an estimate											
^b Release to McNary, not Rocky Reach to McNary											
^c Some negative travel time values to OKL were in the data, suggesting fish were released earlier than reported, or some escaped before the official release date											

Table 28. Travel time (days) and the number of days to 90% passage for subyearling summer/fall Chinook release groups from 2015 to 2021.

Release Group	Year	Rocky Reach Dam			McNary Dam			Bonneville Dam	
		Mean Travel Time (d)	90% Passage (d)		Mean Travel Time (d)	90% Passage (d)		Mean Travel Time (d)	90% Passage (d)
CJH Segregated Summer Subyearling	2015	35	54		48	63		55	65
	2016	18	31		27	38		31	44
	2017	21	32		32	43		36	46
	2018	15	32		27	46		30	43
	2019	NA	NA		NA	NA		NA	NA
	2020	b	56		b	61		b	62
	2021	37	46		44	53		a	a
	Average	25	42		36	51		38	52
Omak Pond Integrated Summer Subyearlings	2015	27	44		40	52		45	57
	2016	13	27		21	37		24	34
	2017	14	22		24	33		28	37
	2018	NA	NA		NA	NA		NA	NA
	2019	NA	NA		NA	NA		NA	NA
	2020	b	51		b	58		b	61
	2021	33	41		42	47		41	47
	Average	22	37		32	45		34	47
Wild Subyearlings	2015	22	35		42	44		a	a
	2016	28	55		35	59		36	69
	2017	20	66		34	65		30	61
	2018	31	56		44	71		45	53
	2019	36	51		50	62		49	62
	2020	32	44		45	56		37	46
	2021	32	44		45	56		37	46
	Average	29	50		42	59		39	56
a) Sample size too small (<10) for a reliable estimate									
b) Some negative travel time values to OKL were in the data, suggesting fish were released earlier than reported, or some escaped before the official release date									

Table 29. Travel time (days) and the number of days to 90% passage for yearling summer Chinook release groups from 2015 to 2021.

Release Group	Year	Rocky Reach Dam			McNary Dam			Bonneville Dam	
		Mean Travel Time (d)	90% Passage (d)		Mean Travel Time (d)	90% Passage (d)		Mean Travel Time (d)	90% Passage (d)
CJH Segregated Yearlings	2015	30	41		41	55		42	53
	2016	15	26		25	36		28	42
	2017	15	26		24	37		26	38
	2018	13	27		24	36		29	50
	2019	32	61		43	69		58	75
	2020	12	17		23	32		25	30
	2021	24	41		34	48		33	49
	Average	20	34		31	45		34	48
Omak Pond Integrated Yearlings									
	2015	NA	NA		NA	NA		NA	NA
	2016	16	30		25	36		27	39
	2017	22	37		30	44		32	44
	2018	22	42		31	47		39	58
	2019	23	44		36	62		47	68
	2020	13	19		24	29		25	30
	2021	a	a		a	a		a	a
	Average	19	34		29	44		34	48

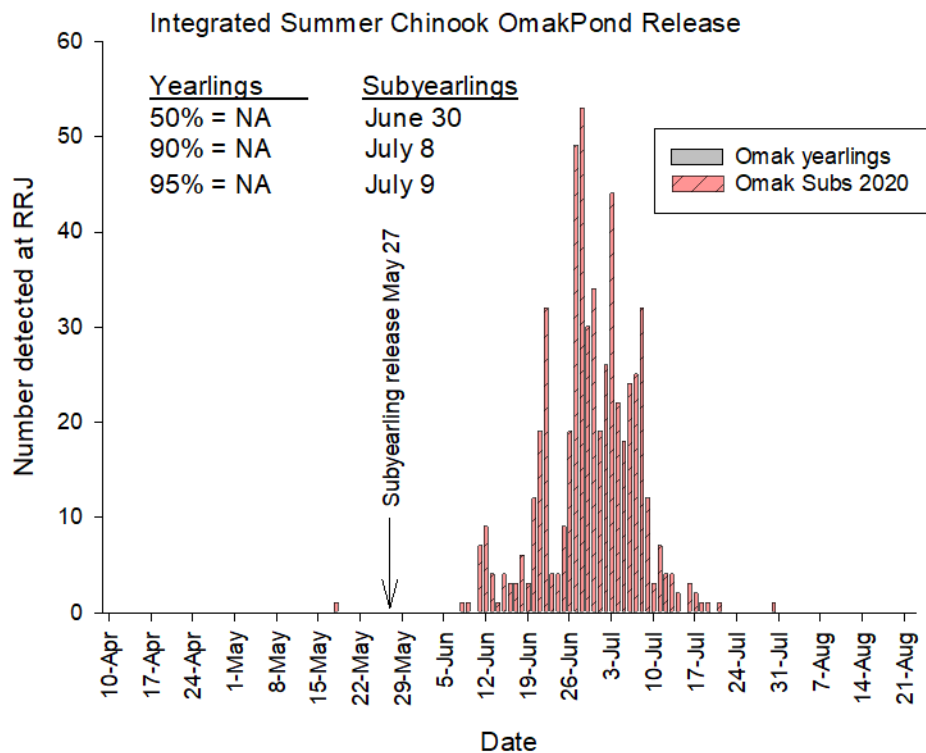
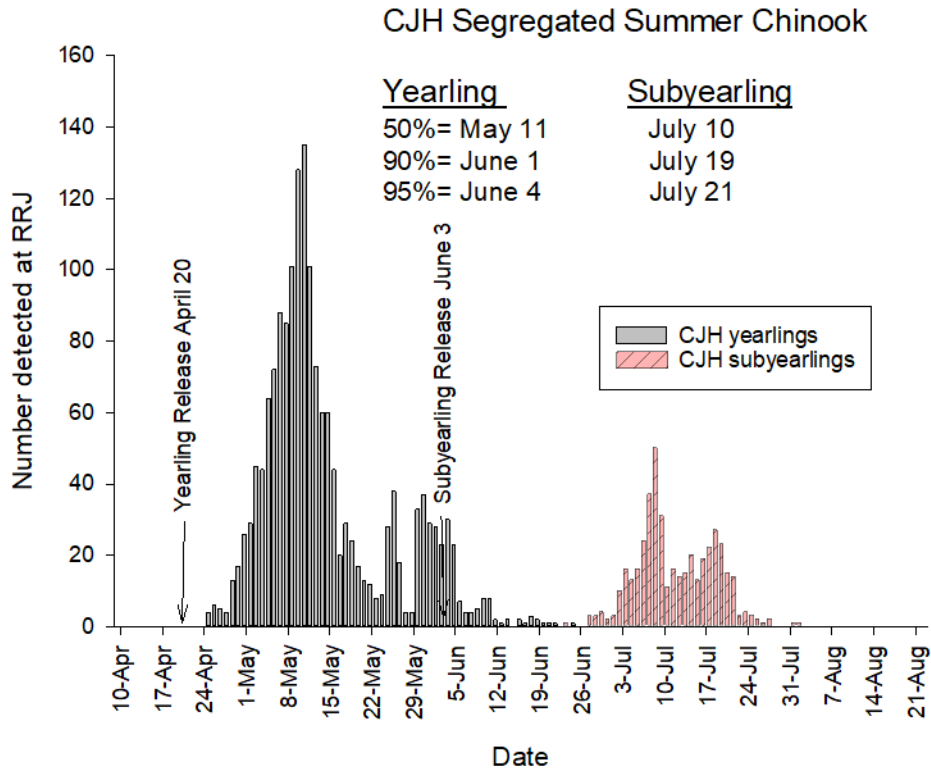


Figure 29. Arrival timing at Rocky Reach Juvenile bypass (RRJ) of PIT tagged Summer Chinook released from the Chief Joseph Hatchery and Omak Pond in 2021.

Smolt-to-Adult Return (SAR)

SAR was estimated using two methods, PIT tags and coded-wire tags.

PIT based estimate of SAR—The most recent brood year that could be fully assessed with PIT tags (through age 5) for SAR was 2016. For CJH segregated Summer Chinook from brood year 2016 (outmigration year 2018), 71 adult fish (age 4&5) returned to Bonneville Dam with a PIT tag, resulting in SAR estimates of 1.4% before harvest and 1.9% with harvested fish added back in (Table 30). For brood year 2016, the SAR back to Wells Dam was 0.9% before harvest and 1.5% with harvested fish added back in (Table 30).

For the brood year 2016 integrated yearling program released from Omak Pond, 35 adult fish (age 4-5) returned to Bonneville Dam with a PIT tag, resulting in SAR estimates of 0.7% before harvest and 0.9% with harvested fish added back in (Table 30). For brood year 2016, the SAR back to Wells Dam was 0.4% before harvest and 0.6% with harvested fish added back in (Table 30).

The subyearling program showed considerably lower SARs, with only 7 adult PIT tagged fish returning back to Bonneville Dam from the segregated program thus far, resulting in an SAR estimate of 0.1% and 0.2% with harvest fish added back. The SAR back to Wells Dam was also 0.1% and 0.2% with harvest added back. For the brood year 2016 integrated sub yearling program at Omak Pond, 2 age-4 adult fish returned in 2021 resulting in an SAR back to Bonneville Dam of 0.04% and 0.1% with harvest fish added back. The SAR back to Wells Dam was 0.02% and 0% (Table 31).

Table 30. Estimate of the smolt to adult return rate (SAR) for yearling Summer Chinook from Chief Joseph Hatchery and Omak Pond. Adult return data were available through 2021, therefore the most recent brood year that could be assessed through age 5 was 2016.

CJH Segregated Yearling Summer Chinook		PIT tag Detections at Bonneville Dam					Excluding Jacks		
Brood Year	Number of PIT tags	Age 2 Mini-Jack	Age 3	Age 4	Age 5	Age 6	Raw SAR	Harvest Corrected SAR	
2013	5017	17	16	28	24	0	1.0%	1.4%	
2014	4951	1	7	35	29	0	1.3%	1.7%	
2015	5024	27	3	18	10	0	0.6%	0.7%	
2016	4921	4	2	40	31	NA	1.4%	1.9%	
2017	4945	0	0	18	NA	NA	NA	NA	
PIT Tag Detections at Wells Dam									
2013	5017	5	12	16	15	0	0.6%	1.0%	
2014	4951	0	4	20	22	0	0.8%	1.4%	
2015	5024	5	2	13	7	0	0.4%	0.7%	
2016	4921	2	1	24	20	NA	0.9%	1.5%	
2017	4945	0	0	10	NA	NA	NA	NA	

Integrated Yearling Summer Chinook from Omak Pond		PIT tag Detections at Bonneville Dam					Excluding Jacks		
Brood Year	Number of PIT tags	Age 2 Mini-Jack	Age 3	Age 4	Age 5	Age 6	Raw SAR	Harvest Corrected SAR	
2013	1204	0	0	0	0	0	NA	NA	
2014	4193	28	4	19	9	0	0.7%	0.9%	
2015	4830	4	8	22	34	0	1.2%	1.6%	
2016	5326	0	0	15	20	NA	0.7%	0.9%	
2017	4987	2	1	24	NA	NA	NA	NA	
PIT Tag Detections at Wells Dam									
2013	1204	0	0	0	0	0	NA	NA	
2014	4193	3	3	12	6	0	0.4%	0.7%	
2015	4830	1	5	17	26	0	0.9%	1.5%	
2016	5326	0	0	11	9	NA	0.4%	0.6%	
2017	4987	2	0	15	NA	NA	NA	NA	

Table 31. Estimate of the smolt to adult return rate (SAR) for subyearling Summer Chinook from Chief Joseph Hatchery and Omak Pond. Adult return data were available through 2021, therefore the most recent brood year that could be assessed through age 5 was 2016.

CJH Segregated Subyearling Summer Chinook		PIT tag Detections at Bonneville Dam					Excluding Jacks		
Brood Year	Number of PIT tags	Age 2 Mini-Jack	Age 3	Age 4	Age 5	Age 6	Raw SAR	Harvest Corrected SAR	
2013	NA	NA	NA	NA	NA	NA	NA	NA	
2014	4967	0	0	0	0	0	0.0%	0.0%	
2015	4983	0	0	0	0	0	0.0%	0.0%	
2016	5029	0	0	7	0	NA	0.1%	0.2%	
2017	5027	1	17	17	NA	NA	NA	NA	
PIT Tag Detections at Wells Dam									
2013	NA	NA	NA	NA	NA	NA	NA	NA	
2014	4967	0	0	0	0	0	0.0%	0.0%	
2015	4983	0	0	0	0	0	0.0%	0.0%	
2016	5029	0	0	5	0	NA	0.1%	0.2%	
2017	5027	0	0	7	NA	NA	NA	NA	

Integrated Subyearling Summer Chinook from Omak Pond		PIT tag Detections at Bonneville Dam					Excluding Jacks		
Brood Year	Number of PIT tags	Age 2 Mini-Jack	Age 3	Age 4	Age 5	Age 6	Raw SAR	Harvest Corrected SAR	
2013	NA	NA	NA	NA	NA	NA	NA	NA	
2014	4941	0	2	3	0	0	0.1%	0.1%	
2015	4979	0	0	0	0	0	0.0%	0.0%	
2016	4571	1	1	2	0	NA	0.04%	0.1%	
2017	0	NA	NA	NA	NA	NA	NA	NA	
PIT Tag Detections at Wells Dam									
2013	NA	NA	NA	NA	NA	NA	NA	NA	
2014	4941	0	0	2	0	0	0.0%	0.1%	
2015	4979	0	0	0	0	0	0.0%	0.0%	
2016	4571	1	1	1	0	NA	0.02%	0.0%	
2017	0	NA	NA	NA	NA	NA	NA	NA	

CWT-based estimate of SAR—Based on expanded CWTs, the 2016 brood year had a SAR of 0.84%, which was below the long-term and 5-year averages. (Table 32).

Table 32. Smolt-to-adult return rate (SARs) for Okanogan/Similkameen summer/fall Chinook, brood years 1989-2015.

Brood Year	Number of tagged smolts released ^a	Estimated adult captures ^b	SAR
1989	202,125	4,293	2.12%
1990	367,207	972	0.26%
1991	360,380	975	0.27%
1992	537,190	2,282	0.42%
1993	379,139	117	0.03%
1994	212,818	1,526	0.72%
1995	574,197	2,842	0.49%
1996	487,776	32	0.01%
1997	572,531	18,570	3.24%
1998	287,948	7,742	2.69%
1999	610,868	2,782	0.46%
2000	528,639	6,765	1.28%
2001	26,315	424	1.61%
2002	245,997	1,979	0.80%
2003	574,908	3,503	0.61%
2004	676,222	12,960	1.92%
2005	273,512	1,662	0.61%
2006	597,276	13,605	2.28%
2007	610,379	4,943	0.81%
2008	516,533	14,894	2.88%
2009	522,295	7,119	1.36%
2010	610,927	10,666	1.75%
2011	625,234	18,757	3.00%
2012	157,390	3,643	2.31%
2013	677,483	5,580	0.82%
2014	749,546	6,053	0.81%
2015	474,928	3,715	0.78%
2016	870,096	7,271	0.84%
Total	13,329,859	165,672	1.24%
5-year Total	585,889	5,252	0.90%
^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.			

DISCUSSION

Rotary Screw Traps (RST)

In past years, primarily attributable to low capture efficiency, the data produced by the RST has proved insufficient to provide for estimation of juvenile production in the previous brood year. 2021 was no exception;

The pooled trap efficiency of approximately 0.38% is lower than in previous years (Rayton and Arterburn 2008, Johnson and Rayton 2007; https://static1.squarespace.com/static/56f45574d51cd42551248613/t/57c06a21e58c62290279a3d7/1472227873603/2006_Screw_Trap_Report_Final.pdf; <https://static1.squarespace.com/static/56f45574d51cd42551248613/t/57c06a12e58c62290279a376/1472227860447/2007RstReportFinal.pdf>), and remains insufficient to precisely estimate juvenile production for the basin. Additionally, the 95% confidence interval for hatchery-origin population was far too broad to provide information useful in making informed decisions. This indicates that, due to the difficulties in accurately estimating trap efficiency and juvenile production, the results of screw trapping activities in 2021 are 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 continue to attempt to conduct more frequent efficiency trials with large release groups ($n \geq 1000$).

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

Historically 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 and out-migrating in measurable quantities, this possibility could be

reexamined. This should be especially relevant once integrated, §10(j) spring Chinook, first released from the Riverside Acclimation pond in April 2015, begin to return and spawn.

Finally, sixteen Pacific lamprey (*Entosphenus tridentatus*) were captured in the RST in 2021. *E. tridentatus* were observed in both 2006 and 2007 but were not observed from 2008 to 2019. The status of this fish, an important cultural and ecological resource in the Okanogan River Basin is not examined in this report, but its presence and absence from the RST is noteworthy.

Juvenile Beach Seine

The CJHP took over the beach seining effort in 2014, adopting methods used by Douglas County PUD and Biomark in 2011-2013. Given the low catch rate of taggable summer/fall Chinook from the RST, beach seining appeared to be a more reliable opportunity to capture large numbers of taggable summer/fall Chinook juveniles. Again in 2021, PIT tags deployed at the beach seine far outnumbered tags deployed at the RST.

Mortality related to capture, handling and tagging was similar to what it has been in previous years. Maintaining water temperatures below 18 °C, reducing MS-222 concentrations in the anaesthetizing solution, and further limiting handling time during tagging and capture likely contributed to this low pre- and post-tagging mortality. The hope for future years is to continue to reduce overall mortality associated with our PIT tagging efforts.

Fish size increased through the tagging period, but the number of fish captured and CPUE began to decrease in early July, which is later than what had been observed previous to that. Interestingly, dates of detection at downstream PIT arrays occurred about the same as they had in 2020.

We do not have absolute certainty regarding natal stream for any of the juvenile Chinook fitted with a PIT tag, but assume the vast majority, especially of fish captured at the Gebber's location, are of Okanogan origin. However, juvenile summer Chinook in the Wells Pool originate from the Methow and Columbia Rivers as well. Therefore, future analyses of returning adults must recognize that some fish may not be destined for the Okanogan. Results from the stable isotope analysis conducted in 2018 indicated that most fish collected from the Gebber's location are of Okanogan River origin (See 2018 Annual Report, Appendix E).

Lower Okanogan Adult Fish Pilot Weir

Discharge conditions on the Okanogan River in 2021 were quite a bit lower than those in previous years, allowing for the installation of the weir until mid- August, which is similar to 2020. Temperatures on the Okanogan River were fairly normal, compared to the 15-year median. Temperature was not a factor for trapping operations once it began on August 18th. Tower observations were relatively low for the majority of the season outside of a couple days in mid-August. Observations of fish from the bank of the downstream pool increased after the water temperature stayed below 18 °C in mid-September. For the majority of the season fish observations 0.8 km. below the weir, at the lower pool, were higher than observations at the weir. When river temperature was lower and gage height was less than 4 feet, Chinook were more likely to mill in deeper pools. In previous years tower observations were much higher in September, so it's reasonable that there were more fish milling in the lower pool than there were milling around the weir in September. Over a 5-day period in mid-August, pickets were up on about half of the weir panels due to a high density of algae in the river. The algae was creating a dense blanket across the weir panels and became too difficult for crew to maintain the weir without creating a head differential across the panels that was within the project's operating criteria. There were a few hours per day when we were able to push pickets down and maintain clean panels with staff, but the majority of time we had to suspend trapping. Continued monitoring of Chinook passage through the weir with respect to temperatures will continue in order to better refine weir operations and future expectations for weir effectiveness.

The number of Chinook handled at the weir ($n = 46$) was much less than the average ($n=466$). Configuration of the weir was similar to that in 2020 with the trap installed downstream, on the edge of the thalweg, and below the deep pool. The fish entrance chute was included with the trap gate again to test whether it would increase entrainment to the trap box. We evaluated the water conditions as it relates to discharge and stage height and think that we should continue to install the trap at the same location as 2021 to continue testing it with the chute.

None of the water quality parameters monitored were at a level that would cause concern regarding an environmental effect of the weir on water quality. There were no dead fish and no fish impinged between pickets (head upstream) at the weir in 2021.

There were seven sockeye trapped in 2021. When pickets were down and the trap was operating, there were no observations of jack or small adult Chinook escaping through the 2" weir panels, but we did observe some sockeye pass through the panels during the day. We will continue to use the 2-inch weir panels again next year to increase the efficiency of Chinook trapping without causing too many sockeye to also use the trap.

There was no way to know exactly how many fish escaped past the weir before it was installed or how many fish swam through while the pickets were up or jumped over the sealing aprons after it was installed. The potential weir effectiveness measure of 0.3% was the lowest to date. Although the barrier broke down in mid-August, this did not affect fish management objectives in 2021. With a lower adult return, CCT was able to collect only a small portion of their full brood stock quota (84) at the weir and remove less than 1% of the hatchery-origin returns. In the future, with larger returns of hatchery fish due to CJH releases we anticipate a much higher pHOS at the weir resulting in higher weir effectiveness. Continuing these evaluations in future years will be critical to determining the long-term viability of the weir as a fish management tool for summer/fall Chinook.

In 2021 CCT F&W staff were able to safely and successfully deploy, operate, and monitor the weir and add to the multi-year evaluation of the weir as a fish management tool for the CJH program. The program experienced a smaller run than the previous year which limited the program's ability to successfully collect brood stock for the hatchery's integrated program and remove hatchery-origin returns to manage pHOS. The weir's importance to successful management of the Okanogan summer/fall Chinook population should continue in the coming years with larger hatchery returns resulting from the increased production at CJH. Experiencing a broad range of environmental conditions spanning the extremely high summer flows of 2012 to the very low and warm flows in 2015 or high algal densities in 2019 and 2021, is important for understanding the range of challenges and resulting weir effectiveness that can be expected through time.

Redd Surveys

Summer/fall Chinook spawning consisted of 3,050 redds in 2021, which was above the long-term average (2,300 for 1989-2021) and above the more recent 5-year average of 2,976. Redd counts were only above average in three reaches of the Okanogan and Similkameen Rivers (O1, O2, and O3) and below average in and all other reaches (Table 15).

The redd count in reach O6 – which most years, supports the largest proportion of natural-origin spawners – was the sixth highest count on record, which dates back to 2006. Likewise, reach S1 in the Similkameen River – which generally supports the highest proportion of hatchery-origin spawners had considerably fewer redds than last year. Still, these two adjacent reaches, along with the O5 reach provided the primary spawning habitat for summer/fall Chinook in the Okanogan/Similkameen basin, comprising 87% of the total spawning in 2021. One objective of the CJHP is to increase the spatial distribution of spawning into the lower reaches of the Okanogan. Historically, a low proportion of the spawning activity has occurred in these reaches (O1 – O4), likely due to lower quality

spawning habitat (increased fine substrate, reduced gradient, increased pool habitat). The 2021 redd counts showed an increase in the proportion of redds in reaches O1 and O2. Although the changes are modest, they represent progress towards a goal that will likely take a long time to fully achieve. CJHP Chinook reared at the Omak Pond acclimation site (located around the break between reach O3 and O4) may be contributing to increased spawning in lower reaches through natal homing. Continued monitoring of redd and carcass distribution will be critical to evaluate this metric.

Chinook spawning in the Okanogan generally begins as water temperatures drop below 15°C. Conditions in 2021 were characterized with average discharge and stream temperatures going into the spawning period (Figure 2). The greatest single week count of redds occurred between October 14 to October 20. Spawning lower in the Okanogan Basin (reaches O1, O2, and O3) appears to have peaked slightly later, with peak counts occurring the week of October 18-22. Few redds were recorded in November, as most spawning was complete by then (Table 15). Although aerial surveys contribute a relatively small portion of the observed redds compared to ground or float surveys, they remain an important tool for documenting spawning, or lack of, in areas not accessible by ground crews.

As in previous years, the fish per redd expansion is based on the sex ratio of fish passing Wells Dam. This method has been used since at least 1998 (Hillman et al. 2014) and is still being applied to both the Methow and Okanogan Chinook populations. However, there is uncertainty that the combined sex ratio of hatchery- and natural-origin summer/fall Chinook at Wells Dam is representative of the Okanogan population because it also includes Methow returns, mainstem released hatchery-origin Chinook, as well as roaming downstream hatchery- and natural-origin Chinook. If the Okanogan has a different ratio of precocial males (jacks) than that of the Wells count, then the Okanogan abundance estimate could be biased. We suggest exploring other approaches to estimating the number of fish per redd in the Okanogan and Similkameen Rivers. Until then, the annual spawning escapement will continue to be calculated using the sex ratio of fish at Wells Dam.

ESCAPEMENT INTO CANADA

Escapement of summer/fall Chinook into Canada had been largely overlooked until recent years, aided by video counts of Chinook passing over Zosel Dam. Spawning escapement to Canada has still been difficult to assess, as the video counts represent run escapement and the relationship between run escapement and spawn escapement is not clear. In 2018, video monitoring at Zosel Dam was discontinued, so we are now further limited in our ability to assess Chinook spawning escapement into Canada. Before 2018, a substantial number of Chinook had been counted passing Zosel Dam, ranging from a low of 737 to a high of 2275 between 2013 and 2017 (Table 20), so there is the potential for Canada-bound Chinook to have a significant contribution to the trans-boundary Okanogan

summer/fall Chinook population. No formal Chinook redd count surveys are currently being conducted in Canada, but Chinook dead pitch counts occur annually.

There is a clear need for increased collaboration between agencies to better monitor and manage this trans boundary population. Researchers and managers for CCT and ONA are continuing to discuss research and monitoring needs as well as potential strategies for accomplishing monitoring goals.

Research & monitoring needs may include:

1. Organization of protocols and methods for formal Chinook spawning grounds surveys in Canada
2. Increased PIT array systems to better assess PIT-tagged fish passage into Canada

Carcass Surveys

Spawning ground monitoring efforts resulted in an 18.1% carcass recovery rate, which was just below the target carcass recovery rate of 20%. However, it is unclear if 20% is necessary to obtain reliable biological-data or what the implications of reduced sampling rates may be. 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).

Spawning grounds surveys beginning in mid-August and lasting through November 8 revealed very few carcasses attributable to pre-spawn mortality, or PSM. Of the 720 female Chinook carcasses recovered, only 0.69% were determined to have expired pre-spawn. Also, few female carcasses had retained a significant portion of their eggs, with an egg retention rate of just 1.83%. In other words, it appears that if a significant pre-spawn mortality event takes place, it occurs prior to the spawning period in October, or even late September, as the carcasses we recover on the spawning grounds are nearly all void of eggs. Given the challenging thermal conditions encountered by Chinook in the Okanogan River, it is likely that the majority of PSM occurs earlier in the season while water temperatures are higher and are a greater risk to fish attempting to travel to or hold near the spawning grounds. If this were true, the current design of our redd/carcass surveys would provide an underrepresentation of actual PSM. Therefore, egg retention and pre-spawn mortality results should be interpreted cautiously. One thing of note is that carcasses that are collected during spring Chinook spawning ground surveys in August and

September are assessed via coded wire tag recovery to determine spring or summer run. During the 2021 surveys, 8 summer Chinook pre-spawn mortality carcasses were collected, in the Similkameen River. 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 up to 5,000 eggs and were only considered pre-spawn mortality if they retained > 4500 eggs. A static fecundity assumption may not be the best approach because younger and smaller females will likely have fewer 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. However, even when considering any female that retained ≥ 1000 eggs, the estimated PSM remained unchanged. 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. 2021 pHOS (0.31) was just above the biological target but above the 5-year average (0.34). The program met the biological target for PNI (>0.67) in 2021 (0.76) after failing to meet it in 2018 and 2019. The 5-year mean PNI (0.73) remains above objective. There was a reduction in hatchery-origin spawners, including CJH segregated fish, on the spawning grounds in 2021. In the future, we suggest that continued aggressive removal of hatchery-origin 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 Chinook recovered on the spawning grounds in the Okanogan Basin were predominantly (79%) from Okanogan and Similkameen acclimated, CJH Integrated Program releases. CJH Segregated fish made up 13% of the hatchery-origin spawners, and 5% of the total spawning escapement. In order to stay under the 5% segregated pHOS goal on the spawning grounds there will need to be more removals of segregated Chief Joseph Hatchery fish before they reach the Okanogan. More aggressive operations of the Chief Joseph Hatchery ladder could help the program obtain this goal. Stray hatchery-origin fish originating from outside the Okanogan made up 2.5% of the total estimated spawners,

which was less than the goal of 5%, although if we include the CJH segregated spawners, the stray rate increases to 7.2%. Okanogan Basin hatchery-origin fish strayed to other areas at a low rate (0.3% to non-target basins and 0.8% to non-target hatcheries, based on RMIS queries of the 2016 BY) and were a small percentage of the spawner composition in other Upper Columbia tributaries in 2021 (less than 1% in any stray basin). Fish released within the Okanogan Basin have consistently homed to their natal stream, and 2021 was not an exception. One of the goals of the CJHP is to redistribute Chinook spawners to the middle and lower portion of the Okanogan River instead of inundating the already saturated Similkameen River with additional spawners. Juvenile Chinook releases from the Omak Pond acclimation site are primarily spawning in the Okanogan River (92% in 2018, 90% in 2019, 83% in 2020, and 86% in 2021) instead of the Similkameen River. Specifically, the Omak Pond-reared Chinook have spawned almost exclusively in the lower (O3 reach) and middle (O5 reach) sections of the Okanogan River.

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. Targets for post release survival have not been established, but it was noteworthy that yearling survival from CJH in 2021 was ~8% higher than the recent average and 3% higher than Carlton Pond. In contrast, 2020 survival from CJH was 16-26% less than yearlings from Carlton Pond in that year. Unfortunately, survival for integrated yearlings from Omak Pond could not be calculated due to considerable uncertainty regarding the PIT tagged yearlings that were released from Omak Pond. The tag file suggests that 4,715 PIT tagged yearling summer Chinook released from Omak Pond (rkm 52), but only 4 were detected at the Lower Okanogan PIT detection array and only 5 were detected at RRJ; therefore, we could not assess the outmigration timing or travel time for integrated yearlings. Additionally, there are only 22 detections of summer Chinook yearlings leaving Omak Pond (normally there are several thousand detections), suggesting that either the antennae array was malfunctioning or PIT tagged fish died or escaped the pond before the release. It's unlikely that the antennae array was malfunctioning because so few fish were detected at OKL and RRJ and it was working fine when the subyearlings were released a month later. It is not likely that a large percentage of them escaped the pond before release or there would be more detections and early detections at OKL. Hatchery staff and records did not reveal an issue related to the mortality in Omak Pond prior to release.

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. Similar to previous years, the hatchery fish migrated out of the system relatively quickly in 2021, with 90% passage of integrated subyearlings at OKL within 7

days and only zero detections at more than 1 month. This assessment of sub-yearling travel time may not be valid because 6 of 54 fish were detected at OKL before the reported release date (5/27/2021). It is unclear if this was due to an undocumented early release or some other cause. These assessments suggest that the program was successful at releasing actively migrating smolts. This analysis did not attempt to account for detection probability at OKL and sample size was relatively small for the Omak Pond release (n=54). 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 out-migrating 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. 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.

SMOLT-TO-ADULT RETURN

The 2016 is the earliest brood year that a PIT-based estimate of SAR could be calculated. The data set for PIT-based estimates of SAR is too short to evaluate trends, but it was encouraging to see that the SAR for the segregated program increased back up to the rate that we saw for BY2013 and BY2014. Also encouraging was that there were actual returns of PIT tagged subyearlings from BY2016 and BY2017 compared to zero we had seen for BY2014 and BY2015. Ocean conditions have been better than previous years which may be helping their survival. It is unclear if CJH programs have been affected more or less than nearby programs. The M&E program should continue to evaluate if PIT tags are an effective tool for evaluating the SAR of subyearling Summer Chinook. PIT tagging resources may be better utilized increasing the sample size of yearling release groups. In future years the program will have more years of data to assess smolt to adult survival differences that can be used to provide insight on two options for the program: 1.) continue PIT tagging the subyearlings or 2.) rear fewer integrated subyearlings and, if possible, convert some of the integrated subyearlings to yearlings.

The CWT based SAR for the most recent full brood returns (2016) was below the 5-year and long-term averages.

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 2022 with the purpose of reviewing data collection efforts and results from 2021 and developing the hatchery implementation and monitoring plan for 2022 (Figure 30). 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 31). 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 2022. APR materials with more details than what is provided within this report can be found at <https://www.cct-fnw.com/annual-program-review/>.

Key Management Questions

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

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

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

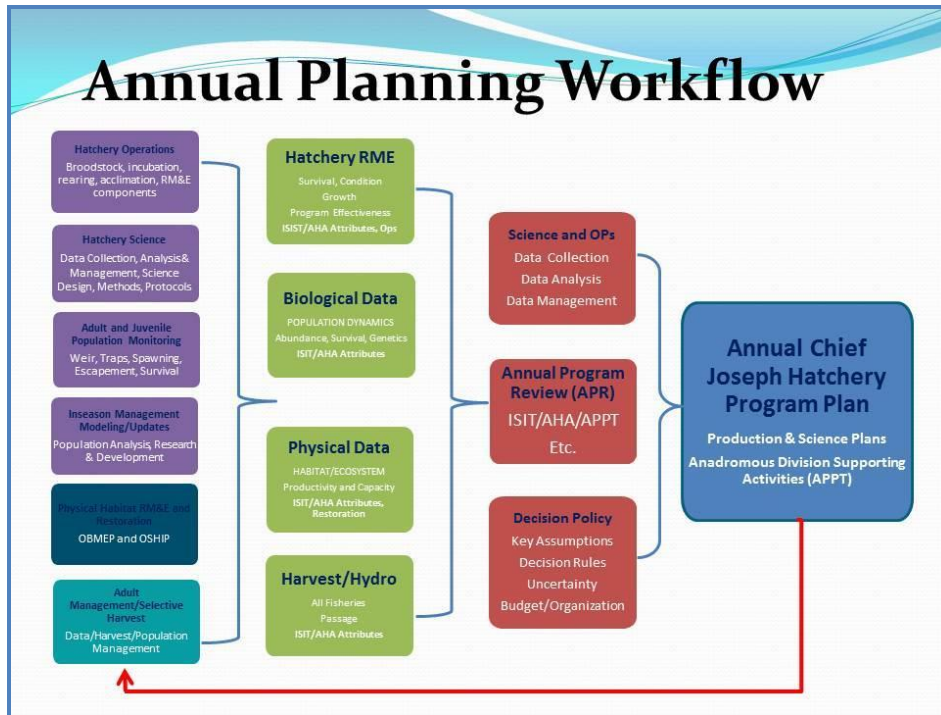


Figure 30. The Chief Joseph Hatchery's annual planning process and workflow.

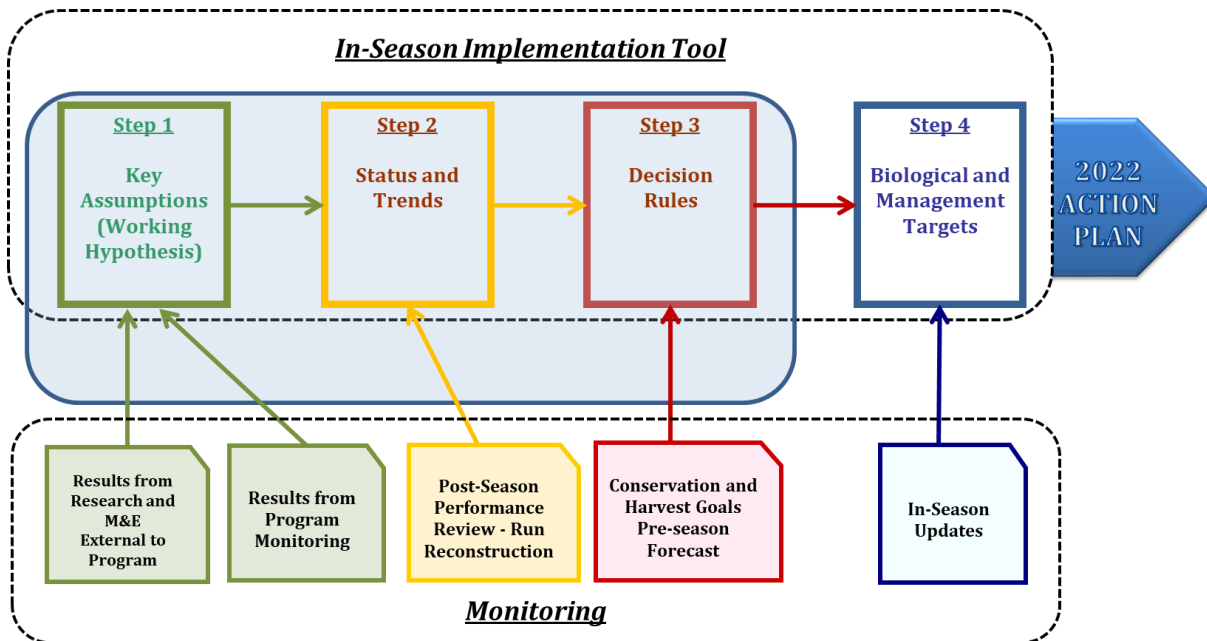


Figure 31. The Chief Joseph Hatchery's analytical workflow.

2022 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 57,500. 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 57,500 upper Columbia would yield 5,205 NORs and 5,135 HORs (Figure 32). The harvest and broodstock collection goals were established from this prediction. With a NOR run size just over 5,000 the broodstock collection recommendation for the integrated program was full production (726 NOB) with 100% pNOB (Figure 32). Likewise, the segregated program should achieve full production with 592 HOB. The model predicted that 1,352 HORs would be captured in the terminal (above Wells Dam) fisheries and that 9 HORs could be removed at the weir. These efforts could result in 3,872 NOS and 1,522 HOS for a pHOS of 24% and a PNI of 0.81. Under this modeling scenario the biological targets will likely be met in 2022. 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, 2022. 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). If the July 15 update includes less hatchery and natural fish than predicted, then CCT and WDFW will manage the harvest and removal of surplus fish in a way that will allow enough natural and hatchery-origin fish to escape to the Okanogan basin spawning grounds ($\text{NOS} \geq 5,250$, total escapement $\geq 7,500$) and also meet the pHOS objective of $< .30$.

ANNUAL MANAGEMENT TARGETS

2021

<-- Most recent return year

Use 5 -year running averages to calculate prior-cumulatives

Recent History:

Average NOB338

Average HOB128

Average pNOB73%

Average NOS4,523

Average HOS1,680

Average pHOS27%

Expected Returns to Wells Dam (most recent update)

2022 Forecast2021 Final

NOR Return (excludes jacks)5,2055,545

HORs from Integrated Program (excludes jacks)3,2223,434

HORs from Segregated Program (excludes jacks)1,9133,980

jeannieh:
Final targets for HORs
based on 2021 PIT
forecast

Runsize Prediction for:2022

Preseason forecast (Columbia)57,500

Applies until:07/15/22

Wells Dam Count thru 07/1516,963

Okanogan NOR Forecast (excludes jacks)5,205

Okanogan HOR Forecast (excludes jacks)5,135

Prespawning Mortality10.0%

NOR Terminal harvest induced mortality rate3.1%

Management Targets

2022 Targets

Harvest*

Okan. HORs retained in Terminal Fisheries1,176

CJH HORs retained in Terminal Fisheries516

Incidental Loss of NORs222

Hatchery and Weir*

Return of Okan. HORs to Hatchery283

Return of CJH HORs to Hatchery1,502

Okan. HORs retained at Weir79

CJH HORs retained at Weir12

Integrated Hatchery Program

Natural Origin Brood (NOB)-Okan (collected)726

Hatch. Origin Brood (HOB)-Okan (collected)-

Projected Annual pNOB-Okan100%

Cumulative pNOB78%

800,000 Yearl.300,000 Subs

Smolt Release-Okanogan

Segregated Hatchery Program

Hatch. Origin Brood (HOB) - Int592

Hatch. Origin Brood (HOB) - Seg (purse seine and ladder)-

500,000 Yearl.400,000 Subs

Smolt Release-CJH

Natural Spawning Escapement

Nat. Origin Spawners (NOS)5,005

Hat. Origin Spawners (HOS) - Int1,709

Hat. Origin Spawners (HOS) - Seg327

Hat. Origin Spawners (HOS) - out-of-basinNA

Total Number of Spawners (excludes jacks)7,041

Effective pHOS25%

PNI0.80

Projected Status of Biolo

Average NOS4,476

Average pHOS29%

Average PNI0.73

Figure 32. The in-season updates management worksheet used to set biological targets for the upcoming year (2021) in the In-Season Implementation Tool

2022 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 33).

KEY ASSUMPTIONS-AHA

		Biological					Segregated Prog
		Baseline	Targets	Transition 1	Transition 2	Long-term	
<u>Natural Production</u>							
	<u>Productivity (Smolts/Spawner)</u>	1307		1307	1307	1307	
	<u>Capacity (Smolts)</u>	3,672,603		3,672,603	3,672,603	3,672,603	
	<u>Juv Passage Survival</u>	27%		27%	27%	27%	
	<u>Ocean Survival (BON to BON)</u>	1.98%		1.98%	1.98%	1.98%	
	<u>Adult Passage Survival</u>	83%		83%	83%	83%	
	Fitness	0.86		0.86	0.86	0.86	
	PNI	0.72	< 0.67	0.71	0.72	0.72	
	Total pHOS	40%	> 30%	40%	40%	40%	
	Segr. pHOS	2%	< 5%	2%	2%	2%	
	<u>Ocean Harvest Rate</u>	21%		21%	21%	21%	
	<u>Lower Columbia Harvest Rate (Zones 1-6, Mouth to MCN)</u>	1%		1%	1%	1%	
	<u>Upper Columbia Harvest Rate (MCN to Wells)</u>	22%		22%	22%	22%	
	<u>Terminal Harvest Rate (Post Wells)</u>	3%		3%	3%	3%	
	Natural Origin Spawners	6,297	< 5,250	6,474	6,297	6,297	
<u>Hatchery Production</u>							
	Local Brood	365		726	726	726	271
	Yearling Release	250,000		800,000	800,000	800,000	500,000
	Sub-yearling Release	300,000		300,000	300,000	300,000	400,000
	<u>SAR (yearling)</u>	1.72%		1.72%	1.72%	1.72%	1.72%
	<u>SAR (sub-yearling)</u>	0.30%		0.30%	0.30%	0.30%	0.30%
	<u>Return Rate to Okanogan</u>	90%		90%	90%	90%	20%
	pNOB	100%		100%	100%	100%	
	NOB	734		604	734	734	
	<u>Relative Reproductive Success</u>	80%		80%	80%	80%	80%
	<u>Ocean Harvest Rate</u>	21%		21%	21%	21%	21%
	<u>Lower Columbia Harvest Rate (Zones 1-6, Mouth to MCN)</u>	3%		3%	3%	3%	3%
	<u>Upper Columbia Harvest Rate (MCN to Wells)</u>	30%		30%	30%	30%	30%
	<u>Pre-terminal Harvest Rate (Ocean to Wells)</u>	46%		46%	46%	46%	46%
	<u>Terminal Harvest Rate (Post Wells)</u>	29%		29%	29%	29%	22%
	Hatchery Surplus	390		430	390	390	3,079
	Average Terminal HOR Run	2,323		7,434	7,434	7,434	4,646
	Expected HOS	1,436		4,596	4,596	4,596	630
<u>Fisheries and Weirs</u>							
	<u>Weir Factor</u>	3%		3%	3%	3%	
	<u>NOR Harvest Release Mortality</u>	9%		9%	9%	9%	

Figure 33. The key assumptions worksheet used in the 2022 In-Season Implementation Tool for the CJHP planning at the Annual Program Review

2022 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 34).

Return year		FPC Reported Dam Count at Wells thru 07/15 (excludes jacks)	% of final count	PUD Counts at Wells Dam		Estimated Return of Okanogan Origin Fish to Wells Dam			%NOR
				NOR All Origins (excludes jacks)	HOR All Origins (excludes jacks)	Okan. NORs	Okan. HORs	CJH HORs	
1998	3	1,060	0.25	970	5,519	841	833.44	-	0.50
1999	4	999	0.11	2,708	4,580	1,562	2,686	-	0.37
2000	5	2,266	0.26	2,726	7,398	1,213	2,291	-	0.35
2001	6	9,766	0.24	10,266	19,195	4,632	7,141	-	0.39
2002	7	23,221	0.34	24,138	42,035	5,207	11,801	-	0.31
2003	8	20,564	0.40	9,194	7,373	2,693	2,948	-	0.48
2004	9	14,762	0.40	23,227	13,989	8,004	2,599	-	0.75
2005	10	14,449	0.42	18,911	15,164	8,615	3,404	-	0.72
2006	11	12,563	0.43	20,262	8,730	10,047	2,749	-	0.79
2007	12	5,532	0.37	7,088	7,789	4,480	3,154	-	0.59
2008	13	8,838	0.35	11,244	13,779	4,337	6,554	-	0.40
2009	14	13,753	0.46	15,184	14,187	5,751	5,782	-	0.50
2010	15	12,264	0.41	5,671	7,167	4,791	5,409	-	0.47
2011	16	3,912	0.12	12,139	19,164	5,256	6,184	-	0.46
2012	17	10,082	0.24	14,424	27,716	5,974	7,793	-	0.43
2013	18	25,571	0.38	34,965	30,179	8,554	5,847	-	0.59
2014	19	26,010	0.46	36,060	21,015	12,798	4,258	-	0.75
2015	20	25,153	0.32	46,030	31,625	14,288	8,252	-	0.63
2016	21	21,479	0.43	28,467	21,542	12,063	4,768	3	0.72
2017	22	15,124	0.44	15,729	18,479	7,775	2,409	1,344	0.67
2018	23	11,886	0.48	6,533	18,347	3,728	2,574	2,251	0.44
2019	24	12,950	0.47	8,499	18,800	3,227	3,754	2,341	0.35
2020	25	25,965	0.46	22,243	36,309	9,343	4,086	1,837	0.61
2021	26	16,963	0.50	11,696	22,095	5,773	3,509	1,841	0.52

Return year	Broodstock																			% Int HORs spawned
	Okanog./Similk Integrated Program												CJH Segregated Program							
	Okan. NORs collecte d	Okan. HORs collecte d	CJH HORs collecte d	Total NORs Spawned	% Okan. Orig.	Okan. NORs spawned	Okan. HORs spawned	CJH HORs spawned	Out of Basin HORs spawned	Total HORs Spawne d	Total Brood	Okanoga n origin pNOB	Okan. HORs collected	CJH HORs collected	Okan. HORs spawne d	CJH HORs spawne d	Out of Basin HORs Spawne d	Total Brood		
1998	239	348		153	50%	77	211			211	364	21%	-	-				-		
1999	248	307		224	50%	112	289			289	513	22%	-	-				-		
2000	184	373		164	50%	82	339			339	503	16%	-	-				-		
2001	135	423		91	50%	46	266			266	357	13%	-	-				-		
2002	270	285		247	50%	124	241			241	488	25%	-	-				-		
2003	449	112		381	50%	191	101			101	482	40%	-	-				-		
2004	541	17		506	50%	253	16			16	522	48%	-	-				-		
2005	551	12		391	50%	196	9			9	400	49%	-	-				-		
2006	579	12		500	50%	250	10			10	510	49%	-	-				-		
2007	504	19		456	50%	228	17			17	473	48%	-	-				-		
2008	418	41		404	50%	202	41			41	445	45%	-	-				-		
2009	553	5		507	50%	254	-			-	507	50%	-	-				-		
2010	503	8		484	50%	242	8			8	492	49%	-	-				-		
2011	498	30		467	71%	332	26			26	493	67%	-	-				-		
2012	112	-		107	90%	96	-			-	107	90%	-	-				-		
2013	477	-		366	90%	329	1			1	367	90%	337	-	327	-	-	327		
2014	651	-		499	90%	449	5			5	504	89%	678	-	444	-	-	444		
2015	659	37		421	90%	379	9			9	430	88%	621	-	334	-	-	334		
2016	660	-		584	90%	526	-			-	584	90%	688	-	482	-	-	482		
2017	657	-		350	90%	315	17			17	367	86%	551	-	349	41	65	390	89%	
2018	305	243	46	193	90%	174	152	29	31	212	405	43%	422	147	185	127	30	312	59%	
2019	419	168	82	381	90%	343	114	56	35	205	586	59%	391	174	297	132	78	429	69%	
2020	676	-	-	530	90%	477	5	-	-	5	535	89%	541	71	391	51	58	442	88%	
2021	705	-	-	426	90%	383	14	-	-	14	440	87%	487	100	326	67	83	393	83%	

Return year	Terminal Harvest Above Wells														
	Tribal Harvest						Recreational Harvest						Terminal Harvest Rates		
	Total Tribal Harvest	Total NORs	Total HORs	Okan. NORs	Okan. HORs	CJH HORs	Total Rec. Harvest	Total NORs	Total HORs	Okan. NORs	Okan. HORs	CJH HORs	NOR	Int HOR	Seg 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	-	-	-	-	-	-	-	5%	41%	-
2004	242	0	242	-	218	-	2,803	1,895	908	1,706	817	-	21%	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	-	17%	29%	-
2007	1,078	467	611	84	550	-	1,803	887	916	798	726	-	20%	40%	-
2008	2,299	588	1711	106	1,540	-	1,665	698	967	628	561	-	17%	32%	-
2009	2,598	363	2235	65	2,012	-	1,062	648	414	583	244	-	11%	39%	-
2010	2,912	354	2558	64	2,174	-	1,019	612	407	551	208	-	13%	44%	-
2011	1,097	449	648	81	577	-	1,017	200	817	180	286	-	5%	14%	-
2012	3,184	656	2528	118	2,250	-	2,470	829	1,641	746	1,559	-	14%	49%	-
2013	3,176	832	2344	150	1,781	-	2,107	179	1,928	161	713	-	4%	43%	-
2014	2,963	1508	1455	271	1,164	-	1,383	321	1,062	289	382	-	4%	36%	-
2015	9,729	6257	3472	1,126	2,639	-	1,660	289	1,371	260	494	-	10%	38%	-
2016	3,141	1889	1252	340	989	3	1,784	237	1,547	213	665	-	5%	35%	-
2017	1,397	746	651	134	143	91	1,568	591	977	532	479	59	9%	26%	11%
2018	1,238	484	754	87	128	204	993	28	965	25	454	106	3%	23%	14%
2019	1,363	129	1234	23	457	234	1,924	91	1,833	82	898	128	3%	36%	15%
2020	1,731	95	1636	17	414	327	1,150	101	1,049	91	525	73	1%	23%	22%
2021	1,586	172	1414	31	208	382	1,437	153	1,284	138	642	90	3%	24%	26%

	Okanogan Natural Spawning Escapement (excludes jacks)										Pre-termin al Harves t Rate	Total Effective Spawners	Total Recruitment	Surplus Fish (HORs only; NORs released to spawn)				
	NOS	HOS - Int	HOS - Seg	HOS-out of basin	Total HOS	Census pHOS	Effectiv e pHOS	Seg pHOS	Effectiv e Seg pHOS	Okanog an PNI				Int HORs at Ladder	Seg HORs at Ladder	Int HORs at weir	Seg HORs at weir	Total
1998	542	437	-	-	437	45%	39%			35%	46%	891	1,556					-
1999	1,182	2,142	-	-	2,142	64%	59%			27%	46%	2,895	2,890					-
2000	926	1,726	-	-	1,726	65%	60%			21%	46%	2,307	2,245					-
2001	4,048	6,047	-	-	6,047	60%	54%			19%	46%	8,885	8,572					-
2002	4,337	9,473	-	-	9,473	69%	64%			28%	46%	11,916	9,635					-
2003	1,892	1,463	-	-	1,463	44%	38%			51%	46%	3,063	4,983					-
2004	5,182	1,392	-	-	1,392	21%	18%			73%	46%	6,295	14,811					-
2005	6,364	2,416	-	-	2,416	28%	23%			68%	46%	8,297	15,942					-
2006	6,536	1,741	-	-	1,741	21%	18%			74%	46%	7,929	18,592					-
2007	2,539	1,509	-	-	1,509	37%	32%			60%	46%	3,746	8,291					-
2008	2,696	3,902	-	-	3,902	59%	54%			46%	46%	5,817	8,026					-
2009	3,903	3,130	-	-	3,130	45%	39%			56%	46%	6,407	10,642					-
2010	3,076	2,623	-	-	2,623	46%	41%			55%	46%	5,175	8,865					-
2011	3,233	4,304	-	-	4,304	57%	52%			57%	46%	6,675	9,727					-
2012	3,333	3,408	-	-	3,408	46%	41%			63%	46%	6,653	11,056					-
2013	5,233	2,336	-	-	2,336	31%	26%			77%	46%	7,102	15,829	54	-	42	-	96
2014	9,470	1,405	-	-	1,405	13%	11%			89%	46%	10,594	23,684	122	-	225	-	347
2015	10,021	3,110	-	-	3,110	24%	20%			82%	46%	12,509	26,441	888	-	29	-	917
2016	8,352	1,734	-	-	1,734	17%	14%			86%	46%	9,739	22,322	232	-	31	-	263
2017	5,239	672	391	16	1,079	17%	14%	6%	5%	86%	46%	6,089	14,388	297	754	86	6	1,143
2018	2,972	1,044	402	52	1,498	34%	29%	9%	8%	60%	46%	4,129	6,898	159	1,301	6	-	1,466
2019	2,422	1,535	949	138	2,621	52%	46%	19%	17%	56%	46%	4,408	5,972	128	666	4	2	798
2020	7,639	2,193	570	176	2,939	28%	24%	5%	5%	79%	46%	9,849	17,290	12	729	151	3	892
2021	4,344	1,870	312	184	2,366	35%	30%	5%	4%	74%	46%	6,089	10,684	86	923	9	0	1,018

Figure 34. The status and trends worksheet in the In-Season Implementation Tool for CJHP planning at the Annual Program Review.

2022 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 (**Error! Not a valid bookmark self-reference.**).

BIOLOGICAL TARGETS AND "PHASE TRIGGERS"		Population Designation: Primary				
		Current Phase: Transition 2 (from Decision Rules)				
		Applied Scenario	Phase 1	Phase 2	Phase 3	
			Recolonization	Local Adapt.	Recovered	
Biological Triggers for Phase Change Rules		Transition 2	Baseline	Transition 1	Transition 2	Long term
	Year	2025	2013	2020	2025	-
	Move up one phase if NORs greater than:	7,000	1,000	5,250	7,000	-
	Move down one phase if NORs less than:	3,000	-	800	3,000	6,000
	Based on N-Year Running Average, where N=	5	[Enter integer between 3 and 10, inclusive]			
Management Control Variables for "Sliding Scale" Rules		Transition 2	Baseline	Transition 1	Transition 2	Long term
Integrated Program	Minimum NORs over Wells Dam	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%
	Maximum Yearling Releases	800,000	250,000	800,000	800,000	800,000
	Maximum Subyearling Releases	300,000	300,000	300,000	300,000	300,000
	Broodstock Required	726	365	726	726	726
	pNOB [Lo] Trigger (NOR run)	2,000	1,100	2,000	2,000	3,000
	pNOB above Trigger	100%	100%	100%	100%	100%
Segregated Program	pNOB below Trigger	100%	100%	100%	100%	100%
	Maximum Yearling Releases	500,000	500,000	500,000	500,000	500,000
	Maximum Subyearling Releases	400,000	400,000	400,000	400,000	400,000
Other Control Variables	Backfill w/ HORs (Y, N)	N	N	N	N	N
	Maximum Weir Efficiency	3%	3%	3%	3%	3%
	Term. Harvest Rate Integrated HORs	29%	29%	29%	29%	29%
	Term. Harvest Rate Segregated HORs	22%	22%	22%	22%	22%
	pNOB Trigger Range (NOR run)	1,000	sets range for "sliding scale pNOB" --applies to all phases			
NOS Escapement Goal		5,250	-	5,250	5,250	5,250

Modeled outcomes versus Biological Targets

	Targets	Status in 2021 (5-year average)	Projected Status in 2022 (5-year average)	Projected Status 2022-2046	
				Median*	Range*
NOS	> 5250	4,523	4,607	4,524	3,918 - 4,720
pHOS	< 30%	27%	27%	44%	27% - 44%
PNI	> 0.67	0.73	0.66	0.69	0.69 - 0.79
Terminal Catch of HORs (Int and Seg)	> 3000	2,197	1,691	3,120	913 - 3,134

Figure 35. 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.

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APPENDIX A: SUMMER/FALL CHINOOK

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 is one summer/fall Chinook CJH acclimation facility on the Okanogan River, Omak (rkm 51) acclimation pond. 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 million summer/fall 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.

In 2021, 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 as well as lower than anticipated fecundity.

Summer/Fall Chinook Salmon

BY 2020 SUMMER/FALL CHINOOK SALMON REARING AND RELEASE

The yearling summer/fall Chinook rearing began February 28, 2021. Marking was completed, for both the integrated and the segregated programs, on August 17, 2021. The segregated summer/fall Chinook were 100% ad-clipped, with a 100k CWT group tagged. The integrated summer/fall Chinook were 100% AD/CWT. The segregated fish were marked into rearing Pond B, while the integrated fish were marked into the lower raceways, and reared until transfer to the acclimation ponds in late October. The segregated group was released on April 19th. Approximately 5,000 PIT tags were added to each group in October 2021. After subtracting shed tags and mortality, a total of 4,881 PIT tags were released from the segregated group (no interrogation at release). See Table A 1 and A 2 for rearing information until release.

Table A 1. Chief Joseph Hatchery brood year 2020 segregated summer/fall yearling rearing summary.

	Month	Total on hand*^	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
HOR	4/30/2021	248,285	595	6	792	99.76%
	5/31/2021	441,354	5,594	262	462	98.62%
	6/30/2021	439,208	2,146	813	262	98.14%
	7/31/2021	438,226	982	1,655	194	97.92%
	8/31/2021	437,263	963	1,787	54	97.70%
	9/30/2021	457,444	336	3,916	44	97.73%
	10/31/2021	456,832	612	2,344	44	97.60%
	11/30/2021	454,303	2,529	3,916	23	97.06%
	12/31/2021	454,026	277	4,224	18	97.00%
	1/31/2022	453,793	233	880	18	96.95%
	2/28/2022	453,704	89	572	20	96.93%
	3/31/2022	453,604	100	1,408	17	96.91%
	4/19/2022	453,575	29	528	17	96.91%
	Tot SEG	453,575	14,485	22,311	17	96.91%

The integrated summer/fall Chinook were shipped to the Omak Acclimation Pond and the Similkameen Acclimation Pond between October 25th and November 4th. Reporting for the Similkameen Pond will reside with WDFW through release.

Omak Acclimation Pond

On November 3rd and 4th, Chief Joseph Hatchery staff transferred 223,814 Integrated BY 20 summer/fall Chinook from Chief Joseph Hatchery to the Omak Acclimation Pond. Approximately 5,000 PIT tags were added to the group in October 2020. At the time of transfer, the fish were approximately 30 fpp, and were programmed to be reared over winter, with a target size at release of 10 fpp. . However, flooding occurred in mid-November, resulting in heavy sedimentation over a 3 week period compromising fish health. It was at the recommendation of the fish health specialist to release the fish immediately to give them a better chance of survival, thus all fish were released on Dec. 3, 2021. After subtracting shed tags and mortality, a total of 4,532 PIT tags were released from this integrated group (no interrogation at release). Table A 2 illustrates feed fed, feeding rate, and mortality to date for the integrated summer/fall Chinook transferred to the Omak Acclimation pond.

Table A 2. Omak Acclimation Pond BY 20 integrated yearling summer/fall Chinook rearing summary.

Table 3. BY-2020 Yearling Summer Chinook Rearing @ Omak Acclimation Pond Summary						
	Month	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
NOR	11/30/2021	216,765	7,076	396	30	96.84%
	12/3/2021	207,773	8,992	132	30	92.82%
	Cumulative:	207,773	16,068	528	30	92.82%

Riverside Acclimation Pond

Riverside Acclimation Pond was not used to rear BY 2020 summer/fall Chinook but was utilized to rear BY 20 10j Spring Chinook.

Similkameen Acclimation Pond

Similkameen Pond was used to rear yearling summer/fall Chinook per the WDFW program funded by CPUD. Adult broodstock used to generate the juveniles for BY 2020 were collected via the CCT purse seine as part of the transition to the collaborative CJH program. On October 25, 2021, Chief Joseph Hatchery staff transferred 391,407 summer/fall Chinook to the Similkameen Pond, with the assistance of WDFW's Eastbank Hatchery staff. At the time of transfer, the fish were approximately 30 fpp, and were programmed for over winter acclimation, with a target size at release of 10 fpp. However, as with the fish transferred to the Omak Pond, the flood occurrence in mid-November resulted in those fish being released at the beginning of December due to health reasons. Cumulative survival, at the date of transfer, was 96.91%. Survival from transfer to release was 98.86%. After subtracting shed tags and mortality, a total of 4,933 PIT tags were released from this integrated group.

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 2020 yearlings, was 84.7% (86.1% for the segregated program and 83.2% for the integrated program).

2021 Broodstock collection

Collection of summer/fall Chinook for BY 2021 occurred between July 7th and August 3rd via the CCT purse seine operation at the mouth of the Okanogan River. Both hatchery-origin and natural-origin brood were collected to supply the integrated and segregated production programs at CJH. As the seine was being pursed, 9-meter transport barges approached the seine vessel and tied off on the opposite side. The broodstock transport barges have two transport tanks, a 300 gallon for HORs and a 600 gallon for NORs. Brood fish were removed from the seine and placed headfirst in a rubber tube, or boot, containing some water and handed to the staff on the barges for placement in the holding tanks. A maximum of 14 HOR and 28 NOR brood could be loaded per barge. Once full, or at the commencement of the purse seine haul, the barges returned to the offload area at Mosquito Park approximately 2 km away. The brood was then removed from the tanks by hand, placed into a boot, then delivered to one of two 2,500 gallon tanker trucks and transported 16 km to the hatchery.

Water temperatures were of major concern during these operations and monitored to minimize trauma to the adult brood. Okanogan River temperatures during July ranged from 70.3° F (20.3° C) to 78.4° F (25.8° 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/fall run timing as possible (Table A 3). If brood collection failed to meet the weekly quota it was adjusted the following week. However, due to low returns and to ensure overall broodstock goals were met, this quota was not followed and broodstock was collected as early as possible. 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. Once at the hatchery, broodstock were offloaded 6 at a time into totes in order to inject with Draxxin and LA200 (liquamycin), with females receiving both while males only receiving LA200. Broodstock were then separated by program and sex and put into their designated raceways. The receiving water was approximately 57° F. The adult ponds had a flow rate of 500 gpm, and an exchange rate of 54 minutes, representing a Flow Index (FI) of 0.56 and a Density Index (DI) of 0.08 at max capacity. Upon arrival, adult ponds were put on well water.

All adult ponds were treated a minimum of three days per week with formalin to control fungus at a rate of 1:6000, for one exchange. Additionally, brood fish were treated twice per week with Chloramine-T at 12 ppm for one exchange to control Columnaris

bacteria. Diquat was also used under an INAD once Columnaris was detected in broodstock, which was from mid-August through October.

Table A 3. Chief Joseph Hatchery summer/fall Chinook weekly broodstock collection objectives and results for brood year 2021.

Chief Joseph Hatchery BY 21 Summer Chinook Weekly Broodstock Collection Objectives

Week	Weekly Quota ¹		Cumulative Proportion	Cumulative Collection	
	Natural Origin ²	Hatchery Origin ³		Natural Origin	Hatchery Origin
July 5 - July 11	22	22	0.04	22	22
July 12 - July 18	22	22	0.08	44	44
July 19 - July 25	108	104	0.27	152	148
July 26 - Aug 1	108	104	0.46	260	252
Aug 2 - Aug 8	132	126	0.69	392	378
Aug 9 - Aug 15	132	126	0.92	524	504
Aug 16 - Aug 22	36	36	0.98	560	540
Aug 23 - Aug 29	12	12	1.00	572	552
*Sept 15 - Oct 15	84			656	

*NOR weir collection

¹Weekly collection short-fall to be added to following week's collection

²Combined collection strategies in priority order: purse seine, tangle-net, Okanogan weir beach seine and CJH ladder

³Combined collection strategies in priority order: purse seine, tangle-net, CJH ladder, Okanogan weir and beach seine

A total of 687 HOB were collected including 297 females, 279 adult males and 11 jacks from the purse seine with 41 males and 59 females transferred from Well Hatchery (Table A 4). However, it's believed some of these were mis-sexed as they entered the hatchery, so these numbers do not match exactly to the table. A total of 678 NOB were collected including 336 females, 338 adult males, and 4 jacks (Table A 4). Some of the fish initialed classified as jacks were actually adult males, thus the difference from Table A 5.

Through the month of November 2021, there were 88 adult male and 89 female mortalities in the HOR brood, representing 72.5% and 75.0% cumulative pre-spawn

survival to date, respectively. For the same time frame, 68 adult NOR summer/fall Chinook males died, and 114 females died, representing 80.3% and 67.4% cumulative pre-spawn survival, respectively. (Table A 4) Brood fish, particularly females, suffered higher than anticipated mortality due to Columnaris disease, which affected us particularly hard once the well water in which these fish are held reached >60°F.

The cumulative pre spawn holding survival, for all summer/fall brood collected, was 72.9% (including jacks) for HOB and 74.0% (including jacks) for NOB (Table A 4); neither program achieving program survival goal of 90%.

Table A 4. Chief Joseph Hatchery summer/fall Chinook Hatchery (HOB) and Natural (NOB) origin broodstock holding survival summary for brood year 2021. (M = adult males, J = jacks and F = adult females). The survival standard for this life stage was 90%.

Month	Beginning of Month			End of Month			Mortality			Monthly Survival (%)			Cumulative Survival (%)		
	M	J	F	M	J	F	M	J	F	M	J	F	M	J	F
July	0	0	0	229	9	295	0	0	0	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
August	229	9	295	278	11	295	1	0	2	99.6%	100.0%	99.3%	99.6%	100.0%	99.3%
Sept	278	11	295	278	11	295	0	0	0	100.0%	100.0%	100.0%	99.6%	100.0%	99.3%
Oct	278	11	295	38	9	29	76	0	71	72.7%	100.0%	75.9%	72.4%	100.0%	75.4%
Nov	38	9	29	0	0	0	11	9	16	71.1%	0.0%	44.8%	72.5%	18.2%	75.0%
Total	320	11	356	0	0	0	88	9	89				72.5%	18.2%	75.0%
July	0	0	0	319	4	289	3	0	0	99.1%	100.0%	100.0%	99.1%	100.0%	100.0%
August	319	4	289	327	4	329	1	0	1	99.7%	100.0%	99.7%	98.8%	100.0%	99.7%
Sept	327	4	329	333	4	334	1	0	1	99.7%	100.0%	99.7%	98.5%	100.0%	99.4%
Oct	333	4	334	168	4	176	7	0	15	97.9%	100.0%	95.5%	96.4%	100.0%	94.9%
Nov	168	4	176	0	0	0	14	0	50	91.7%	100.0%	71.6%	92.3%	100.0%	80.1%
Total	168	4	176	0	0	0	26	0	67				92.3%	100.0%	80.1%

Hatchery staff began collection of NOR brood from the weir on September 7, 2021 and concluded on September 28, 2021 with 7 wild males and 6 wild females caught and transferred to the hatchery for broodstock. Fish were transferred from the weir trap manually.

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. We recognize that fish collected late may have arrived at any point in their run timing; however, the efforts to collect fish in late August into September at least offer the opportunity to include fish that arrive later in the run timing.

Spawning

Spawning of summer/fall Chinook began on October 5, 2021 with the segregated program, and continued through November 2, 2021 for segregated program and November 8, 2021 for the integrated program. Beginning with the 2018 brood year, the segregated

and integrated programs will be spawned on separate days. As with the spring Chinook, the summer/fall Chinook program is also 100% ELISA sampled. For the 2021 brood, there were 8,827 eggs culled for the segregated program and 3,878 eggs culled for the integrated program.

Total NOB spawned included 205 males, no jacks, and 234 females. (Table A 5) Total HOR spawn included 217 males, 2 jacks, and 267 females. Total eyed egg take for the season was 1,470,713. Egg survival from green egg to eyed egg for NOB averaged 72.1% (Table A 5). Egg survival for HOB averaged 74.5%. Survival was lower than the key assumption of (90%) for this life stage.

Table A 5. Chief Joseph Hatchery brood year 2021 summer/fall Chinook spawning and incubation results.

	Spawn Date	Total Adults Spawned			Eyed Eggs On Hand	Mortality (Pick off)	Non-Viable Eggs**	Culled eggs	Adjusted Total Egg Take	Cumulative Survival (%)
		M	J	F						
HOR	10/5/2021	42	0	42	171,194	11,920	1,889	-	185,003	93.5%
	10/12/2021	69	1	70	179,768	88,640	4,462	-	272,870	67.0%
	10/19/2021	50	0	97	296,360	86,841	4,253	-	387,454	77.3%
	10/26/2021	29	1	45	101,490	66,063	3,784	8,827	180,164	60.6%
	11/2/2021	27	0	13	36,822	15,376	1,734	-	53,932	70.5%
	Total:	217	2	267	785,634	268,840	16,122	8,827	1,079,423	74.5%
NOR	10/6/2021	22	0	22	81,841	4,399	1,372	-	87,612	94.9%
	10/13/2021	44	0	44	155,453	26,750	9,225	-	191,428	85.3%
	10/20/2021	41	0	40	130,742	32,910	3,679	-	167,331	79.9%
	10/27/2021	43	0	44	91,807	96,364	-	3,878	192,049	48.8%
	11/3/2022	37	0	68	174,643	93,289	5,439	-	273,371	65.2%
	11/8/2021	18	0	16	50,593	11,452	-	-	62,045	81.5%
	Total:	205	0	234	685,079	265,164	19,715	3,878	638,420	72.1%

Broodstock origin

Broodstock were interrogated for coded-wire tags by program throughout October and the first week of November. Beginning October 5th, segregated fish were spawned on Tuesday of each week, while integrated fish were spawned on Wednesdays. A total of ten spawning events occurred in 2021. All ad-clipped chinook incorporated in the integrated and segregated programs were sampled at 100% for CWTs regardless of electronic detection via T-wand. Collected samples were then frozen until mid-December where CWTs are extracted and analyzed in the laboratory during winter months.

All broodstock collected for the summer/fall Chinook segregated program came from an Upper Columbia River hatchery program. The CJH integrated program was the

largest contributor to segregated brood with (n=326) 67% of adults coming from either the Similkameen or Omak Pond (Table A 6). Other Upper Columbia River Hatcheries contributed (n=92) 19%, most of which were from DCPUD releases near Wells, (6.1%), Chelan Falls, (5.7%) and Wells Hatchery (5%). A portion of snouts (n=52) indicated detection during spawning events but a coded-wire tag was not found during extraction. Reasons for this include but are not limited to rapidly shaking a Northwest Marine Technologies (NMT) T-Wand when scanning for a CWT (false positive in the field), failure to detect a tag in the lab (false negative), metals in the soil that transfer to a fish during handling or hooks or other metal debris in the fish's head. The unknown component represents 10.7% of the 2020 segregated brood (Table A 6). The mark rate for brood year 2013-2017 segregated releases vary between 99% and 24% ad-clipped + CWT however, overall mark rate between these brood years averages 68.5%. All summer/fall Chinook programs upstream of Priest Rapids Dam are expected to have a 100% tag rate (except for CJH segregated). We would expect a portion of no CWT detection in the lab with the CJH segregated adult returns after adjusting for tag loss, the number of estimated non-CWT recoveries (n=52) can be assigned to the segregated CJH program. The overall composition of the segregated program (tagged and non-tagged) to the segregated brood was 14%.

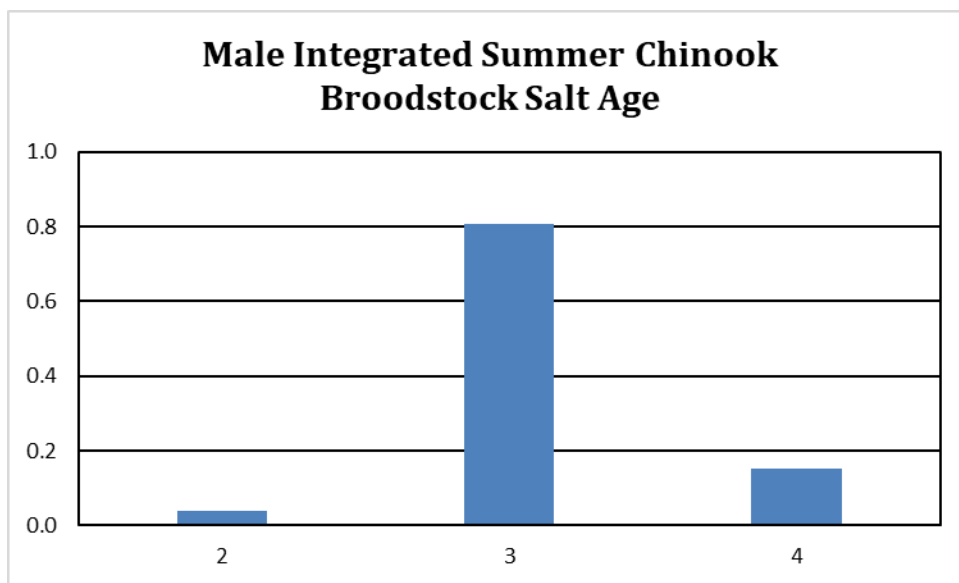
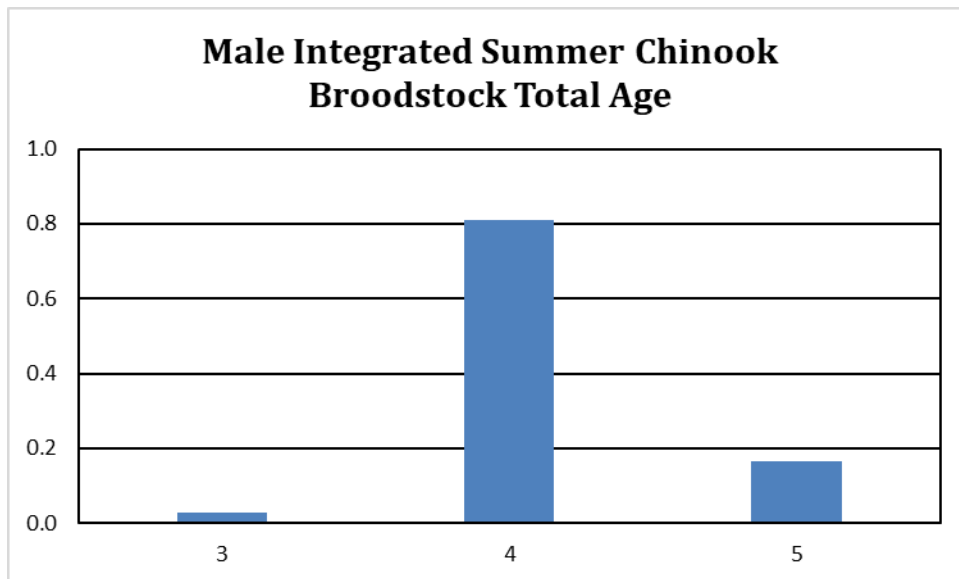
Table A 6 Composition of hatchery-origin brood, by program, collected for the CJH segregated program in 2021.

Category	Hatchery Program	Brood	% of Brood	
Okanogan Integrated	Similkameen	196	40.3 %	67%
	Omak Pond	130	26.7 %	
CJH Segregated	Chief Joseph	16	3.3%	14%
	Chief Joseph (non-tagged)	52	10.7 %	
Other UCR summer/fall Chinook hatchery	Chelan Falls	28	5.7%	19%
	DCPUD	30	6.1%	
	Entiat	5	1%	
	WDFW	4	<1%	
	Wells	25	5%	
Total		486	100.0%	

*Brood values are adjusted to account for segregated no tag fish and are rounded to the nearest whole number.

Integrated Program Broodstock Age Structure

Scales are taken from summer/fall Chinook integrated program broodstock in order to capture the age of successfully spawned fish. In 2021, the integrated and segregated programs were comprised of mostly four and five-year old male and female fish (Figure A 1).



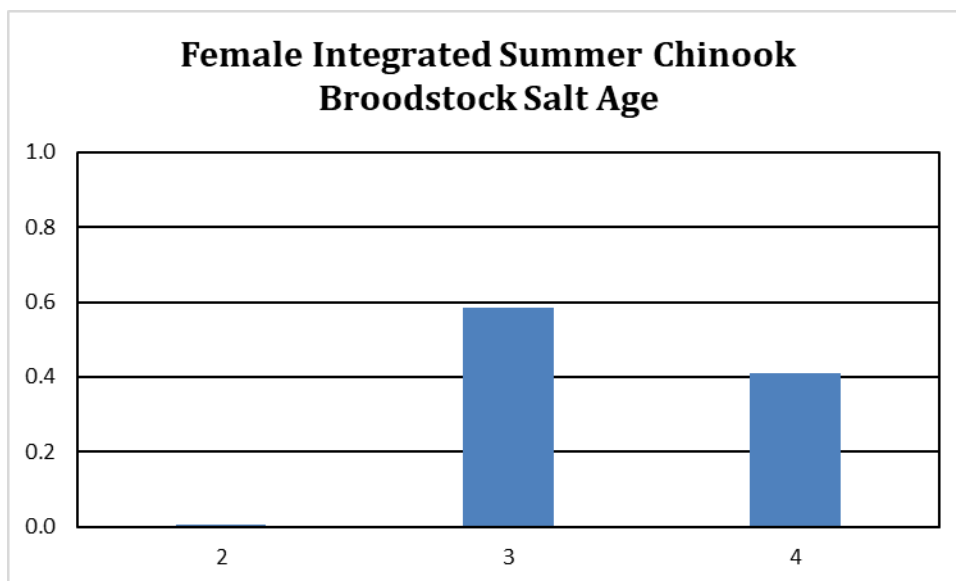
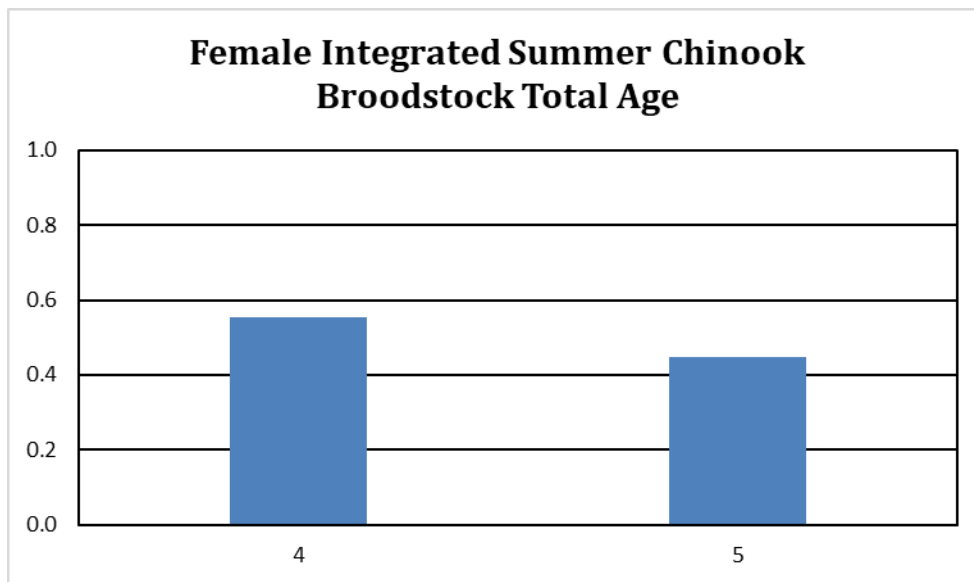
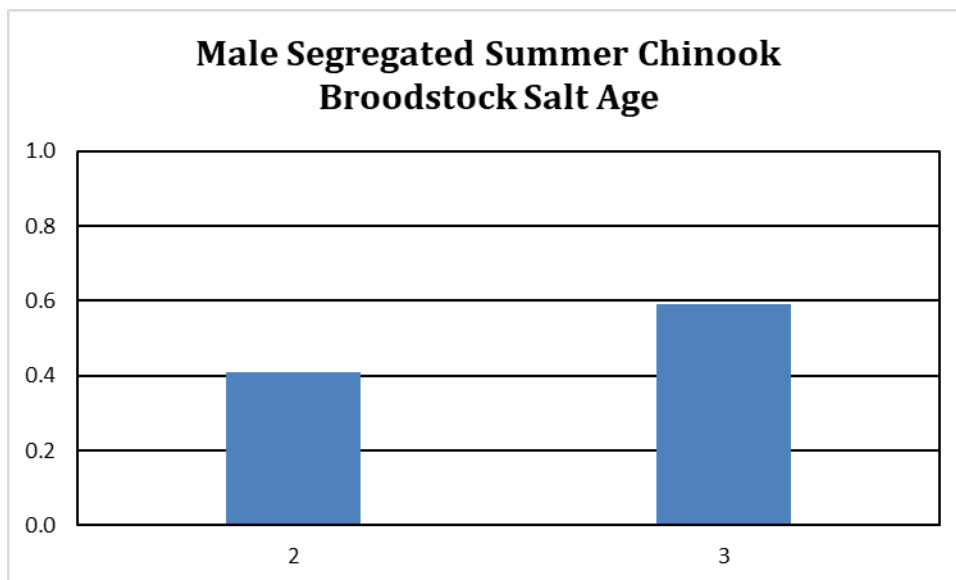
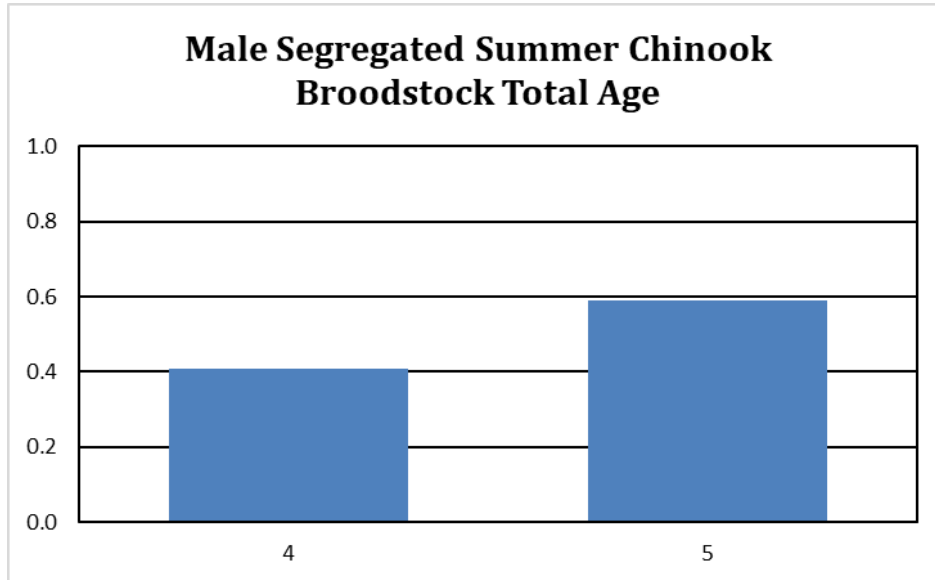


Figure A 1. The total and salt ages of the 2021 broodstock, males and females, collected for the Okanogan summer/fall Chinook integrated program.

Segregated Program Broodstock Age Structure

Coded wire tags are extracted from summer/fall Chinook segregated program broodstock and later read in order to capture the age of successfully spawned fish (Figure A 2).



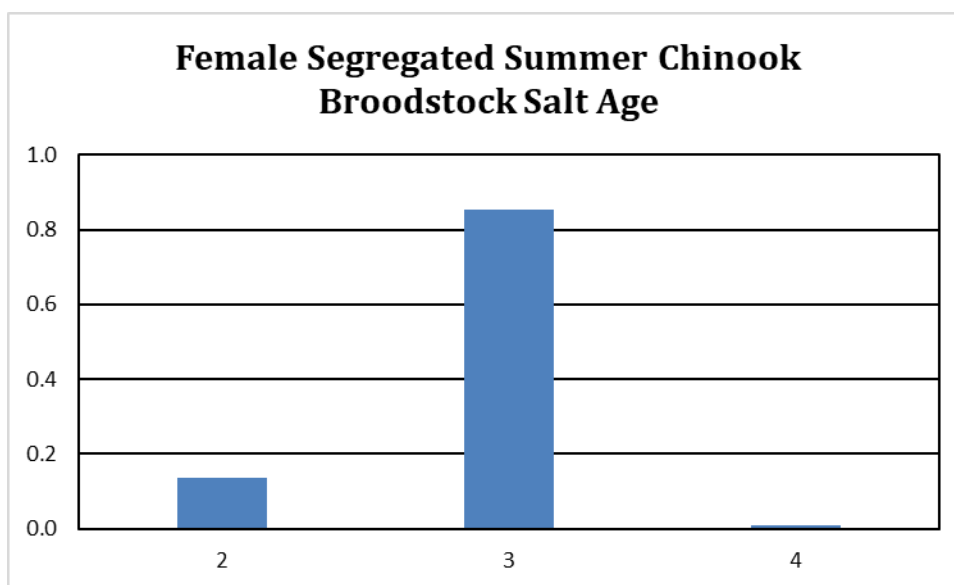
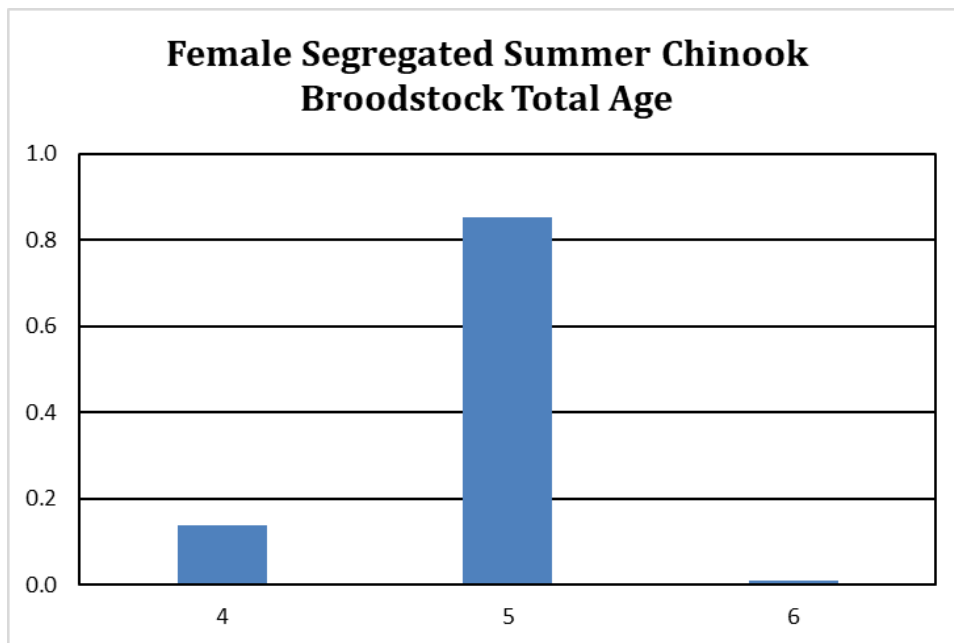


Figure A 2 The total and salt ages of the 2021 broodstock, males and females, collected for the Chief Joseph Hatchery segregated program.

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; A total of 8,827 eggs from 2 females were culled from the segregated program and 3,878 eggs from one female were culled from the integrated program. 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 back into their individual trays for hatching. Incubation water temperatures were initially manipulated to the level necessary to synchronize the hatching and ponding of the spawn takes throughout October and November 2021 and to achieve the size-at-release target for both yearling and sub-yearling summer/fall Chinook programs.

Rearing

The first group of brood year 2021 segregated sub-yearlings were brought out of incubation and transferred into early rearing troughs in mid- February 2022 (Table A 6). During this time, the group was introduced to feed in the early rearing troughs and reared for a period of two weeks. After the initial rearing period inside, they were transferred outside to the standard raceways via the fry transfer line. No inventories were taken during transfers, to prevent excess handling stress.

The first group of integrated yearlings were brought out of incubation and transferred into early rearing troughs in early April 2022 while the first group of segregated yearlings was brought out in mid-April 2022 (Table A 7). During this time, the group was introduced to feed in the early rearing troughs and reared for a period of two weeks. After the initial rearing period inside, they were transferred outside to the standard raceways via the fry transfer line. No inventories were taken during transfers, to prevent excess handling stress.

Table A 7. Chief Joseph Hatchery brood year 2020 summer/fall Chinook sub-yearling rearing summary.

	Month	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
HOR	2/28/2022	135,338	1,404	38	680	98.97%
	3/31/2022	134,915	423	310	204	98.66%
	4/30/2022	134,733	182	883	104	98.53%
	5/31/2022	134,709	11	560	58	98.52%
	Total	134,709	2,020	1,791	58	98.52%

Table A 7. Chief Joseph Hatchery brood year 2020 summer/fall Chinook yearling rearing summary.

	Month	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
HOR	4/30/2022	512,948	11,938	379	1,029	97.73%
	5/31/2022	505,573	5,530	781	238	96.67%
	Subtotal:	505,573	17,468	1,160	238	96.67%
NOR	4/30/2022	578,013	14,850	678	586	97.50%
	5/31/2022	575,955	2,058	1,455	169	97.15%
	Subtotal:	575,955	16,908	2,133	169	97.15%
	Cumulative:	505,573	34,376	3,293	NA	93.45%

Chief Joseph Hatchery Ladder

The CJH ladder is operated with the primary purpose of adult management (reducing pHOS) but can also be utilized to collect brood for the segregated program in years of low abundance or if the purse seine is not effective due to environmental conditions. The CJH fish ladder began operation on May 17, 2021, for spring chinook broodstock collection, with the first summer/fall chinook adult management activities occurring on August 5th. All hatchery Chinook and Sockeye were removed from the ladder and utilized for Tribal subsistence and ceremonial food purposes. All steelhead and NOR Chinook were returned to the river via a water-to-water transfer.

From August 5th thru September 15th, 1,559 hatchery-origin summer/fall Chinook were removed at the CJH ladder and were utilized for tribal subsistence purposes (Table A 8). A total of 197 natural-origin summer/fall Chinook (184 adults, 13 jacks), no NOR steelhead or HOR steelhead were trapped during summer/fall Chinook ladder operations (Tables A 9 and A 10).

Table A 8 Chief Joseph Hatchery adult summer/fall Chinook ladder operations from June to September 2021.

Month	# of Ladder Trap Checks	HOR Adults Surplussed	HOR Jacks Surplussed	NOR Adults RTS	NOR Jacks RTS	HOR Adults RTS	HOR Jacks RTS
June	1	0	0	1	0	11	0
July	0	0	0	0	0	0	0
Aug	4	1,451	145	164	13	208	101
Sept	1	108	0	19	0	0	0
Total	6	1559	145	184	13	219	101

RTS= Return to stream

Table A 9 Chief Joseph Hatchery adult spring Chinook, Sockeye, and steelhead ladder operations from May to September 2021.

Month	# of Ladder Trap Checks	HOR Spring Chinook Surplussed	HOR Spring Chinook Jacks Surplussed	NOR Spring Chinook RTS	NOR Spring Chinook Jacks RTS	Sockeye Surplussed	AD Present Steelhead RTS	AD Absent Steelhead RTS
May	4	0	0	11	0	0	46	55
June	5	0	0	47	1	0	8	0
July	0	0	0	0	0	0	0	0
Aug	2	2	0	8	0	0	0	0
Sept.	1	0	0	0	0	0	0	0
Total	12	2	0	66	1	0	54	55

RTS= Return to stream

Table A 10 Chief Joseph Hatchery annual summer/fall Chinook, Sockeye, and steelhead collected during summer/fall Chinook ladder operations.

Date	HOR Chinook surplussed	HOR jacks ⁽¹⁾ surplussed	NOR Chinook RTS	NOR jack RTS	HOR Chinook Brood	Sockeye	AD Present Steelhead RTS	AD Absent Steelhead RTS	Coho RTS
Aug.- Nov. 2013	1,263	523	247	69	9	10	38	0	0
July- Nov. 2014	2,835	1,778	861	245	87	31	69	122	181 ⁶
July- Oct. 2015	6,773	1,651	1,671	369	2,174	180	1,192	401	2
June- Oct. 2016	5,359	995	465	91	1,965	5	113	45	0
June- Oct. 2017	3,818	492	401	62	0	33	0	10	0
June- Aug. 2018	2,226	309	157	22	147	3	4	10	0
June- Aug. 2019	1,404	41	14	1	0	0	19	65	0
June- Aug. 2020	1,053	88	59	3	0	0	3	3	0
June- Sept. 2021	1,559	145	184	13	0	0	0	0	0
Total	26,290	6,022	4,059	875	4,382	262	1,438	656	2

⁽¹⁾ Includes mini jacks

⁽²⁾ 24% AD Present steelhead were HORs

⁽³⁾ 67% AD Present steelhead were HORs

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

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

⁽⁶⁾ Surplussed fish

RTS= Return to stream

The ladder was closed and dewatered mid-September for the season. The protocol was to sample 20% (one of five) of the adipose-clipped summer/fall Chinook for code-wire tags (CWT). Snouts with positive CWT detection were held frozen until December 2021 when CWT extraction and reading took place in the Chief Joseph Hatchery lab. Recovery data were expanded by the tag rate at the hatchery of origin and the sample rate at the ladder. Please refer to the Methods section for details on the expansion process for recovered tags. Beginning with jacks in 2016, snouts without a tag were assumed to be from the CJH segregated program.

Seven summer/fall Chinook hatchery programs were encountered at the CJH ladder in 2021, with the majority coming from the CJH segregated program (59%), Wells Hatchery (18%) and Chelan Falls (9%) (Table A 11). Approximately half of the recoveries were from ad-clipped, non-coded wire tagged (CWT) fish and are presumed to be from the CJH segregated program since this is the only program above Priest Rapids that releases ad-clipped, non-CWT fish.

Table A 11 Summary of summer/fall Chinook coded-wire tags encountered and expansions for the CJH ladder in 2021.

Category	Hatchery Program	# Tags	Expanded Abundance	% of Ladder Surplus
Okanogan Integrated	Omak Yearlings	11	59.6	3.8%
	Omak Subyearlings	0	0	0%
	Similkameen	6	26.6	1.7%
CJH Segregated	Segregated yearlings	35	178.8	11.4%
	Segregated subyearlings	19	97.0	6.2%
	No CWT, presumed Segr	131	646.8	41.4%
Other UCR summer/fall Chinook hatchery	Wells	48	282.7	18.1%
	Chelan	28	146	9.3%
	DCPUD	14	74.5	4.8%
	WDFW	8	41.5	2.7%
	Entiat NFH	2	10.2	<1%
Total		302	1563.7	100%

Table A 12 Percent of CJH ladder surplus adult (age 4+) summer/fall Chinook each year estimated to be from various facilities based on CWT assessment. Similkameen includes some returns from Bonaparte Pond releases (2010 and 2011). Chelan includes returns from the Turtle Rock program (2010 and 2011). 2017 was the first year of adults (4-year-olds) to CJH. 2018 was the first return year with a full complement of brood years in the return (through age 5).

	# Surplus Fish	Facility/Program									
		CJH Seg. ^a	Omak	Similk ^b	Wells	Chelan ^c	Carlton	Entiat	Dryden ^d	Priest	Other
2013	1,061	0%	0%	10%	22%	33%	8%	0%	26%	1%	1%
2014	2,008	0%	0%	10%	28%	26%	8%	2%	11%	0%	0%
2015	6,802	1%	0%	13%	34%	29%	6%	4%	12%	0%	0%
2016	5,788	5%	2%	3%	50%	26%	2%	2%	8%	0%	0%
2017	4,310	21%	7%	1%	35%	28%	2%	1%	5%	0%	<1%
2018	2,249	58%	4%	3%	16%	13%	2%	1%	3%	0%	<1%
2019	1,404	53%	<1%	3%	30%	8%	<1%	1%	4%	0%	0%
2020	1,053	69%	0%	1%	21%	5%	2%	0%	1%	0%	0%
2021	1,559	59%	4%	2%	20%	9%	3%	<1%	3%	0%	0%
Avg.	2,915	30%	2%	5%	28%	20%	4%	1%	8%	0%	0%

^aIncludes recoveries with 'no coded wire tags' in 2013-present: 2013 (47), 2014 (152), 2015 (71), 2016(45), 2017(76), 2018 (177), 2019 (130), 2020 (132), 2021 (131) ; starting in 2017 recoveries with 'no coded wire tags' were classified as CJH segregated fish which was the first year of adults (4+) returned back to the CJH^bIncludes Bonaparte Pond releases, 2013

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

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

APPENDIX B

2022 Production Plan

Table B 1. Summer/Fall Chinook - Integrated Program

Chief Joseph Hatchery Production Plan

Brood Year:	2022	Planting Goal:	1,100,000
Species:	Summer Chinook	Pounds:	86,000
Stock:	Okanogan		
Origin:	Wild		
Program:	Integrated		

Egg Take Goal:	1,485,000	Adult Goal:	656
		<i>Assumed Fecundity</i>	5,000
Estimated Release Data:		<i>Average Fecundity (BY16-BY21)</i>	4,096

Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
05/15/23	06/01/23	300,000	50.0	9.1	6,000	2,722	Sub-Yearlings	Omak	Ad Clipped	100% CWT
04/15/24	04/30/24	400,000	10.0	45.4	40,000	18,144	Yearlings	Similkameen	Ad Clipped	100% CWT
04/15/24	04/30/24	400,000	10.0	45.4	40,000	18,144	Yearlings	Omak	Ad Clipped	100% CWT

Notes: Egg take goal includes 3% for culling.
 Adult Goal includes 10% pre-spawn mortality
 10% Green to Eyed egg mortality
 Rearing mortality 10.7% for all groups

Rearing Summary:

Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed Fry	Released	Location
EA SU Chinook Sub	Okanogan	June	392,850	353,565	335,887	319,092	300,000	Omak
EA SU Chinook YR	Okanogan	April	523,800	471,420	447,849	425,457	400,000	Similkameen
EA SU Chinook YR	Okanogan	April	523,800	471,420	447,849	425,457	400,000	Omak

Table B 2. Summer/Fall Chinook – Segregated Program (CJH Site Release)

Chief Joseph Hatchery Production Plan

Brood Year:	2022	Planting Goal:	900,000
Species:	Summer Chinook	Pounds:	58,000
Stock:	Okanogan		
Origin:	Hatchery		
Program:	Segregated		

Egg Take Goal:	1,240,000	Adult Goal:	552
		<i>Assumed Fecundity</i>	5,000
Estimated Release Data:		<i>Average Fecundity (BY16-BY21)</i>	3,944

Start Date:	End Date:	Num Released	fish per lb.	Wt. grams	Total weight (lb.)	Total weight (kg)	Life Stage	Release Site	Mark Type	Tagged
05/15/23	06/01/23	400,000	50.0	9.1	8,000	3,629	Sub-Yearlings	CJ Hatchery	Ad Clipped	100k CWT
04/15/24	04/30/24	500,000	10.0	45.4	50,000	22,680	Yearlings	CJ Hatchery	Ad Clipped	100k CWT

Notes:

Egg take goal includes 5% for culling.

Adult Goal includes 10% pre-spawn mortality

10% Green to Eyed egg mortality

Rearing mortality is 9.7% for yearlings, 11.7% for sub-yearlings.

Rearing Summary:

Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Poned	Fed Fry	Released	Location
EA SU Chinook Sub	Okanogan	June	530,100	477,090	453,236	430,574	400,000	CJ Hatchery
EA SU Chinook YR	Okanogan	April	647,900	583,110	553,955	526,257	500,000	CJ Hatchery

APPENDIX C

pHOS and Effective pHOS

Table C 1. Annual Chinook spawning grounds data for the Okanogan Basin from 2006 to 2021, including pHOS and effective pHOS values per reach.

2021												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	39	2.31	90	4.4%	4	1	3	34.8%	65.2%	31	59	0.35
O2*	167	2.31	386	3.9%	15	6	9	34.8%	65.2%	134	252	0.35
O3	108	2.31	249	24.9%	62	47	15	75.8%	24.2%	189	60	0.76
O4	52	2.31	120	35.8%	43	29	14	67.4%	32.6%	81	39	0.67
O5	542	2.31	1252	17.5%	219	90	129	41.1%	58.9%	515	737	0.41
O6	1159	2.31	2677	20.4%	546	48	498	8.8%	91.2%	235	2442	0.09
S1	945	2.31	2183	17.3%	378	216	162	57.1%	42.9%	1247	936	0.57
S2	38	2.31	88	6.8%	6	6	0	100.0%	0.0%	88	0	1.00
Totals	3050		7046	18.1%	1273	443	830			2521	4525	0.36
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS	0.36
											effective pHOS	0.31

2020												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	% hatchery	% wild	HOS	NOS	pHOS
O1	25	2.67	67	10.5%	7	5	2	71.4%	28.6%	48	19	0.71
O2	51	2.67	136	18.4%	25	17	8	68.0%	32.0%	93	44	0.68
O3	270	2.67	721	19.7%	142	84	58	59.2%	40.8%	426	294	0.59
O4	103	2.67	275	15.6%	43	24	19	55.8%	44.2%	153	122	0.56
O5	683	2.67	1824	21.6%	393	110	283	28.0%	72.0%	510	1313	0.28
O6	1254	2.67	3348	25.2%	843	117	726	13.9%	86.1%	465	2883	0.14
S1	1445	2.67	3858	25.7%	993	295	698	29.7%	70.3%	1146	2712	0.30
S2	296	2.67	790	20.0%	158	44	114	27.8%	72.2%	220	570	0.28
Totals	4127		11019	23.6%	2604	696	1908			3062	7957	0.28
											pHOS	0.28
											effective pHOS	0.24

2019												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	12	2.3	28	0.0%	0	0	0	51.6%	48.4%	14	13	0.52
O2*	154	2.3	354	0.3%	1	1	0	51.6%	48.4%	183	171	0.52
O3	275	2.3	633	11.4%	72	52	20	72.2%	27.8%	457	176	0.72
O4*	92	2.3	212	4.3%	9	4	5	51.6%	48.4%	109	102	0.52
O5	600	2.3	1380	5.2%	72	34	38	47.2%	52.8%	652	728	0.47
O6	505	2.3	1162	15.6%	181	76	105	42.0%	58.0%	488	674	0.42
S1	694	2.3	1596	7.9%	126	70	56	55.6%	44.4%	887	709	0.56
S2	39	2.3	90	6.7%	6	4	2	66.7%	33.3%	60	30	0.67
Totals	2371		5453	8.6%	467	241	226			2849	2604	0.52
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS	0.52
											effective pHOS	0.47

2018												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	11	2.301	25	0.0%	0	0	0	31.6%	68.4%	8	17	0.32
O2*	74	2.301	170	0.0%	0	0	0	31.6%	68.4%	54	116	0.32
O3	211	2.301	486	16.1%	78	40	38	51.3%	48.7%	249	237	0.51
O4*	133	2.301	306	2.6%	8	1	7	31.6%	68.4%	97	209	0.32
O5	618	2.301	1422	9.4%	134	49	85	36.6%	63.4%	520	902	0.37
O6	507	2.301	1167	16.3%	190	33	157	17.4%	82.6%	203	964	0.17
S1	501	2.301	1153	11.4%	131	48	83	36.6%	63.4%	422	730	0.37
S2*	57	2.301	131	4.6%	6	2	4	31.6%	68.4%	41	90	0.32
Totals	2112		4860	11.3%	547	173	374			1594	3266	0.33
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS effective pHOS	0.33
												0.28

2017												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	2	2.039	4	0.0%	0	0	0	17.0%	83.0%	1	3	0.17
O2	62	2.039	126	6.3%	8	4	4	50.0%	50.0%	63	63	0.50
O3*	192	2.039	391	2.3%	9	5	4	17.0%	83.0%	66	325	0.17
O4	111	2.039	226	7.1%	16	5	11	31.3%	68.8%	71	156	0.31
O5*	830	2.039	1692	3.5%	60	10	50	17.0%	83.0%	287	1405	0.17
O6	1237	2.039	2522	24.9%	628	66	562	10.5%	89.5%	265	2257	0.11
S1	710	2.039	1448	31.3%	453	106	347	23.4%	76.6%	339	1109	0.23
S2	77	2.039	157	17.2%	27	8	19	29.6%	70.4%	47	110	0.30
Totals	3221		6568	18.3%	1201	204	997			1139	5429	0.17
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS effective pHOS	0.17
												0.14

2016												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	2	2.01	4	0.0%	0	0	0	21.2%	78.8%	1	3	0.21
O2	57	2.01	115	10.5%	12	6	6	50.0%	50.0%	57	57	0.50
O3	52	2.01	105	13.4%	14	1	13	7.1%	92.9%	7	97	0.07
O4*	130	2.01	261	4.2%	11	4	7	21.2%	78.8%	55	206	0.21
O5	907	2.01	1823	12.6%	230	44	186	19.1%	80.9%	349	1474	0.19
O6	2338	2.01	4699	22.9%	1075	56	1019	5.2%	94.8%	245	4455	0.05
S1	1645	2.01	3306	36.7%	1214	395	819	32.5%	67.5%	1076	2231	0.33
S2	145	2.01	291	68.3%	199	78	121	39.2%	60.8%	114	177	0.39
Totals	5276		10605	26.0%	2755	584	2171			1905	8700	0.18
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS effective pHOS	0.18
												0.15

2015												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	36	3.215	116	0.0%	0	0	0	22.4%	77.6%	26	90	0.22
O2*	113	3.215	363	2.8%	10	5	5	22.4%	77.6%	81	282	0.22
O3	284	3.215	913	6.7%	61	22	39	36.1%	63.9%	329	584	0.36
O4*	79	3.215	254	4.3%	11	2	9	18.2%	77.6%	46	197	0.19
O5	1008	3.215	3241	8.7%	283	74	209	26.1%	73.9%	847	2393	0.26
O6	859	3.215	2762	36.0%	994	63	931	6.3%	93.7%	175	2587	0.06
S1	1611	3.215	5179	32.9%	1702	516	1186	30.3%	69.7%	1570	3609	0.30
S2	286	3.215	919	25.2%	232	56	176	24.1%	75.9%	222	698	0.24
Totals	4276		13747	24.0%	3293	738	2555			3297	10439	0.24
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS effective pHOS	0.24
												0.20

2014												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	11	2.86	31	3.2%	1	1	0	13.4%	86.6%	4	27	0.13
O2*	57	2.86	163	0.6%	1	0	1	13.4%	86.6%	22	141	0.13
O3	191	2.86	546	14.5%	79	19	60	24.1%	75.9%	131	415	0.24
O4	111	2.86	317	17.0%	54	7	47	13.0%	87.0%	41	276	0.13
O5	851	2.86	2434	11.3%	275	42	233	15.3%	84.7%	372	2062	0.15
O6	1010	2.86	2889	27.1%	783	67	716	8.6%	91.4%	247	2641	0.09
S1	1737	2.86	4968	15.5%	770	129	641	16.8%	83.2%	832	4136	0.17
S2	285	2.86	815	60.0%	489	64	425	13.1%	86.9%	107	708	0.13
Totals	4253		12164	20.2%	2452	329	2123			1756	10407	0.14
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS effective pHOS	0.14
												0.12

2013												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1	3	2.31	7	0.0%	0	0	0	32.6%	67.4%	2	5	0.33
O2*	2	2.31	5	0.0%	0	0	0	32.6%	67.4%	2	3	0.33
O3	158	2.31	365	8.2%	30	8	22	26.7%	73.3%	97	268	0.27
O4	46	2.31	106	8.5%	9	2	7	22.2%	77.8%	24	83	0.22
O5	397	2.31	917	5.7%	52	15	37	28.8%	71.2%	265	653	0.29
O6	1661	2.31	3837	11.3%	432	80	352	18.5%	81.5%	711	3126	0.19
S1	1254	2.31	2897	13.1%	379	188	191	49.6%	50.4%	1437	1460	0.50
S2	26	2.31	60	13.3%	8	4	4	50.0%	50.0%	30	30	0.50
Totals	3547		8194	11.1%	910	297	613			2567	5627	0.31
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS effective pHOS	0.31
												0.27

2012												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	12	3.07	37	2.7%	1	1	0	42.3%	57.7%	16	21	0.42
O2*	54	3.07	166	0.0%	0	0	0	42.3%	57.7%	70	96	0.42
O3	159	3.07	488	11.5%	56	38	18	67.9%	32.1%	331	157	0.68
O4	68	3.07	209	7.2%	15	6	9	40.0%	60.0%	84	125	0.40
O5	555	3.07	1704	15.0%	256	123	133	48.0%	52.0%	819	885	0.48
O6	765	3.07	2349	22.9%	537	110	427	20.5%	79.5%	481	1867	0.20
S1	914	3.07	2806	17.6%	494	288	206	58.3%	41.7%	1636	1170	0.58
S2	152	3.07	467	11.6%	54	31	23	57.4%	42.6%	268	199	0.57
Totals	2679		8225	17.2%	1413	597	816			3704	4521	0.45
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS	0.45
											effective pHOS	0.40

2011												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1*	3	3.1	9	0.0%	0	0	0	53.6%	46.4%	5	4	0.54
O2*	20	3.1	62	0.0%	0	0	0	53.6%	46.4%	33	29	0.54
O3	101	3.1	313	17.6%	55	34	21	61.8%	38.2%	194	120	0.62
O4	55	3.1	171	8.2%	14	10	4	71.4%	28.6%	122	49	0.71
O5	593	3.1	1838	19.6%	361	160	201	44.3%	55.7%	815	1024	0.44
O6	942	3.1	2920	16.4%	478	116	362	24.3%	75.7%	709	2212	0.24
S1	1217	3.1	3773	20.0%	753	537	216	71.3%	28.7%	2690	1082	0.71
S2	192	3.1	595	19.2%	114	95	19	83.3%	16.7%	496	99	0.83
Totals	3123		9681	18.3%	1775	952	823			5063	4618	0.52
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS	0.52
											effective pHOS	0.47

2010												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1	9	2.81	25	11.9%	3	2	1	66.7%	33.3%	17	8	0.67
O2	58	2.81	163	6.1%	10	5	5	50.0%	50.0%	81	81	0.50
O3	67	2.81	188	15.9%	30	11	19	36.7%	63.3%	69	119	0.37
O4	89	2.81	250	16.8%	42	24	18	57.1%	42.9%	143	107	0.57
O5	357	2.81	1003	24.0%	241	87	154	36.1%	63.9%	362	641	0.36
O6	431	2.81	1211	29.1%	352	172	180	48.9%	51.1%	592	619	0.49
S1	895	2.81	2515	24.9%	625	296	329	47.4%	52.6%	1191	1324	0.47
S2	212	2.81	596	24.8%	148	79	69	53.4%	46.6%	318	278	0.53
Totals	2118		5952	24.4%	1451	676	775			2773	3178	0.47
											pHOS effective pHOS	0.47
												0.41

2009												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1	3	2.54	8	26.2%	2	0	2	0.0%	100.0%	0	8	0.00
O2	32	2.54	81	8.6%	7	4	3	57.1%	42.9%	46	35	0.57
O3	91	2.54	231	13.4%	31	18	13	58.1%	41.9%	134	97	0.58
O4	138	2.54	351	9.1%	32	18	14	56.3%	43.8%	197	153	0.56
O5	621	2.54	1577	22.1%	348	159	189	45.7%	54.3%	721	857	0.46
O6	787	2.54	1999	25.0%	500	153	347	30.6%	69.4%	612	1387	0.31
S1	1091	2.54	2771	25.4%	703	373	330	53.1%	46.9%	1470	1301	0.53
S2	207	2.54	526	28.5%	150	75	75	50.0%	50.0%	263	263	0.50
Totals	2970		7544	23.5%	1773	800	973			3443	4100	0.46
											pHOS effective pHOS	0.46
												0.40

2008												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1	4	3.25	13	30.8%	4	2	2	50.0%	50.0%	7	7	0.50
O2	51	3.25	166	6.0%	10	9	1	90.0%	10.0%	149	17	0.90
O3	60	3.25	195	20.5%	40	26	14	65.0%	35.0%	127	68	0.65
O4	96	3.25	312	11.5%	36	25	11	69.4%	30.6%	217	95	0.69
O5	374	3.25	1216	20.4%	248	141	107	56.9%	43.1%	691	524	0.57
O6	561	3.25	1823	36.5%	665	341	324	51.3%	48.7%	935	888	0.51
S1	801	3.25	2603	33.0%	859	512	347	59.6%	40.4%	1552	1052	0.60
S2	199	3.25	647	24.3%	157	116	41	73.9%	26.1%	478	169	0.74
Totals	2146		6975	28.9%	2019	1172	847			4155	2820	0.60
											pHOS effective pHOS	0.60
												0.54

2007												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1	3	2.2	7	30.3%	2	1	1	50.0%	50.0%	3	3	0.50
O2*	16	2.2	35	0.0%	0	0	0	38.1%	61.9%	13	22	0.38
O3	116	2.2	255	21.6%	55	25	30	45.5%	54.5%	116	139	0.45
O4*	63	2.2	139	0.7%	1	0	1	38.1%	61.9%	53	86	0.38
O5	549	2.2	1208	37.5%	453	169	284	37.3%	62.7%	451	757	0.37
O6	554	2.2	1219	42.6%	519	197	322	38.0%	62.0%	463	756	0.38
S1	652	2.2	1434	45.9%	658	253	405	38.4%	61.6%	552	883	0.38
S2	55	2.2	121	24.0%	29	9	20	31.0%	69.0%	38	83	0.31
Totals	2008		4418	38.9%	1717	654	1063			1688	2730	0.38
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
												pHOS effective pHOS
												0.38
												0.33

2006												
reach	redds	fish per redd	spawners per reach	% sampled	total carcasses	hatchery carcasses	wild carcasses	%hatchery	%wild	HOS	NOS	pHOS
O1	10	2.02	20	19.8%	4	2	2	50.0%	50.0%	10	10	0.50
O2*	56	2.02	113	2.7%	3	1	2	23.0%	77.0%	26	87	0.23
O3	175	2.02	354	8.8%	31	9	22	29.0%	71.0%	103	251	0.29
O4	145	2.02	293	5.5%	16	6	10	37.5%	62.5%	110	183	0.38
O5	840	2.02	1697	7.1%	120	15	105	12.5%	87.5%	212	1485	0.13
O6	1366	2.02	2759	10.5%	291	44	247	15.1%	84.9%	417	2342	0.15
S1	1388	2.02	2804	18.1%	508	138	370	27.2%	72.8%	762	2042	0.27
S2	278	2.02	562	18.9%	106	33	73	31.1%	68.9%	175	387	0.31
Totals	4258		8601	12.5%	1079	248	831			1814	6787	0.21
*Indicates '%hatchery' and '%wild' values were estimated from basin carcass totals (only performed when carcasses recovered represented <5% of spawners for that reach)												
											pHOS effective	0.21
											pHOS	0.18

Table C 2. Number of hatchery- and natural-origin (wild) summer/fall Chinook carcasses collected in each reach of the Okanogan (O1-O6) and Similkameen rivers from 1993 to 2021.

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	2,123
	Hatchery	1	0	19	7	42	67	129	64	329
2015	Wild	0	5	39	9	209	931	1186	176	2,555
	Hatchery	0	5	22	2	74	63	516	56	738
2016	Wild	0	6	13	7	186	1019	819	121	2,171
	Hatchery	0	6	1	4	44	56	395	78	584
2017	Wild	0	4	4	11	50	562	347	19	997
	Hatchery	0	4	5	5	10	66	106	8	204
2018	Wild	0	0	38	7	85	157	83	4	374
	Hatchery	0	0	40	1	49	33	48	2	173
2019	Wild	0	0	20	5	38	105	56	2	226
	Hatchery	0	1	52	4	34	76	70	4	241
2020	Wild	2	8	58	19	283	726	698	114	1,908
	Hatchery	5	17	84	24	110	117	295	44	696
2021	Wild	3	9	15	14	129	498	162	0	830
	Hatchery	1	6	47	29	90	48	216	6	443
Avg.	Wild	1	3	19	9	104	287	345	66	833
	Hatchery	1	4	22	8	61	84	303	50	532

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

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

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

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

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

Age at Maturity

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

Hatchery-Origin Male Salt Age Carcasses Recovered							
Survey Year	0	1	2	3	4	5	Total
1993	0	0	33	0	0	0	33
1994	0	5	23	92	0	0	120
1995	0	2	23	27	17	0	69
1996	0	3	17	24	5	0	49
1997	0	0	1	25	2	0	28
1998	0	9	64	12	9	0	94
1999	2	0	35	74	2	0	113
2000	7	65	6	104	8	0	190
2001	0	47	625	3	11	0	686
2002	0	10	267	419	0	1	697
2003	0	18	30	146	27	0	221
2004	0	2	100	67	18	0	187
2005	0	12	19	104	15	0	150
2006	0	7	15	11	27	0	60
2007	0	122	116	56	5	3	302
2008	0	18	460	137	3	0	618
2009	0	43	33	158	2	0	236
2010	4	20	293	29	7	0	353
2011	0	144	47	118	0	0	309
2012	1	31	168	63	7	0	270
2013	0	7	27	22	2	1	59
2014	0	55	58	39	0	0	152
2015	0	17	234	49	0	0	300
2016	0	6	15	74	4	0	99
2017	0	3	19	20	5	0	47
2018	0	0	32	7	1	0	40
2019	0	3	21	18	1	0	43
2020	0	0	5	8	0	0	13
2021	0	1	4	6	0	0	11
<i>Average</i>	<i>0</i>	<i>22</i>	<i>96</i>	<i>66</i>	<i>6</i>	<i>0</i>	<i>191</i>
<i>10-year average</i>	<i>0</i>	<i>12</i>	<i>58</i>	<i>31</i>	<i>2</i>	<i>0</i>	<i>103</i>

Hatchery-Origin Female Salt Age Carcasses Recovered							
Survey Year	0	1	2	3	4	5	Total
1993	0	0	10	1	0	0	11
1994	0	0	3	141	1	0	145
1995	0	0	9	44	82	0	135
1996	0	0	21	74	31	1	127
1997	0	0	2	107	16	0	125
1998	0	1	28	30	32	0	91
1999	1	0	31	393	13	2	440
2000	0	1	4	307	49	0	361
2001	0	1	256	19	42	0	318
2002	0	0	54	921	9	0	984
2003	0	1	9	368	54	0	432
2004	0	0	22	103	69	0	194
2005	0	0	11	303	64	2	380
2006	0	0	10	21	48	0	79
2007	0	0	53	178	22	4	257
2008	0	0	197	267	25	1	490
2009	0	0	9	516	22	0	547
2010	0	0	155	120	42	1	318
2011	0	1	22	602	6	0	631
2012	0	1	153	140	25	0	319
2013	1	0	34	188	7	0	230
2014	0	0	23	127	5	0	155
2015	0	1	138	102	5	0	246
2016	0	0	6	283	13	0	302
2017	0	1	19	38	37	0	95
2018	0	0	46	59	7	0	112
2019	0	0	3	10	0	0	13
2020	0	0	9	3	0	0	12
2021	0	1	6	11	0	0	18
<i>Average</i>	<i>0</i>	<i>0</i>	<i>46</i>	<i>189</i>	<i>25</i>	<i>0</i>	<i>261</i>
<i>10-year average</i>	<i>0</i>	<i>0</i>	<i>44</i>	<i>96</i>	<i>10</i>	<i>0</i>	<i>150</i>

Natural-Origin Male Salt Age Carcasses Recovered							
Survey Year	0	1	2	3	4	5	Total
1993	0	0	8	19	3	0	30
1994	0	3	13	22	10	0	48
1995	0	0	6	11	4	0	21
1996	0	1	7	4	1	0	13
1997	0	3	8	8	1	0	20
1998	0	3	32	27	5	0	67
1999	0	0	22	39	8	1	70
2000	0	6	24	27	12	0	69
2001	0	13	82	168	8	0	271
2002	0	15	85	232	52	1	385
2003	0	12	55	171	34	0	272
2004	0	19	226	166	303	3	717
2005	0	1	129	447	28	4	609
2006	0	1	14	189	116	0	320
2007	0	17	67	53	226	5	368
2008	0	8	258	263	13	2	544
2009	0	10	21	276	31	0	338
2010	0	3	90	123	50	0	266
2011	0	10	46	228	17	0	301
2012	1	14	160	112	58	0	345
2013	0	6	83	140	12	0	241
2014	0	43	135	633	76	0	887
2015	0	8	809	402	113	0	1332
2016	0	1	53	548	109	1	712
2017	0	0	15	176	159	3	353
2018	0	2	29	49	25	0	105
2019	0	0	40	42	6	0	88
2020	0	2	92	518	41	0	653
2021	0	0	32	230	33	0	295
<i>Average</i>	<i>0</i>	<i>7</i>	<i>91</i>	<i>184</i>	<i>54</i>	<i>1</i>	<i>336</i>
<i>10-year average</i>	<i>0</i>	<i>8</i>	<i>145</i>	<i>285</i>	<i>63</i>	<i>0</i>	<i>501</i>

Natural-Origin Female Salt Age Carcasses Recovered							
Survey Year	0	1	2	3	4	5	Total
1993	0	0	5	25	3	0	33
1994	0	0	2	36	29	0	67
1995	0	0	7	27	11	0	45
1996	0	0	3	18	2	0	23
1997	0	0	12	31	10	0	53
1998	0	0	21	51	12	0	84
1999	0	0	32	132	34	0	198
2000	0	0	9	106	32	0	147
2001	0	0	11	237	12	0	260
2002	0	0	18	199	90	0	307
2003	2	2	29	130	45	0	208
2004	0	0	37	233	539	2	811
2005	0	0	28	566	71	7	672
2006	0	0	2	250	256	2	510
2007	0	0	8	72	601	12	693
2008	0	0	12	269	19	3	303
2009	0	0	3	473	112	0	588
2010	0	0	20	195	226	1	442
2011	0	0	12	416	58	0	486
2012	0	0	15	195	196	0	406
2013	0	0	5	254	27	0	286
2014	0	3	24	809	189	0	1025
2015	0	0	66	342	426	1	835
2016	0	0	4	927	288	4	1223
2017	0	0	4	127	367	7	505
2018	0	0	10	102	63	0	175
2019	0	0	87	22	0	0	109
2020	0	0	4	720	102	0	826
2021	0	0	0	265	97	0	362
<i>Average</i>	<i>0</i>	<i>0</i>	<i>17</i>	<i>249</i>	<i>135</i>	<i>1</i>	<i>403</i>
<i>10-year average</i>	<i>0</i>	<i>0</i>	<i>22</i>	<i>376</i>	<i>176</i>	<i>1</i>	<i>575</i>

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

Hatchery-Origin Male							
Salt Age - Percent of carcasses recovered within origin/sex class							
Survey Year	0	1	2	3	4	5	Total
1993	0%	0%	100%	0%	0%	0%	1
1994	0%	4%	19%	77%	0%	0%	1
1995	0%	3%	33%	39%	25%	0%	1
1996	0%	6%	35%	49%	10%	0%	1
1997	0%	0%	4%	89%	7%	0%	1
1998	0%	10%	68%	13%	10%	0%	1
1999	2%	0%	31%	65%	2%	0%	1
2000	4%	34%	3%	55%	4%	0%	1
2001	0%	7%	91%	0%	2%	0%	1
2002	0%	1%	38%	60%	0%	0%	1
2003	0%	8%	14%	66%	12%	0%	1
2004	0%	1%	53%	36%	10%	0%	1
2005	0%	8%	13%	69%	10%	0%	1
2006	0%	12%	25%	18%	45%	0%	1
2007	0%	40%	38%	19%	2%	1%	1
2008	0%	3%	74%	22%	0%	0%	1
2009	0%	18%	14%	67%	1%	0%	1
2010	1%	6%	83%	8%	2%	0%	1
2011	0%	47%	15%	38%	0%	0%	1
2012	0%	11%	62%	23%	3%	0%	1
2013	0%	12%	46%	37%	3%	2%	1
2014	0%	36%	38%	26%	0%	0%	1
2015	0%	6%	78%	16%	0%	0%	1
2016	0%	6%	15%	75%	4%	0%	1
2017	0%	6%	40%	43%	7%	0%	1
2018	0%	0%	80%	18%	3%	0%	1
2019	0%	7%	49%	42%	2%	0%	1
2020	0%	0%	38%	62%	0%	0%	1
2021	0%	9%	36%	55%	0%	0%	1
<i>Average</i>	<i>0%</i>	<i>10%</i>	<i>43%</i>	<i>41%</i>	<i>6%</i>	<i>0%</i>	<i>100%</i>
<i>10-year average</i>	<i>0%</i>	<i>9%</i>	<i>48%</i>	<i>40%</i>	<i>2%</i>	<i>0%</i>	<i>100%</i>

Hatchery-Origin Female							
Salt Age - Percent of carcasses recovered within origin/sex class							
Survey Year	0	1	2	3	4	5	Total
1993	0%	0%	91%	9%	0%	0%	1
1994	0%	0%	2%	97%	1%	0%	1
1995	0%	0%	7%	33%	61%	0%	1
1996	0%	0%	17%	58%	24%	1%	1
1997	0%	0%	2%	86%	13%	0%	1
1998	0%	1%	31%	33%	35%	0%	1
1999	0%	0%	7%	89%	3%	0%	1
2000	0%	0%	1%	85%	14%	0%	1
2001	0%	0%	81%	6%	13%	0%	1
2002	0%	0%	5%	94%	1%	0%	1
2003	0%	0%	2%	85%	13%	0%	1
2004	0%	0%	11%	53%	36%	0%	1
2005	0%	0%	3%	80%	17%	1%	1
2006	0%	0%	13%	27%	61%	0%	1
2007	0%	0%	21%	69%	9%	2%	1
2008	0%	0%	40%	54%	5%	0%	1
2009	0%	0%	2%	94%	4%	0%	1
2010	0%	0%	49%	38%	13%	0%	1
2011	0%	0%	3%	95%	1%	0%	1
2012	0%	0%	48%	44%	8%	0%	1
2013	0%	0%	15%	82%	3%	0%	1
2014	0%	0%	15%	82%	3%	0%	1
2015	0%	0%	56%	41%	2%	0%	1
2016	0%	0%	2%	94%	4%	0%	1
2017	0%	1%	20%	40%	39%	0%	1
2018	0%	0%	41%	53%	6%	0%	1
2019	0%	0%	23%	77%	0%	0%	1
2020	0%	0%	75%	25%	0%	0%	1
2021	0%	6%	33%	61%	0%	0%	1
<i>Average</i>	0%	0%	25%	62%	13%	0%	100%
<i>10-year average</i>	0%	1%	33%	60%	7%	0%	100%

Natural-Origin Male							
Salt Age - Percent of carcasses recovered within origin/sex class							
Survey Year	0	1	2	3	4	5	Total
1993	0%	0%	27%	63%	10%	0%	1
1994	0%	6%	27%	46%	21%	0%	1
1995	0%	0%	29%	52%	19%	0%	1
1996	0%	8%	54%	31%	8%	0%	1
1997	0%	15%	40%	40%	5%	0%	1
1998	0%	4%	48%	40%	7%	0%	1
1999	0%	0%	31%	56%	11%	1%	1
2000	0%	9%	35%	39%	17%	0%	1
2001	0%	5%	30%	62%	3%	0%	1
2002	0%	4%	22%	60%	14%	0%	1
2003	0%	4%	20%	63%	13%	0%	1
2004	0%	3%	32%	23%	42%	0%	1
2005	0%	0%	21%	73%	5%	1%	1
2006	0%	0%	4%	59%	36%	0%	1
2007	0%	5%	18%	14%	61%	1%	1
2008	0%	1%	47%	48%	2%	0%	1
2009	0%	3%	6%	82%	9%	0%	1
2010	0%	1%	34%	46%	19%	0%	1
2011	0%	3%	15%	76%	6%	0%	1
2012	0%	4%	46%	32%	17%	0%	1
2013	0%	2%	34%	58%	5%	0%	1
2014	0%	5%	15%	71%	9%	0%	1
2015	0%	1%	61%	30%	8%	0%	1
2016	0%	7%	77%	15%	0%	0%	1
2017	0%	0%	4%	50%	45%	1%	1
2018	0%	2%	28%	47%	24%	0%	1
2019	0%	0%	45%	48%	7%	0%	1
2020	0%	0%	14%	79%	6%	0%	1
2021	0%	0%	11%	78%	11%	0%	1
<i>Average</i>	0%	3%	30%	51%	15%	0%	100%
<i>10-year average</i>	0%	2%	34%	51%	13%	0%	100%

Natural-Origin Female Salt Age - Percent of carcasses recovered within origin/sex class							
Sample Year	0	1	2	3	4	5	Total
1993	0%	0%	15%	76%	9%	0%	1
1994	0%	0%	3%	54%	43%	0%	1
1995	0%	0%	16%	60%	24%	0%	1
1996	0%	0%	13%	78%	9%	0%	1
1997	0%	0%	23%	58%	19%	0%	1
1998	0%	0%	25%	61%	14%	0%	1
1999	0%	0%	16%	67%	17%	0%	1
2000	0%	0%	6%	72%	22%	0%	1
2001	0%	0%	4%	91%	5%	0%	1
2002	0%	0%	6%	65%	29%	0%	1
2003	1%	1%	14%	63%	22%	0%	1
2004	0%	0%	5%	29%	66%	0%	1
2005	0%	0%	4%	84%	11%	1%	1
2006	0%	0%	0%	49%	50%	0%	1
2007	0%	0%	1%	10%	87%	2%	1
2008	0%	0%	4%	89%	6%	1%	1
2009	0%	0%	1%	80%	19%	0%	1
2010	0%	0%	5%	44%	51%	0%	1
2011	0%	0%	2%	86%	12%	0%	1
2012	0%	0%	4%	48%	48%	0%	1
2013	0%	0%	2%	89%	9%	0%	1
2014	0%	0%	2%	79%	18%	0%	1
2015	0%	0%	8%	41%	51%	0%	1
2016	0%	0%	0%	76%	24%	0%	1
2017	0%	0%	1%	25%	73%	1%	1
2018	0%	0%	6%	58%	36%	0%	1
2019	0%	0%	80%	20%	0%	0%	1
2020	0%	0%	0%	87%	12%	0%	1
2021	0%	0%	0%	73%	27%	0%	1
Average	0%	0%	9%	63%	28%	0%	100%
10-year average	0%	0%	10%	60%	30%	0%	100%

Contribution to Fisheries

Table C 5. Estimated number and percent of hatchery-origin Okanogan/Similkameen summer/fall Chinook captured in different fisheries, brood years 1989-2015.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1989	2,360 (80)	553 (19)	0 (0)	53 (2)	2,966
1990	355 (89)	34 (8)	0 (0)	12 (3)	401
1991	220 (86)	37 (14)	0 (0)	0 (0)	257
1992	422 (91)	28 (6)	2 (0)	10 (2)	462
1993	24 (80)	6 (20)	0 (0)	0 (0)	30
1994	372 (92)	23 (6)	2 (0)	7 (2)	404
1995	643 (93)	9 (1)	12 (2)	25 (4)	689
1996	6 (100)	0 (0)	0 (0)	0 (0)	6
1997	6,483 (92)	136 (2)	36 (0)	424 (6)	7,079
1998	4,414 (89)	251 (5)	45 (1)	223 (5)	4,933
1999	1,359 (68)	224 (11)	31 (2)	384 (19)	1,998
2000	3,139 (69)	533 (12)	222 (5)	675 (15)	4,559
2001	184 (58)	81 (25)	31 (10)	23 (7)	319
2002	706 (56)	200 (16)	90 (7)	258 (21)	1,254
2003	711 (38)	568 (30)	130 (7)	466 (25)	1,875
2004	3,153 (39)	2,162 (26)	694 (8)	2,168 (27)	8,177
2005	470 (46)	306 (30)	79 (8)	167 (16)	1,022
2006	3,136 (37)	3,352 (40)	469 (6)	1,419 (17)	8,376
2007	1,549 (44)	992 (28)	67 (2)	905 (26)	3,513
2008	4,226 (38)	2,576 (39)	218 (2)	3,969 (36)	10,989
2009	2,005 (36)	2,155 (39)	207 (5)	1,138 (21)	5,505
2010	3,193 (38)	3,933 (46)	247 (4)	1,110 (13)	8,483
2011	5,801 (40)	5,812 (40)	456 (3)	2,598 (18)	14,667
2012	771 (35)	827 (37)	13 (1)	619 (28)	2,230
2013	1,627 (656)	1,952 (368)	15 (16)	1,357 (148)	4,951
2014	742 (325)	980 (123)	2(4)	1,019 (119)	2,743
2015	631 (219)	609 (90)	4 (1)	591 (75)	1,835
<i>Average</i>	<i>1,804 (101)</i>	<i>1,050 (40)</i>	<i>114 (3)</i>	<i>727 (24)</i>	<i>3,693</i>
<i>Median</i>	<i>771 (69)</i>	<i>533 (25)</i>	<i>31 (2)</i>	<i>424 (16)</i>	<i>2,230</i>

APPENDIX D

Glossary of Terms, Acronyms, and Abbreviations

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SAR = smolt to adult return.

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

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

Spatial Distribution = Geographic spawning distribution of adult salmon.

Spawner Abundance = Total number of adult spawners each year.

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

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

AHA = All H Analyzer

APPT = Annual Program Planning Tool

APR = Annual Program Review

BiOp = Biological Opinion

BKD = Bacterial Kidney Disease

BPA = Bonneville Power Administration

CA = Coordinated Assessments

CBFWA = Columbia Basin Fish and Wildlife Authority

CCT = Confederated Tribes of the Colville Indian Reservation

cfs = Cubic feet per second

CJH = Chief Joseph Hatchery

CJHP = Chief Joseph Hatchery Program

Colville Tribes = Confederated Tribes of the Colville Reservation

CTFWP = Colville Tribes Fish & Wildlife Program

CRITFC = Columbia River Inter-Tribal Fish Commission

CWT = Coded Wire Tag

DI = Density Index

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

APPENDIX E

Technical Memorandum: Minijack Rates for 2020 Chief Joseph Hatchery Integrated and Segregated Chinook Releases



Date: August 2, 2021

From: Andrea Pearl; andrea.pearl@colvilletribes.com (509) 634-1364

To: Matthew McDaniel, Casey Baldwin, Anthony Cleveland, Jim Andrews

CC: Kirk Truscott

Subject: Minijack rates for 2021 Chief Joseph Hatchery Chinook release groups

Background

This technical memorandum will summarize the results of gonadal-somatic index (GSI) sampling conducted by the Chief Joseph Hatchery Program (CJHP) in May 2021, and provide estimates for the rate of early maturation (“minijack rate”) from each yearling group released in 2021 (brood year 2019).

Early maturation of male hatchery-origin Chinook salmon is a concern throughout the Columbia River basin, with some hatchery releases exhibiting minijack rates of over 70% (Harstad et al. 2014). The production of high levels of minijacks is not consistent with the goals and objectives of the CJHP, which intends to produce adult fish for harvest and conservation. Additionally, the National Marine Fisheries Service (NMFS) requested that the Confederated Tribes of the Colville Indian Reservation (CCT) include an evaluation of early maturation on all yearling Chinook programs because early maturation is considered a ‘take surrogate’ for potential competitive interactions with natural-origin fish (NMFS 2017). The reporting requirements of NMFS were based on the methodology described in Harstad et al. (2014) that used a blood plasma test to evaluate the level of 11-ketotestosterone to estimate initiation of male maturation as mini-jacks. Absent funding to implement the 11-KT method, the CJHP elected to use a visual and GSI approach to evaluate early maturation. The GSI approach has been implemented by the USFWS for the Leavenworth complex for a number of years with good success (Matt Cooper,

personal communication). The CJHP staff believe the GSI evaluation presented herein meets the intent of the reporting requirement (#6) described in the NMFS determination letter.

Methods

Prior to release, approximately 300 fish were collected from each yearling 2021 Chief Joseph Hatchery (CJH) release group for dissection and examination. Similar to 2020, these fish were held at CJH after their cohorts had been released for approximately one month. This was to allow for additional maturation and facilitate distinction between mature and immature fish. The release groups are:

- Segregated spring Chinook; released from Chief Joseph Hatchery, hatchery-origin broodstock collected at the Chief Joseph Hatchery Ladder
- Segregated summer Chinook; released from Chief Joseph Hatchery, hatchery-origin broodstock collected from the Columbia River near the mouth of the Okanogan River
- Integrated spring Chinook; released from the Riverside Acclimation Pond, natural-origin MetComp broodstock from Winthrop National Fish Hatchery
- Integrated summer Chinook; released from the Omak Acclimation Pond, natural- and hatchery-origin broodstock primarily of Okanogan-origin stock
- Integrated summer Chinook; released from the Similkameen Acclimation Pond, natural- and hatchery-origin broodstock primarily of Okanogan-origin stock

Fish were euthanized with MS-222, and processed in accordance with the USFWS GSI sampling protocol (Pfannenstein 2016, see Appendix A). Males were classified as either mature or immature based on a visual inspection of the gonads, and the gonadal-somatic index (GSI) was also calculated for statistical estimation of minijack rates for each release group.

After data was collected, GSI values were analyzed using a mixture model (Medeiros, see Appendix B) in an attempt to identify immature and mature sub-populations and estimate the minijack rate within each sampled release group.

Results

Based on the visual assessment of maturity, CJH yearlings overall displayed moderate rates of early maturity (0.00%-3.08%, Table 1). The mixture model was fit to all release groups and encompassed a smaller range of expected rates of early maturation (0.00% - 15.12%, Table 1). There was no distinct separation in Log10 GSI between immature and mature fish in any of the release groups. Nevertheless, a cutoff value for classifying sampled fish as mature or immature, and therefore a minijack rate, could be modeled for all groups (Figures 1-5). Histograms that display the distribution of Log10 GSI for each sampled release group are presented in Figures 1-5. Annual rates of early maturation are recorded in Table 2.

Table 1. Mini-jack rate for each Chief Joseph Hatchery release group from brood year 2019.

Release Group	Release Location	Males Examined	Visually classified immature	Visually classified mature	Visual mini-jack Rate	Modeled mini-jack rate
Segregated Spring Yearlings	Chief Joseph Hatchery	130	126	4	3.08%	4.62%
Segregated Summer Yearlings	Chief Joseph Hatchery	153	152	1	0.65%	3.92%
Integrated Spring Yearlings	Riverside Acclimation Pond	145	143	2	1.38%	8.39%
Integrated Summer Yearlings	Omak Acclimation Pond	172	171	1	0.58%	15.12%
Integrated Summer Yearlings	Similkameen Acclimation Pond	151	151	0	0.00%	0.00%

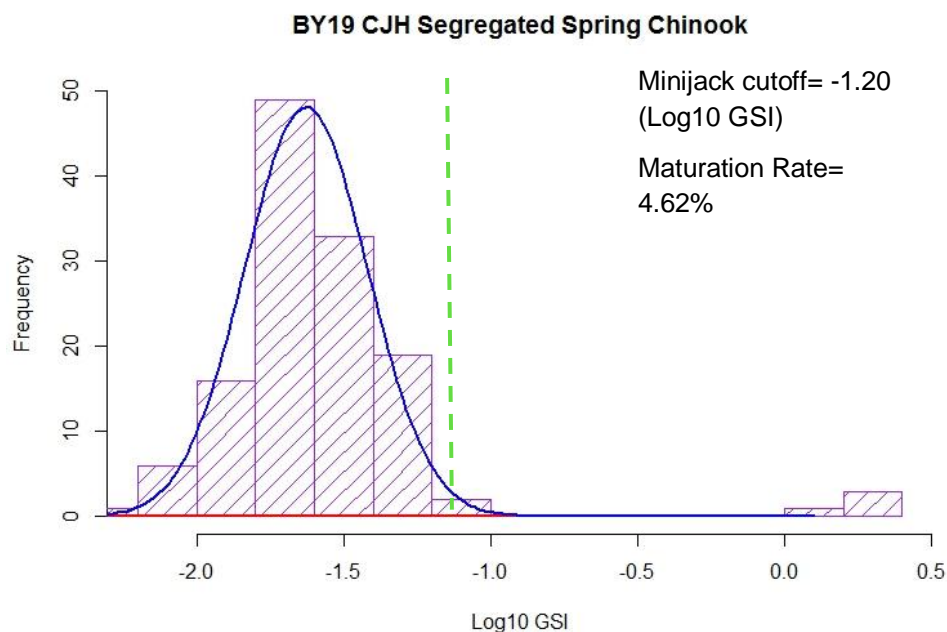


Figure 1. Distribution of Log10 GSI for the segregated spring Chinook released from the Chief Joseph Hatchery. The cutoff value is marked by the vertical green dashed line. It marks the point of differentiation between immature fish (appearing to the left of the cutoff line) and mature fish (appearing to the right of the line). The solid blue line shows the distribution function of immature fish, and the solid red line shows the distribution function of mature fish.

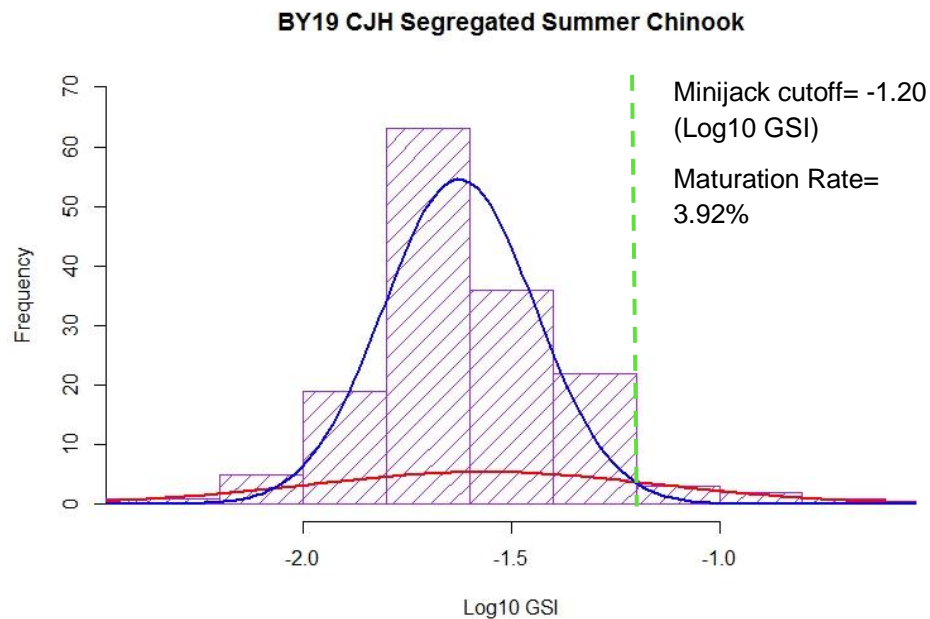


Figure 2. Distribution of Log10 GSI for the segregated summer Chinook released from the Chief Joseph Hatchery. The cutoff value is marked by the vertical green dashed line. It marks the point of differentiation between immature fish (appearing to the left of the cutoff line) and mature fish (appearing to the right of the line). The solid blue line shows the distribution function of immature fish, and the solid red line shows the distribution function of mature fish.

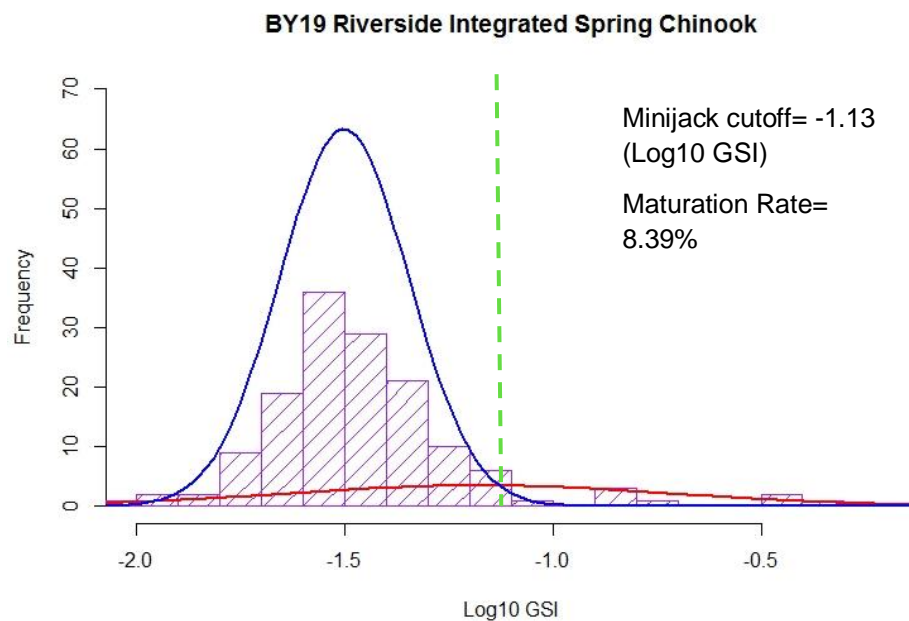


Figure 3. Distribution of Log10 GSI for the integrated spring Chinook released from the Riverside Acclimation Pond. The cutoff value is marked by the vertical green dashed line. It marks the point of differentiation between immature fish (appearing to the left of the cutoff line) and mature fish (appearing to the right of the line). The solid blue line shows the distribution function of immature fish, and the solid red line shows the distribution function of mature fish.

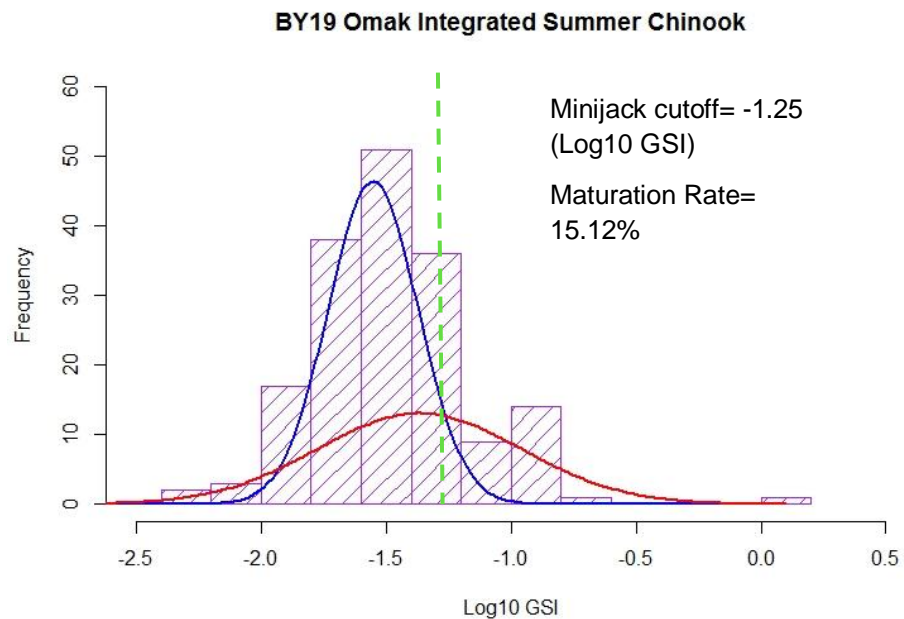


Figure 4. Distribution of Log10 GSI for the integrated summer Chinook released from the Omak Acclimation Pond. The cutoff value is marked by the vertical green dashed line. It marks the point of differentiation between immature fish (appearing to the left of the cutoff line) and mature fish (appearing to the right of the line). The solid blue line shows the distribution function of immature fish, and the solid red line shows the distribution function of mature fish.

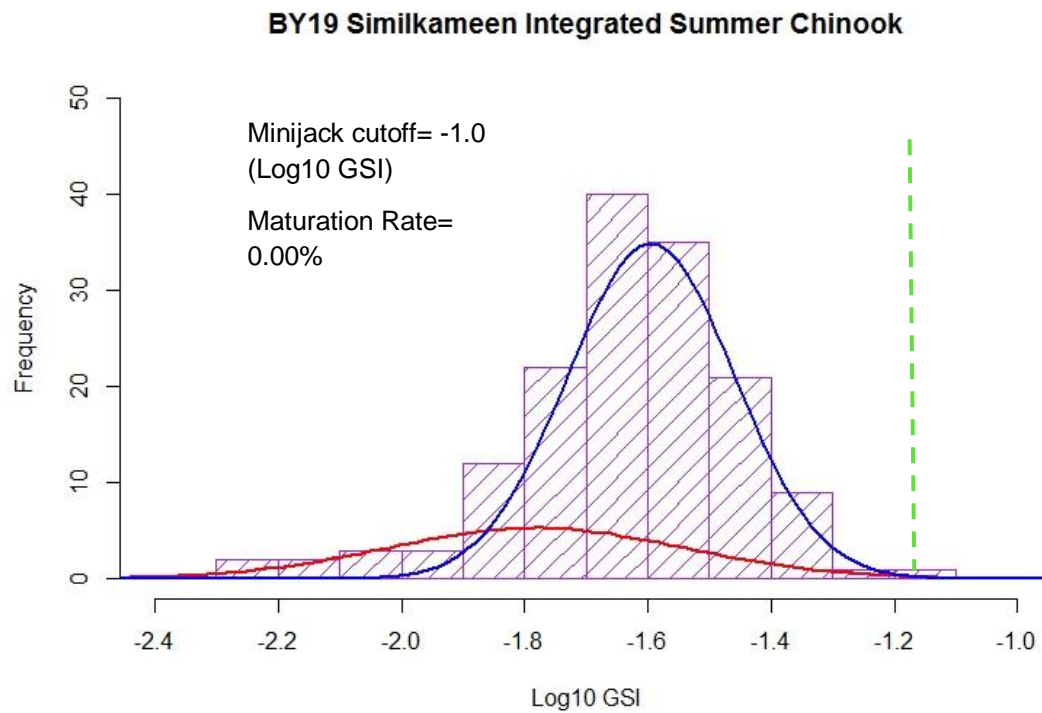


Figure 5. Distribution of Log10 GSI for the integrated summer Chinook released from the Similkameen Acclimation Pond. Since a cutoff value differentiating immature and mature subpopulations was not determinable, subpopulations distribution functions and the cutoff value are not displayed.

Table 2. Annual predicted minijack rate for all CJH release groups.

Year		CJH Segregated Spring Chinook	CJH Segregated Summer Chinook	Riverside Integrated Spring Chinook	Omak Integrated Summer Chinook	Similkameen Integrated Summer Chinook
2018	Visual Estimate	3.23%	4.29%	1.34%	0.00%	0.75%
	Modeled Estimate	4.52%	N/A	N/A	N/A	N/A
2019	Visual Estimate	31.29%	14.29%	37.41%	19.63%	14.25%
	Modeled Estimate	19.02%	43.06%	42.17%	29.63%	N/A
2020	Visual Estimate	11.11%	25.30%	23.74%	49.66%	20.14%
	Modeled Estimate	19.26%	65.06%	43.88%	54.36%	46.53%
2021	Visual Estimate	3.08%	0.65%	1.38%	0.58%	0.00%
	Modeled Estimate	4.62%	3.92%	8.39%	15.12%	0.00%

Discussion and Recommendations

The data and analyses presented herein suggest that the early maturation rates for brood year 2019 releases were much lower than that of brood year 2018 and 2017. The decrease in minijack rates occurred with all of the Chinook release groups and were comparable to other Columbia River hatchery programs (Harstad et al. 2014).

Although the range of rates of minijacking between release groups estimated by visual assessment and the mixture model were similar for some groups, there was not perfect agreement between the two methodologies. This predictive exercise should be paired with a retrospective analysis which uses PIT tag data to estimate actual rates of minijacking within each release group. Such an analysis could shed light on whether one method of estimating minijack rate is

more accurate than the other. Or, if PIT analysis shows rates of early maturation that are strongly divergent from both of the GSI-based estimates, that could provide a basis for future implementation of 11-KT testing.

Visual determination of maturity state is subjective and is likely only useful when the state of maturity has progressed to the point where it becomes so clear that observer error or bias can be overcome. Similarly, the mixture model relies on an ability to differentiate between two distinct, normally distributed populations within a sample. Holding the fish for an additional month post-release allowed more time for gonadal development in the early maturing fish. Similar to the 2019 and 2020 releases, this allowed for mixture model convergence at a much higher rate than in 2018, and may have contributed to reducing Type II error in the visual determination. Although this implies that the minijack rates reported in 2019 may have been artificially low, such a determination cannot be confidently made without supportive PIT tag data. It is recommended that a holdover period similar to what was employed in 2019-2021 be maintained in future years.

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'NAD Sampling Protocols

Supplies List

Sampling How-To

Data Summary and Analysis Methods

Notes from 2016



By Katy Pfannenstein

Mid-Columbia River Fishery Resource Office

US Fish and Wildlife Service

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NAD Supplies List [Bracketed numbers are **minimum** numbers needed for ONE CREW, 4-6 people, for 300 fish]

Daily consumables:

- Data sheets: Length/weight sheet AND gonad weight sheet (Rite in the Rain) Paper number tabs (Rite in the Rain)
- Paper towels (brown single fold, ~100/pack)

General:

- [3] Clipboards
- [3] Mechanical pencils + lead
- [2] Tables
- [4] Chairs
- [4] Buckets to raise table (small white)
- [2] Power strips
- [2] Extension cords
- Garbage bags
- Absorbent lab paper to cover work surfaces (roll)
- Duct tape
- Large scissors and a sharpie
- Extra batteries (9 volt + AA)
- Buckets + aerators
- Counting clickers
- Camera/iPad

Length and weight station:

- Tricane Methanesulfonate (MS 222)
- [1] Tub for fish
- [1] Dip net
- [1] Pit scanner + [1] stand
- [4] large sponges + [1] cookie tray
- [1] Scale for weights + [1] smolt weight pan
- [1] Length board

Dissecting station:

- [1 or 2] Micro scale (minimum power 0.001 g) + power cords
- [4] Scissors + [4] tweezers
- [2] Buckets for garbage (5 gallon)
- S/M/L glove boxes
- Weigh boats for scales
- Portable lights

'NAD Sampling How-To

1. Prepare TWO different data sheets: one with fish ID, fork length, weight, smolt index (0-3), pit #, and the other with fish ID, sex (M/F), maturation (0-2), and gonad weight. Each fish will have an individual fish ID number, which will be matched up during data entry. Measure fish body weight to the nearest 0.1 g and gonad weight to 0.0001 g.

PRE-RELEASE JUVENILE SAMPLING DATA SHEET Page ____ of ____

Date: ____/____/20____ Samplers: _____

Hatchery: _____ Species/Stock _____

Group: _____ Bank: _____ Raceway(s) _____

Other: _____

Smolt index (0 = unk, 1= parr, 2= trans, 3=smolt) Maturity (0=unknown, 1=immature, 2=mature)

Fish ID#	Fork Ln (mm)	WGHT (gms)	Smolt Index (0-3)	PIT # (last 4)	CWT ID #	Sex (M/F)	Maturity (0-2)	Gonad Wt. (gms)	Comment



PRE-RELEASE JUVENILE SAMPLING DATA SHEET Page ____ of ____

Date: ____/____/20____

Hatchery: _____ Species/Stock _____

Group: _____ Bank: _____ Raceway(s) _____

Other: _____

Smolt index (0 = unk, 1= parr, 2= trans, 3=smolt) Maturity (0=unknown, 1=immature, 2=mature)

Fish ID#	Sex (M/F)	Maturity (0-2)	Gonad Wt. (gms)	Comment

2. Collect fish from hatchery ponds. Random sample? Keep different ponds separate? CWT? Pit Tag?

3. Set up stations. Note length/weight station is at standing height.



4. Smolt index: 1. Parr, dark marks (bottom fish), 2. Transitional, faded marks (middle fish), 3. Smolt, silver, no marks (top fish)



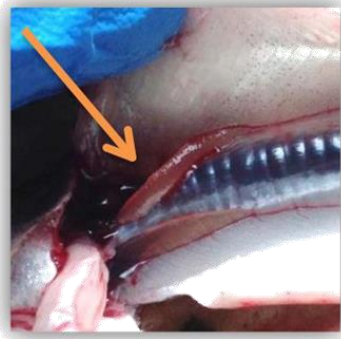
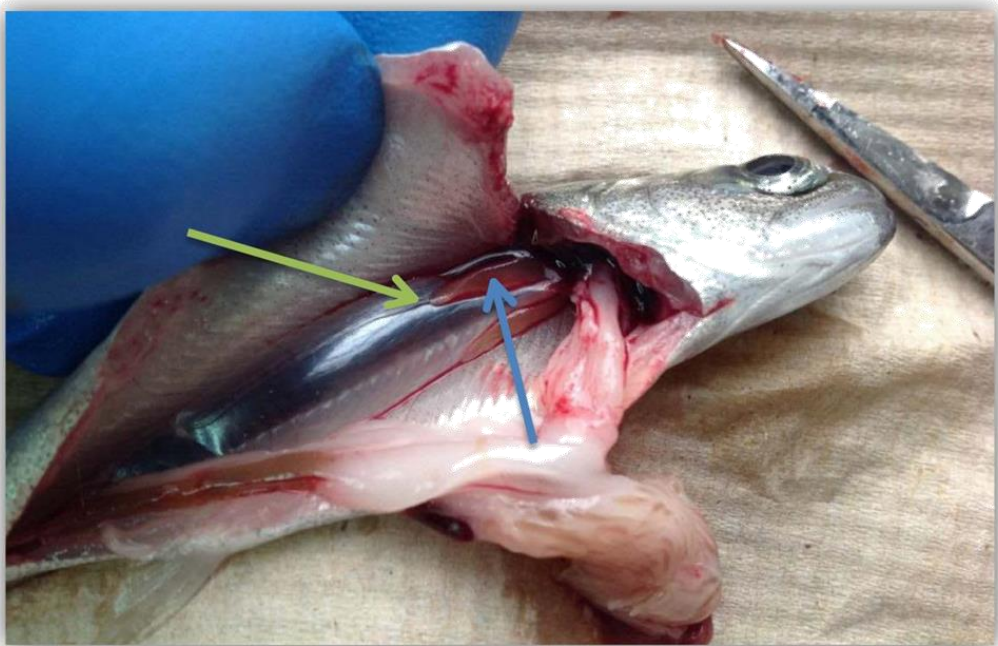
5. Set out 15-20 fish in a row on the sponges. Add number tags to fish. Assess smolt index while all fish are in the line. Obtain weights and lengths, place on paper towel to pass to the dissecting crew.



6. Fish dissection: Cut open belly from vent (shallow incision), cut behind gill, open fish and gently remove guts to expose air bladder. Both male and female gonads are located on the top/edge of the air bladder (orange arrow on mature male).



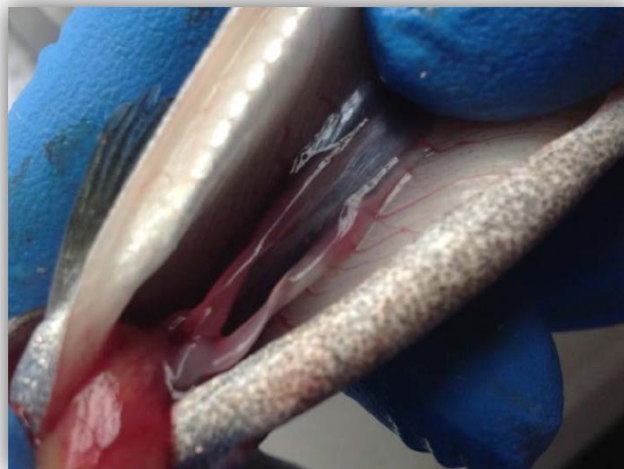
7. Female identification: 1. Ovary forms a point and then narrows to oviduct – thread like (green arrow) 2. Ovary is angular, has ridge (blue arrow), 3. Granulated (orange arrow), 4. Color (red arrow) is not a good indicator as it can vary from pink to white.



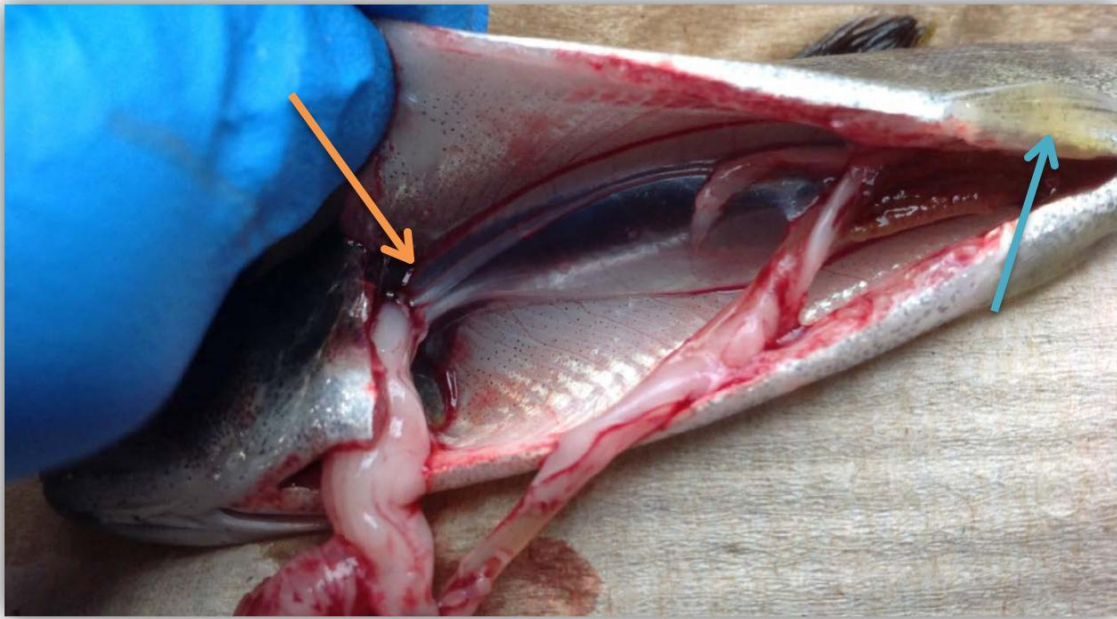
8. Immature male identification: Testes are thready throughout, smooth and round, no development or thickness (green arrows).



9. Mature male identification: Testes thicken, become white/translucent, smooth, tapers to tail.



10. Visually identify fish sex. If female, record fish number and sex on datasheet. If male, visually identify if immature or mature PRIOR to weighing gonads, record visual call and then remove and weigh gonads.
11. Removal of testes for weighing: Use a fine point tweezers, start as near to the anterior insertion as possible (orange arrow), gently lift the entirety of the 'nad off of air bladder down to the tail (blue arrow). Place on the back of your hand and remove second 'nad. Weigh both complete testes. If you were only able to remove one, double the weight on the datasheet, and note that only one was weighed.



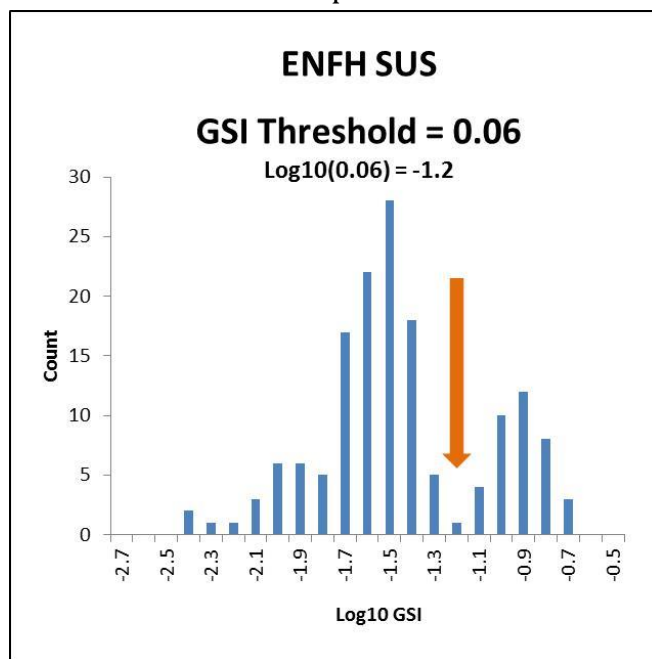
12. To use the scale: Close all doors, zero balance, open door, place 'nads in weight boat, close doors, wait for number to stabilize. 'Nads will evaporate and become lighter in a short period of time.

13. Enjoy all the 'nad jokes you can handle and interagency mingling!



NAD Data Summary and Analysis Methods

- Enter data and QA/QC work, make sure to include specific banks/raceways.
- Calculate Gonadosomatic Index (GSI = gonad weight (g) / weight (g) *100).
- Calculate Condition Factor ($K = (10^5) * \text{weight} / \text{length}^3$).
- Calculate the $\text{Log}_{10}(\text{GSI})$ and graph the frequencies in a histogram to visually see the bimodal pattern of the immature and mature males. Use this graph to determine the GSI threshold that separates immature and mature males.



- From the GSI threshold, calculate the counts, percentages, average length, weight, and condition factor for immature and mature males.
- In a summary table, for both males and females, include gender counts, percentages, and average length, weight, and condition factors. For males, summarize visual counts for immature and mature fish and the percentage of mature fish. Summarize GSI counts and percent for immature and mature fish and list the average length, weight, and condition factor for each group. Make sure to note what GSI threshold was used.

Table x. Leavenworth National Fish Hatchery Complex juvenile pre-release/early-maturation sampling, April 5-8, 2016.

Pre-Release Data								Visual Count			GSI* Count			GSI Immature Male Averages			GSI Mature Male Averages		
Site	Species	Gender	Count	Percent	Ln	Wt	K	Immature	Mature	%	Immature	Mature	%	Ln	Wt	K	Ln	Wt	K

- Perform additional statistics as desired (Were the raceways different? Feed differences? Circular tanks vs. raceways, differences between years, etc.). Normality, chi-squared goodness of fit, t-test, Anova, etc.

NAD Sampling Notes (What worked? What didn't?)

- Print off more data sheets than you think you need. The two data sheet system works best; the dissectors can record their own data.
- Have two people per dissection scale- the more people that use the scale, the more awkward it gets.
- Weighing all male gonads vs. writing "T" for threads/trace? What is best for level of accuracy desired?
- Can we eyeball maturation, i.e., distinguish between 1 (immature) and 2 (mature)?
- Can maturation be determined by gonad weight or % GSI? OR is maturation highly variable and dependent on stock and/or sampling date?
- For data analysis, "T" weight gonads were given a gonad weight of 0.00001 g for a visual representation on the graphs.
- Steelhead that were expressing milt were assigned a maturity level of 3, and were counted, but not weighed. For data analysis, they were assigned a gonad weight of 1.0 g in order to calculate GSI and to be visually represented on the graphs.

Thank you to everyone who participated in the 2016 'NAD sampling: USFWS, WDFW, Chelan PUD, Douglas PUD and Grant PUD!

References:

Larsen, D. A., B. R. Beckman, K. A. Cooper, D. Barrett, M. Johnston, P. Swanson, and W. W. Dickhoff. 2004. Assessment of high rates of precocious male maturation in a spring Chinook salmon supplementation hatchery program. Transactions of the American Fisheries Society 133:98–120.

Harstad, D. L., D. A. Larsen, and B. R. Beckman. 2014. Variation in minijack rate among hatchery populations of Columbia River basin Chinook salmon. Transactions of the American Fisheries Society 143:768-778.

Mixture model and maturity cutoff calculation

For Data Analyses: Determine cutoff for maturing vs. non-maturing fish

From Dr. Lea Medeiros, University of Idaho Post-Doc

Example using C16 11-kT data from minijack study

Export list of Log(conc) or Conc (and convert to Log(conc) once imported into R studio)

Import C16 CSV using import button in rStudio

- Make sure that the separator is set to "Comma" if importing a CSV... sometimes wants to import as whitespace

Copy and paste the code below the line into rStudio

```
# Load the appropriate packages
```

```
library(mixtools)
```

```
library(diptest)
```

```
library(Hmisc)
```

```
# Define variables (columns in imported CSV)
```

```
LC=C16$Log
```

```
  # Only define variables for which you have columns
```

```
  # If value shows up as factor instead of num you have a non-numeric value in the CSV
```

```
# Determine if distribution is bimodal
```

```
dip.test(LC) # returns dip statistic (D) and p-value, as well as what hypothesis (i.e., initial or alternate) to accept. If alternate is accepted, proceed.
```

```
# Determine the variables for the normal curves in the bimodal distribution
```

```
model=normalmixEM(LC)
```

```
plot(model, whichplots = 2)
```

```
#Make sure things look right but won't actually use this graph as it plots on a density scale and may cause confusion. However, this should look pretty spot on (final graph will just be scaled up by a constant determined later on) so make sure that the point where the two curves intersect is where you are expecting the cutoff to be
```

```
# Determine cutoff
```

```
index.lower <- which.min(model$mu)
```

```
find.cutoff <- function(proba=0.5, i=index.lower) {
```

```
  ## Cutoff such that Pr[drawn from bad component] == proba
```

```
  f <- function(x) {
```

```
    proba - (model$lambda[i]*dnorm(x, model$mu[i], model$sigma[i]) /  
            (model$lambda[1]*dnorm(x, model$mu[1], model$sigma[1]) +
```

```
model$lambda[2]*dnorm(x, model$mu[2], model$sigma[2])))
```

```
  }
```

```
  return(uniroot(f=f, lower=-2, upper=2)$root) # Careful with division by zero if  
changing lower and upper
```

```

}
cutoff <- c(find.cutoff(proba=0.5)) # Can change to have range around 50/50 probability,
but this is the value we use to determine if a fish is maturing or not

# Define curves from normalmixEM for plotting on histogram
h <- hist(LC,ylim=c(0,140),breaks=20) # will produce basic histogram of data used for stats
it produces; may need to alter ylim to reflect frequency of tallest bin and breaks
xfit <- seq(-0.7,1.4,length=200)
      #First number should minimum bin, second number should be maximum bin, length
      is number of plots pointed (higher number = smoother curve... to a point)
yfit1 <- model$lambda[1]*dnorm(xfit,mean=model$mu[1],sd=model$sigma[1])
yfit2 <- model$lambda[2]*dnorm(xfit,mean=model$mu[2],sd=model$sigma[2])
yfit1 <- yfit1*diff(h$mids[1:2])*length(LC)
yfit2 <- yfit2*diff(h$mids[1:2])*length(LC)

# Plot pretty graph
v1 = seq(-0.65,1.35,length=11) # offset from minimum bin by 0.05 so that ticks are in
middle of bins
v2 = c(0.2, 0.32, 0.50, 0.80, 1.26, 2.0, 3.2, 5.0, 7.9, 12.6, 20.0) # actual ng/mL values on log
scale
hist(LC, breaks = 20, density = 10, col = "purple", xaxt="n", xlab = "Plasma [11-kt] (ng/mL)",
ylim = c(0, 140), main = "Plasma [11-kT] in Yakima River Juvenile Males")
lines(xfit, yfit1, col="red", lwd=2)
lines(xfit, yfit2, col="blue", lwd=2)
axis(side = 1, at = v1, labels = v2)
abline(v=cutoff, col="green", lty=2, lwd=2)
text(0.05,135, paste("Minijack cutoff", "\n =", round(10^(cutoff), 2),"(ng/mL)" ))

```

APPENDIX F

Genetic evaluation of yearling Chinook in the Okanogan basin: Analysis Report

Background: (Work Element 2) Currently, little is known about the success or effectiveness of recent reintroduction efforts of an ESA 10j-listed experimental population of spring-Chinook in the Okanogan Basin, dating back to 2015. Spawning grounds surveys have revealed minimal evidence of spawning, though annual electrofishing efforts in fall (September and October) have produced intriguing numbers of juvenile, apparently stream-type Chinook in tributaries. A better understanding of the origin of these fish would help resource managers to assess the effectiveness of reintroduction efforts and inform adaptive management strategies.

Recent advancements in genetic testing have led to improved tools for salmon conservation. Parentage assignment, or Parental-based tagging (PBT), Genetic Stock Identification (GSI), and genetic sibship analysis have all been successfully demonstrated and are now widely implemented as effective tools for helping to understand population structure and status (Hess et al 2011; Steele et al 2019). CCT is interested in applying these genetic analyses to gain information on the origin of naturally produced Chinook captured by electro-fishing in tributaries of the Okanogan basin as well as by rotary screw trapping within the mainstem channel of the Okanogan River, dating back to 2018.

Field Sampling: (Work Element 2) (to be completed by CCT).

CCT currently has 92 archived samples from juvenile yearlings collected via electrofishing and smolt trapping in the Okanogan basin between 2015 and 2020. We anticipate collecting an additional 50-60 samples in 2021.

Analyses: (Work Element 2) (to be completed by the Hagerman Genetics Lab).

Desired genetic analyses include genotyping, to include 1) parentage assignment using single nucleotide polymorphisms (SNPs); 2) run/strain assignment (*e.g.*, summer-run, spring-run); 3) Genetic stock identification *to existing reporting groups*; 4) Full Sibship analysis/assignments.

Results:

Of the 104 samples, there were 40 that successfully genotyped and were included in GSI analysis (Table 1). A large number of sample failures (missing greater than 10% of genotypes at 254 SNP loci) were distributed across sites and sample years and may be due to low quality of the tissues and inclusion of multiple non-target species. Of the 64 samples that failed to genotype, there were 18 that were genetically identified as Coho salmon (N=16), *O. mykiss* (N=1) and Sockeye salmon (N=1, Table 2). The largest collection size that successfully genotyped from a single year consisted of 33 individuals collected from 2019. There were no PBT assignments found among all fish that genotyped. GSI assignments showed that although the 2019 collection contained almost all spring run Chinook salmon, all the other collection years had limited samples and were comprised of only summer-run fish (i.e., ocean-type lineage; upper Columbia summer-run stock “18_UCOLSF”; Table 3). The 2019 collection individuals were found to be all from the spring run lineage (mostly from the upper Columbia spring GSI group, “10_UCOLSP”) except for a single individual from the summer run. Of the spring run 2019 collection fish (N=32), the effective spawner size (NE) was 17 (95%CI 10 – 35) and a total of 17 unique full sibling families were reconstructed (Table 4). There were no full-sibling pairs found across any of the sites but several full-sibling families contained more than 2 full siblings within sites; the largest full sibling family contained 9 fish from a single spawner pair in Omak Creek. Chinook salmon spawners were found to have multiple mates but only spawned within a single site (Table 4).

Table 1. Basic information on genotyping success across collections.

Year	Location	failed	GSI	Total
2013	Okanogan River - Screw Trap	4	1	5
2014	Okanogan River - Screw Trap	1		1
2015	Okanogan River - Screw Trap		3	3
2019	Okanogan - Aeneas Creek	4		4
	Okanogan - Loup Loup Creek	29	13	42
	Okanogan - Omak Creek	4	14	18
	Okanogan - Salmon Creek	1	4	5
	Okanogan - Tunk Creek		2	2
2020	Okanogan - Loup Loup Creek	12	1	13
	Okanogan - Salmon Creek	1		1
	Okanogan - Wanacut Creek	2		2
2021	Okanogan - Bonaparte Creek	4		4
	Okanogan - Loup Loup Creek	2	1	3
	Okanogan River - Screw Trap		1	1
		64	40	104

Table 2. Genetic species identification of the samples that failed to genotype.

Year	Location	Genetic Species ID					total
		kisutch	kisutch?	mykiss	nerka	unknown	
2013	Okanogan River - Screw						
	Trap				1	3	4
2014	Okanogan River - Screw						
	Trap			1			1
2019	Okanogan - Aeneas Creek	4					4
	Okanogan - Loup Loup						
	Creek	4	2			23	29
	Okanogan - Omak Creek					4	4
	Okanogan - Salmon Creek					1	1
	Okanogan - Loup Loup						
2020	Creek	6				6	12
	Okanogan - Salmon Creek					1	1
	Okanogan - Wanacut Creek					2	2
	Okanogan - Bonaparte						
2021	Creek					4	4
	Okanogan - Loup Loup						
	Creek					2	2
		14	2	1	1	46	64

Note: Species identification provided confirmation for Coho (*O. kisutch*), steelhead or resident trout (*O. mykiss*), and Sockeye Salmon (*O. nerka*). “Kisutch?” indicates Coho is the likely species but is based on low quality data.

Table 3. Genetic stock identification assignments across collection sites.

Year	Location	07_DESCSP	Stream-type				Ocean-type 18_UCOLSF	Total
			10_UCOLSP	12_HELLSC	13_SFSALM	16_UPSALM		
2013	Okanogan River - Screw Trap						1	1
2015	Okanogan River - Screw Trap						3	3
2019	Okanogan - Loup Loup Creek	1	12					13
	Okanogan - Omak Creek		9	1	1	2	1	14
	Okanogan - Salmon Creek		4					4
	Okanogan - Tunk Creek		2					2
2020	Okanogan - Loup Loup Creek						1	1
2021	Okanogan - Loup Loup Creek						1	1
	Okanogan River - Screw Trap						1	1
		1	27	1	1	2	8	40

Table 4. Full sibling family membership among sample sites in the Okanagan 2019 collection.

Cross	Omak Creek	Salmon Creek	Loup Loup Creek	Tunk Creek	Total	Mom	Dad
F01XM01	3				3	F01	M01
F02XM02	9				9	F02	M02
F03XM03	1				1	F03	M03
F11XM11		4			4	F11	M11
F04XM04			1		1	F04	M04
F04XM07			1		1	F04	M07
F04XM08			2		2	F04	M08
F04XM12			2		2	F04	M12
F05XM05			1		1	F05	M05
F06XM06			1		1	F06	M06
F06XM08			1		1	F06	M08
F06XM13			1		1	F06	M13
F07XM09			1		1	F07	M09
F09XM09			1		1	F09	M09
F10XM09			1		1	F10	M09
F08XM10				1	1	F08	M10
F08XM11				1	1	F08	M11
18_UCOLSF	1				1		
Total	14	4	13	2	33		

References: (Work Element 2)

Hess, J. E., Matala, A. P., & Narum, S. R. (2011). Comparison of SNPs and microsatellites for fine-scale application of genetic stock identification of Chinook salmon in the Columbia River Basin. *Molecular Ecology Resources*, 11(Suppl. 1), 137– 149. <https://doi.org/10.1111/j.1755-0998.2010.02958.x>

Steele, C. A., M. Hess, S. Narum, and M. Campbell. 2019. Parentage-based tagging: reviewing the implementation of a new tool for an old problem. *Fisheries* 44: 412– 422.

Supplemental Figure 1. Sibling matrix from the COLONY analysis for the Okanagan 2019 collection of spring Chinook salmon juveniles.

