The Chief Joseph Hatchery Program
Spring Chinook

2018 Annual Report

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This report includes both hatchery production/operations and the corresponding monitoring activities completed through April of 2019. It is structured to meet the RM&E technical report formatting requirements for BPA, and therefore the hatchery production portion is included in Appendix A.

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

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Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government or the Confederated Tribes of the Colville Reservation.

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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 to mitigate 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 government 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 River Public Utility Districts (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 2018 during the sixth year of operation for the spring Chinook program. Early run forecast for returning spring Chinook to Leavenworth was short of total program needs, so the program operated the ladder at CJH to collect returning adults from the BY 2013 and 2014 production. The spring Chinook programs collected enough brood to meet full production levels. 622 spring Chinook broodstock were collected at the CJH ladder from May-July 2018. The segregated spring Chinook program broodstock survival was 93.1% for females, and 93.7% for males with a combined survival of 93.5% (see Appendix C for Glossary of Terms, Acronyms, and Abbreviations). The total green egg take for the segregated spring Chinook program was 1,010,800 (92% of full program). Green egg to eyed egg survival was 42.7%. This survival was much lower than the standard (90%). With the lower than anticipated hatchery survival of eggs the segregated spring Chinook program was 48% of full program by April 30, 2018. The Non-Essential Experimental Population (Endangered Species Act, Section 10(j)) spring Chinook reintroduction program (10(j), hereafter) received its full component of 206,138 eyed eggs from the Winthrop National Fish Hatchery (WNFH) in October.

Releases of spring Chinook yearling smolts included 200,827 (100% of full program) 10(j) smolt released from the Riverside Acclimation Pond (Riverside, WA, USA). Additionally, 555,636 segregated spring Chinook smolts were released directly from Chief Joseph Hatchery (79% of full program).

Apparent survival of yearlings to PTAGIS Location Code 'RRJ' (Rocky Reach Dam juvenile bypass; Wenatchee, WA, USA) was 70-71%. This is similar to, or slightly less than previous years and approximated survival rates of other nearby programs in the upper Columbia River. Apparent survival of yearlings to PTAGIS Location Code 'MCN' (McNary Dam; Plymouth, WA, USA) was 44% for the segregated program from CJH and 60% for the 10(j) program released from CJHP's Riverside Acclimation Pond. Although the survival of the segregated yearlings to 'MCN' was less than nearby programs in 2018, it was similar to two of the last three years from that location. The majority (>90%) of PIT-tagged hatchery smolts released from 'Riverside Pond' migrated to the lower Okanogan River within two weeks of release. Both programs had 90% of their detections at 'RRJ' by May 12 (less than one month after release). This assessment suggests that the program was successful at releasing actively migrating smolts.

The CJH Monitoring & Evaluation Program collected field data to determine spring Chinook population status, trends, and hatchery effectiveness centered on six major activities; 1) rotary screw traps (juvenile outmigration, natural-origin smolt PIT tagging), 2) spawning ground surveys (redd and carcass surveys) (viable salmonid population [VSP] parameters), 3) environmental DNA (eDNA) analysis (VSP parameter—distribution/spatial structure), 4) electrofishing (natural-origin smolt PIT tagging, genetic sampling), and 5) coded wire-tag analysis (extraction and reading).

Rotary screw trap operations began on April 3 and continued through June 17, capturing 8,794 natural-origin Chinook and 2,140 hatchery-origin Chinook. There were no natural-origin fish captured that were likely yearling Chinook. The program will continue to monitor the presence of yearling Chinook during screw trap operations.

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

PIT tags were also used to evaluate spring Chinook presence and distribution in the Okanogan from adults tagged at Wells Dam. Of the 1,475 returning fish with a PIT tag to the Okanogan, 295 (20%) had a final detection in a U.S. tributary with the majority of them in Loup Loup, Omak, and Johnson creeks. There were 16 (0.4%)

final detections in a Canadian tributary to the Okanagan, all of them in Vaseux Creek. The majority of fish (901; 61%) were detected at the lower Okanogan mainstem PIT array ('OKL') and/or at Zosel Dam near Oroville, WA, USA; 156 (11%) were detected on the Okanogan mainstem PIT array in Canada ('OKC') and/or at Skaha Dam near Okanogan Falls, CAN.

2018 marked the first year for spring Chinook redd and carcass surveys. Walked and floated visual surveys occurred between July 24 and September 25 on nine streams in the Okanogan River basin. Two redds were detected in Omak Creek, and four live fish were detected on three streams (Salmon, Omak and Johnson creeks). A total of 18 carcasses were recovered during spring Chinook surveys, one at Bonaparte Creek and the remainder in the Similkameen River. Of these carcasses, nine were ultimately determined to be spring Chinook-the Bonaparte Creek fish plus eight carcasses from the Similkameen River. Based on the two redds that were detected in Omak Creek and a fish per redd ratio of 2.301, the spawning escapement in 2018 was 5 spring Chinook.

The CJH coded wire tag lab was in its third year of operation in 2018. Coded wire tags were extracted and read from Chinook snout recoveries from broodstock, ladder surplus, purse seine harvest, and creel and spawning ground surveys. Spring Chinook were encountered during the summer Chinook ladder operations (generally early July to early August). All the recoveries were from the Chief Joseph Hatchery segregated (80%) and integrated programs (20%).

The most recent brood year that could be fully assessed (through age 5) for stray rate of Okanogan 10(j) fish to spawning areas outside the Okanogan was 2013. There were zero carcass recoveries in the target stream (Okanogan), which biased the CWT-based stray/homing rate evaluation because the PIT tag run escapement estimate predicted that 1,401 hatchery spring Chinook returned to the Okanogan and most of them were likely from the 10(j) program. However, using the CWT recovery data for the Okanogan 10(j) program, the 2013 brood year had a stray rate of 15.4% (estimated 32) to non-target streams and 1.3% to non-target hatcheries and 81% to CJH. The PIT tag analysis of homing estimated that 58% of returning 10(j) fish went to the Okanogan and 42% went to the CJH. The objective of this program is to return fish to the Okanogan River and technically, the fish that return to CJH are considered strays. However, these fish are raised at CJH from egg to fall parr so a relatively high return rate to that facility should be expected. Despite the high return rate to CJH, the run escapement trend in the Okanogan suggests that the program is successful at reintroducing fish to the Okanogan.

CJH segregated spring Chinook had a lower stray rate to non-target streams and hatcheries. For BY13, the CWT-based stray rate for non-target streams and hatcheries was 2.1% and 0.0%, respectively. The homing rate to the Chief Joseph Hatchery was 96.5%. CJH segregated spring Chinook strays were not recovered in the Entiat or Wenatchee rivers and comprised 1.5% of the Methow hatchery spawning escapement for return year 2018. This assessment may have been biased towards lower than actual stray rates due to the lack of carcass recoveries in the Okanogan. Although the PIT tag assessment confirmed high homing fidelity to CJH (100%), the sample size of CJH segregated fish that returned to Bonneville Dam was small (14).

The CCT Chief Joseph Dam tailrace spring Chinook fishery opened after the commencement of the First Salmon Ceremony, held by CCT on May 28, 2018. Tribal members used selective gear to harvest Carson stock spring Chinook with hook and line and dip and hoop net gear type, although all Chinook retained were caught via hook and line. Creel surveys show that a total of 80 anglers spent 502.4 effort hours to harvest an estimated 97.5 adipose fin-clipped spring Chinook. Post-release mortality was assessed at 5% on adipose fin-clipped spring Chinook (2.5) for a total harvest of 100 spring Chinook. The fishery was closed on June 27, 2018 to allow for the collection of broodstock via the CJH ladder.

An Annual Program Review (APR) was held in March 2019 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. The plan for 2019 is to operate the hatchery at full program level of 900,000 spring Chinook. To achieve full production, CJH operations would require the collection of 640 adult spring Chinook from the CJH ladder. The pre-season forecast for Upper Columbia spring Chinook Salmon in 2019 was 11,200 which, if realized, would be the second lowest return of spring Chinook to the Upper Columbia since 2000. Given the low pre-season forecast we anticipate it will be a difficult year to collect broodstock and local fishery opportunities will be limited. If LNFH has surplus brood, CJH staff will work with LNFH staff to supplement CJH brood collection with fish collected at LNFH.

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.

Integrated Program = The CJH integrated spring Chinook program consists of MetComp eggs or Okanogan broodstock which are spawned at CJH and then reared at acclimation sites on the Okanogan River. Fish are released directly to the Okanogan River with the intention of adults returning to the Okanogan for natural spawning as part of an ESA-listed section 10(j) experimental population.

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

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

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

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

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

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

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

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

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

SAR = smolt to adult return.

Segregated Program = The CJH segregated spring Chinook program consists of CJH broodstock which are then spawned at CJH and the offspring reared at acclimation ponds at the hatchery. These fish are released directly to the Columbia River with the intention of adults returning back to the hatchery ladder.

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 would produce adult offspring 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

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)

HPUE- Harvest Per Unit Effort

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

INTRODUCTION

Salmon (*Oncorhynchus* spp.*)* and steelhead (*O. mykiss*) face many anthropogenic challenges resulting from 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 have profoundly impacted Native American tribes, including the Confederated Tribes of the Colville Reservation. Hatcheries have been used as a replacement or to supplement the natural-origin production of salmon and steelhead throughout the Pacific Northwest. However, hatcheries and hatchery practices can pose biological and evolutionary risks to wild populations (Busack and Currens 1995; Ford 2002; McClure et al. 2008). As more studies lead to a better understanding of hatchery effects and effectiveness, hatchery reform principles were developed (Mobrand et al. 2005; Paquet et al. 2011). The Chief Joseph Hatchery Program (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 (*i.e.,* natural-origin, or naturally spawning fish on the in-stream spawning grounds) and hatchery broodstock (*i.e.*, hatchery-origin adult returns collected for use in hatchery spawning programs) (HSRG 2009). 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 Confederated 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 (NEP) of spring Chinook in the Okanogan utilizing section 10(j) of the Endangered Species Act (ESA). 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 program in 2014. The program will be guided by all three HGMPs.

At full program the facility will rear up to 900,000 spring Chinook. Up to 700,000 segregated spring Chinook will be released from CJH and up to 200,000 Methow Composite stock (of Chewuch and Methow rivers origin; MetComp, hereafter) 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 2018, a complete set of brood year spawners (age 3 to 5) returned to the Okanogan from the NEP releases.

The CJHP will increase harvest opportunity for all anglers throughout the Columbia River and Pacific Ocean. The reintroduction of spring Chinook as a NEP into the Okanogan River is intended as a conservation and recovery activity, and direct harvest is neither authorized nor planned in the current phase of reintroduction. Incidental harvest of the NEP does occur throughout its range and this harvest is managed through ESA-take authorization for the various fisheries by NMFS.

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).

To make full use of the best science available the program operates on the following general principles[1]:

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

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

1. Rotary screw traps (juvenile outmigration, natural-origin smolt PIT tagging)
2. Spawning ground surveys (redd and carcass surveys)(VSP parameters)
3. eDNA collection (VSP parameter—distribution/spatial structure)
4. Electrofishing (natural-origin smolt PIT tagging, genetic sampling)
5. 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)

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

2. Query RMIS for coded wire tag (CWT) recoveries to evaluate strays, smolt-to-adult returns, and stock composition
3. Query PTAGIS for PIT tag returns at mainstem dams and tributaries and strays to out of basin

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 / reduction of the proportion of hatchery origin spawners (pHOS)

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 is approximately 185 km long and drains 2,316,019 ha, making it the third-largest subbasin to the Columbia River. Its headwaters are in Okanagan Lake in British Columbia, from which it flows south through a series of four lakes before crossing into Washington State at Lake Osoyoos. Seventy-six percent of the basin 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.

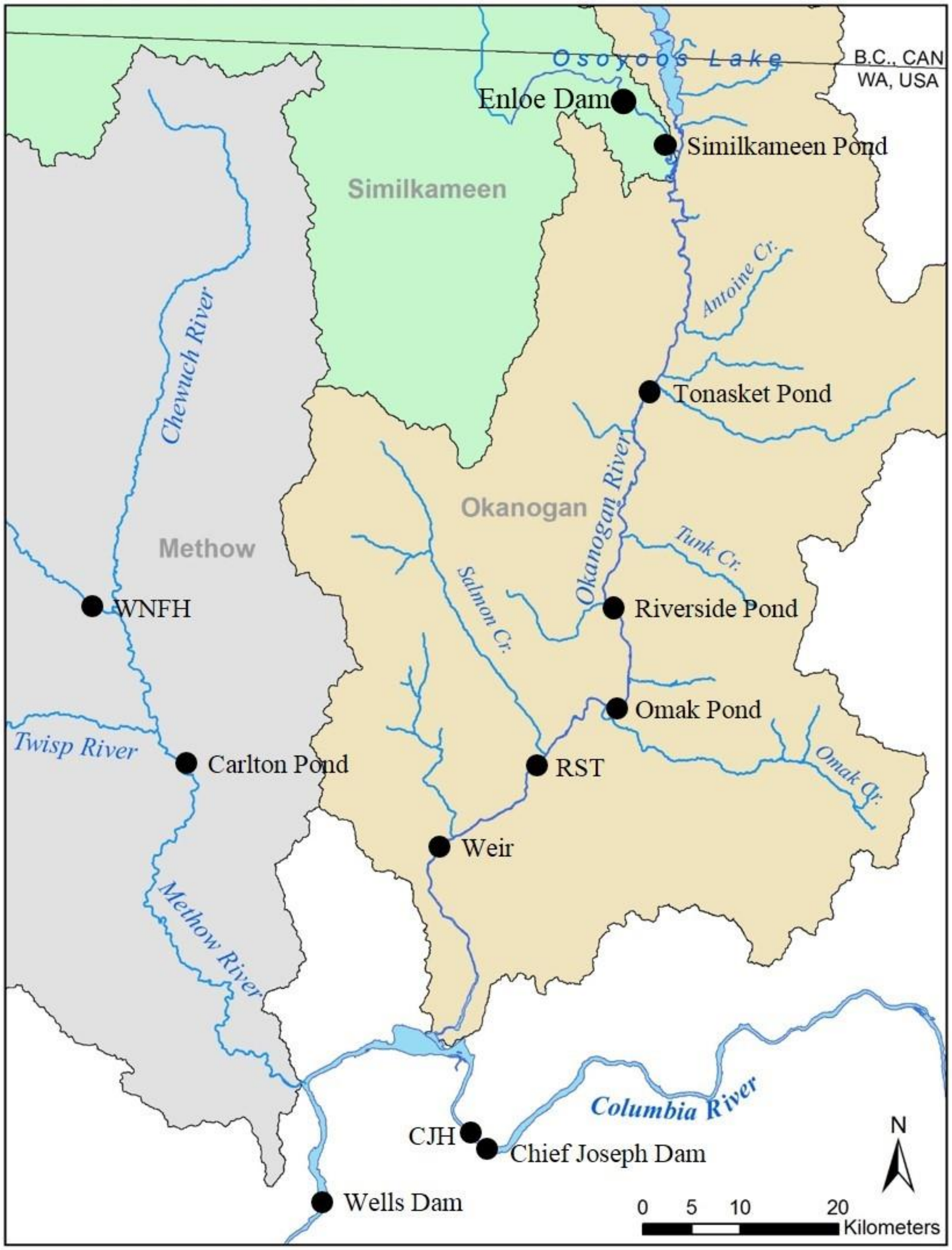

Figure 1. Map of the U.S. portion of the Okanogan River Basin, the Chief Joseph Hatchery (CJH), Winthrop National Fish Hatchery (WNFH), Okanogan adult weir (Weir), rotary screw trap (RST), and Chinook Salmon acclimation sites.

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

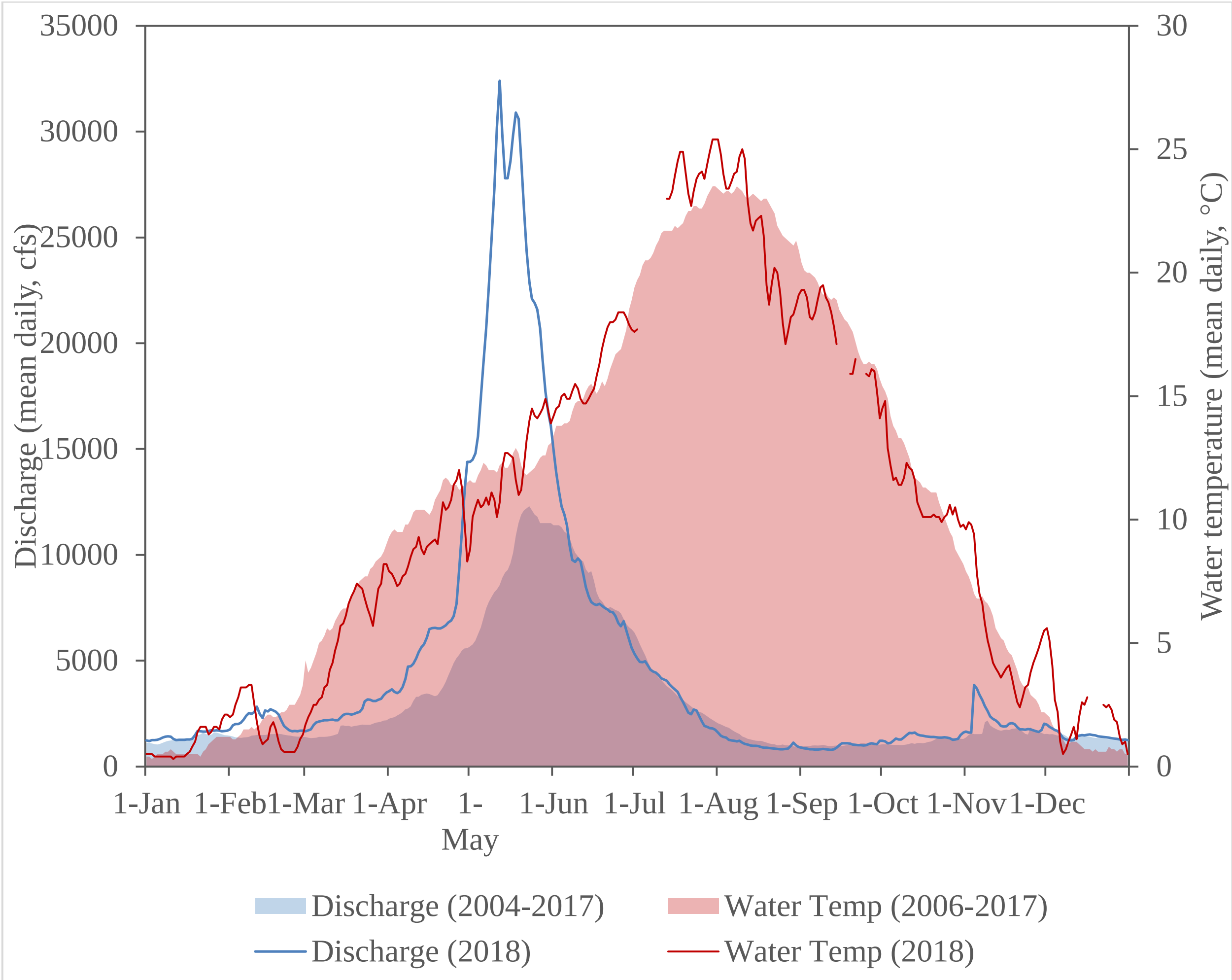

Figure 2. Okanogan River mean daily discharge (blue lines) and water temperature (red lines) at Malott, WA (USGS Stream Gage 12447200).

METHODS

Tag and Mark Plan

HATCHERY SPRING CHINOOK. —Table 1 describes the general tag and mark plan for spring Chinook.

Table 1. General marking and tagging plan for Okanogan spring Chinook as part of the Chief Joseph Hatchery Program.

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

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 U.S. Geological Survey (USGS)– Pacific Northwest Environmental DNA Laboratory (PNW eDNA Lab), Boise, ID. No genetic analyses are currently being conducted. Annual tissue collection targets are at least 200 samples for: (1) natural-origin yearling (>130 mm) Chinook handled at the rotary screw trap and (2) natural- and hatchery-origin (100 each) Chinook encountered during carcass surveys on the spawning grounds.

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

Rotary Screw Trap

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 March 12 to June 21, 2018. Trapping typically occurred continuously from Monday at 0600 until Saturday at 0600 during each week of operation. Trapping operations were suspended during May 7-31 due to high river discharge. 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 were 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 due to their ESA-listed status. Unmarked (adipose fin present) Chinook captured in the RST that were ≥ 65 mm total length received a 12 mm full duplex PIT tag, provided that water temperatures were below 17°C. A tissue sample (fin clip) was collected from all yearling unmarked Chinook for future genetic analyses.

Spring-Chinook Presence and Distribution

Environmental DNA

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

As a proof of concept, sampling was initiated in 2012 with five mainstem Okanogan River sites and 11 Okanogan tributary sites as well as 32 sites throughout the Methow basin (See Laramie et al. 2015a and CJHP 2013 Annual Report). Sampling was conducted in June and August 2012 at all sites. In 2013, sampling was conducted only in the Okanogan basin, at eight additional tributary sites not visited during the proof-of-concept study. These sites were sampled in June and in tributary streams with potential for spring-Chinook recolonization. In 2014, all previously sampled sites in the Okanogan basin were re-visited and sampled (U.S. sites on 12-13 July 2014, and Canada sites on 2 October 2014). All sampling was conducted following the methods and protocols described in Laramie et al 2015b, and available as PNAMP Method ID# 5476 (www.monitoringresources.org/Document/Method/Details/5476). Several tributaries have produced consistent annual detections of Chinook eDNA, including Salmon Creek and Omak Creek, as well as Shingle Creek and Vaseux Creek to a lesser degree. In 2018, sites in both the U.S. and Canadian portions of the Okanogan basin were re-sampled to monitor status and trends in spatial distribution during the early stages of the reintroduction effort. We increased the temporal coverage of sampling in 2018 to include a March sampling event (n = 20 sites) in addition to the consistent fall sampling event (17 sites). This additional sampling event in late winter was intended to target juvenile Chinook production in tributary habitats to assess the distribution of successful spawning.

Spring Chinook Run Escapement

2018 was the first year with a full complement of returning brood years (ages 3-5). Monitoring for distribution and abundance of spring Chinook consists of eDNA and PIT tag sampling and analysis at tributary and mainstem Okanogan sites, supplemented with redd surveys initiated in 2018. Monitoring programs throughout the Columbia basin are implanting PIT tags into both hatchery- and natural-origin spring Chinook as juveniles that might stray to the Okanogan as returning adults. Additionally, monitoring programs at Bonneville and Wells dams tagged returning adult spring Chinook, which greatly increased the probability of encountering spring Chinook with a PIT tag in the Okanogan. In 2018, the spatial distribution of spring Chinook was evaluated using a combination of eDNA and PIT tag data.

Spring Chinook salmon run escapement estimates to the Okanogan River basin and its tributaries were based on a WDFW-provided estimate of total spring Chinook salmon with a final location upstream of Wells Dam, the tag rate of returning adult spring Chinook salmon with a PIT tag implanted at Wells Dam by WDFW, and the final PIT array detection site of those fish.
Tagging rate was calculated by the equation:

$$\text{Tag Rate} = \frac{WDFW\ Sample}{Total\ Fish\ Above\ Wells}$$

where the WDFW Sample is the number of fish released by WDFW as part of their PIT tagging efforts, including fish captured as part of the study that already carried a PIT tag, and the Total Fish Above Wells is the number of total adult spring Chinook Salmon WDFW estimated to have an ultimate fate above Wells Dam.

Run escapement was then calculated at each PIT tag detection site within the Okanogan River basin. Run escapement estimates were calculated by the equation:

$$\text{Run Escapement} = \frac{Final\ Detections}{Tag\ Rate}$$

where Final Detections is the number of PIT tags from the WDFW sample with a final detection at a given site. To calculate tributary run escapement for a tributary with multiple detection sites, (e.g., SA0 and SA1 within Salmon Creek) the total run escapement estimate for each detection site was summed.

Determining detection efficiency is an important aspect of PIT tag expansions for run escapement and other evaluations such as stray rate. Detection efficiency could only be calculated for the lower most detection site (OKL) by using detections at upstream sites to determine the probability that a fish would be detected when entering the Okanogan. To determine the detection efficiency at the OKL array, we used the formula:

$$Detection\ efficiency = 1 - \left(\frac{Tr}{OKL}\right) * 100$$

Where:

Tr = Number of unique PIT detections at all tributary (and Canadian) arrays upstream of OKL, which were not detected at OKL

OKL = Total number of unique PIT detections at OKL (lower Okanogan array; Malott, WA, USA)

Spawning Ground Surveys

The objectives[2] for spawning surveys were to:

1. Estimate the run escapement of hatchery- and natural-origin spring Chinook to the Okanogan basin and the spatial structure of the returning spawners.
2. Estimate total spawning escapement based on the number of Chinook redds per tributary
3. Estimate the proportion of natural spawners composed of hatchery-origin recruits (pHOS)
4. Estimate pre-spawn mortality and mean egg retention for natural- and hatchery-origin spawners
5. Determine the source (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)

[2] Note: Sufficient carcass recovery (i.e., adequate sample rate) is necessary to make statistically valid estimates and is not likely to be feasible when adult spawning densities are extremely sparse (e.g., during the initial years of this reintroduction effort). For example, stray rate estimates can be extremely skewed by single or few carcass recoveries and should be interpreted accordingly.

6. Estimate out-of-population stray rate for Okanogan hatchery Chinook and estimate genetic contribution to out-of-basin populations (emigration)
7. Determine age composition of returning adults through scale analysis
8. Monitor status and trends of demographic and phenotypic traits of natural-origin- and hatchery-origin spawners (age-at-maturity, length-at-age, run timing, smolt-to-adult return ratio, or SAR)

Redd Surveys

Spring Chinook spawning ground surveys involved walking in and along accessible stretches of tributary streams to the Okanogan River (Table 2), passing through areas surrounded by private land only if landowner permission had been granted. Streams in which PIT arrays had detected returning spring Chinook or which contained higher amounts of suitable spawning habitat were chosen for multiple surveys occurring on a weekly or semi-weekly basis, whereas streams without PIT detections were typically surveyed only once. Redd and carcass surveys were also conducted concurrent with summer Chinook pre-spawn mortality surveys on the Similkameen River by floating the river in single-seat pontoon rafts.

Redds were characterized by large disturbances in gravel substrate comprised of a tail spill pillow and a pit into which a trained observer determined that eggs had been deposited. Once detected, a point was plotted using a handheld GPS unit, and the redd location was marked with flagging tape. In addition to the location, the date of first and any subsequent detections of a redd was noted, as was the presence of Chinook salmon.

Table 2. Tributaries to the Okanogan River that were surveyed for spring Chinook Salmon redds and carcasses.

Stream	Description	Reach Length (rkm)
Antoine Creek	Antoine Creek/Okanogan River Confluence to below Rylie's Canyon	1.6
Aeneas Creek	Aeneas Creek/Okanogan River Confluence to the barrier	0.4
Bonaparte Creek	Bonaparte Creek/Okanogan River Confluence to Bonaparte Falls	1.6
Johnson Creek	Johnson Creek/Okanogan River Confluence to 7 Lakes Rd.	1.0
Loup Loup Creek	Loup Loup Creek/Okanogan River Confluence to Loup Loup Creek diversion	2.3
Omak Creek	Omak Creek/Okanogan River Confluence to below Dutch Anderson Rd.	24.0
Salmon Creek	Salmon Creek/Okanogan River Confluence to Conconully Dam	31.0
Tunk Creek	Tunk Creek/Okanogan River Confluence to the falls	1.2
Similkameen	Mouth to Enloe Dam	14.6

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).

Assumptions include:

Assumption I – Each redd was constructed by a single female Chinook, and each female Chinook constructed only one redd (Murdoch et al 2009)

Assumption II - Every redd was observable and correctly enumerated

Carcass Surveys

During the course of spawning grounds surveys, any detected Chinook salmon carcasses were collected and sampled. Sex, fork length (FL), postorbital-hypural length (POH) to the nearest cm., adipose presence/absence, egg retention, date, and location of carcass recovery were recorded. 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 the 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 PIT tags and all PIT detections were recorded and later uploaded to PTAGIS. Carcasses were scanned with a T-wand (Northwest Marine Technology, Inc., Shaw Island, WA USA) for coded wire tags (CWT). If present, the snout was removed from the carcass, individually bagged, and labeled with species, origin, FL, river of recovery and date. The coded wire tag was extracted from the snout at the Chief Joseph Hatchery lab after the season was complete. After examination, in streams that were to be surveyed more than once, carcasses were Floy-tagged (Floy Tag & Mfg., Inc.) with a unique identifying number and returned to the location in which they were detected. Recaptures of these carcasses on subsequent surveys were recorded, such that a tributary-level population estimate could be inferred from the capture-mark-recapture histories.

Anecdotally, observations of live Chinook during spawning ground surveys were also recorded, but not on the Similkameen River, which is occupied by many summer/fall Chinook as well during the survey period. For carcasses that were recovered in the Similkameen River, where spring and summer Chinook overlap in time and space, a carcass was determined to be a spring Chinook only if either a coded wire tag or implanted PIT tag designated it as a spring run fish. All natural-origin carcasses recovered in the Similkameen River were treated as summer Chinook. This was determined to be the most likely outcome, given the robust natural-origin summer Chinook population in the Okanogan River basin, and the dearth of natural-origin spring Chinook. .

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

Spawner Escapement

Spawner escapement was calculated for each tributary by multiplying the number of redds detected within a stream by the fish-per-redd ratio, which was calculated by the ratio of male to female fish that are observed passing over Wells Dam. This number was then divided by the percent of stream miles accessible to anadromy and capable of supporting spring Chinook redd construction and reproduction within a tributary that were surveyed. Total Okanogan spring Chinook spawner escapement was calculated by the total sum of spawner escapement for all Okanogan River tributaries within the U.S. portion of the basin.

Tributaries were determined to be occupied if and only if at least one redd was detected within that stream during spawning grounds surveys. Although other methods may be used for monitoring tributary habitat use (*e.g*., eDNA surveys, PIT tag monitoring, electrofishing), spawner occupancy was determined only by the detection of, or failure to detect, a redd within a tributary during a spawning grounds survey.

pHOS and PNI

The CJH spring Chinook programs do not have objectives for origin composition of broodstock or natural spawners. The CJH program is a segregated harvest program, and therefore uses only hatchery origin returns to the ladder, or segregated broodstock or eggs from other facilities such as Leavenworth National Fish Hatchery (LNFH), Carson National Fish Hatchery and Little White Salmon National Fish Hatchery. The Okanogan spring Chinook reintroduction program, or 10(j), receives eggs from WNFH, which uses hatchery-origin broodstock from the

Methow River. This program is still in the reintroduction phase, and therefore does not have objectives for pHOS or the proportion of natural influence (PNI). However, documenting the return of 10(j) hatchery fish and natural-origin spawners is important to monitoring the success of the program. Future management changes from a reintroduction program to a supplementation program with local-brood collection will depend on the documentation of natural-origin returns.

Hatchery-Origin Stray Rates

Chief Joseph Hatchery was the only homing location for the segregated spring Chinook, although Wells Hatchery was determined to be an "*en-route* hatchery". For the 10(j) program, any location within the Okanogan River basin was classified as a homing location, and all others were considered to be stray locations.

The percentage of strays was calculated by the formula:

$$\% \, Stray = \left\{\frac{NT}{NT+T}\right\}*100$$

Where:

NT = number of final detections at a non-target hatchery or tributary

T = number of final detections at a target hatchery or tributary

Assessment of Brood Year Strays Using CWT

To calculate stray rates, an "All Recoveries" query was submitted to the RMIS database for all the tag codes associated with a given release group. Fishery Codes were restricted to 50 (Hatchery) and 54 (Spawning Grounds), such that fish harvested in other fisheries prior to reaching a final destination were excluded from the analysis. The total sum of RMIS-provided "Estimated Number" field for each "Recovery Location Name" was used to determine the total number of fish returning to either home or stray locations.

Assessment of Return Year Strays Using PIT tags

Given the small sample size of CWT recovered within the Okanogan basin, it is useful to consider other information regarding the performance of the hatchery fish to meet their intended objectives. PIT tags offer an additional opportunity to evaluate straying and homing as supplemental information to the CWT assessment. To evaluate the return year stray rate using PIT tags, the PTAGIS database was queried for all segregated spring Chinook released from Chief Joseph Hatchery and 10(j) spring Chinook released from Riverside Pond for detections at the Bonneville Dam fishways in 2018. PTAGIS was then queried for the complete tag history of each group to determine each fish's final detection location. Fish with a final detection at an en route dam fishway were excluded from the stray rate calculation.

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 the Rocky Reach Dam Juvenile bypass (RRJ) and McNary Dam Juvenile bypass (MCN); see Figure 4. 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 were compared to nearby hatcheries with yearling spring Chinook releases.

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 (OKL), RRJ, MCN and Bonneville Dam were determined using queries of the PIT Tag Information System (PTAGIS) database (https://www.ptagis.org) and DART (http://www.cbr.washington.edu/dart). The OKL PIT tag interrogation site is located at rkm 25 and is within 2 km of the inundation effects of Wells Dam.

Figure 4. Overview of Okanogan Chinook migration corridor and points of interest throughout region.

Smolt-to-Adult Return

To calculate SAR using PIT tags, the following equation was employed:

$$\text{SAR} = \frac{PIT\ Tags\ Released}{PIT\ Tags\ Detected\ as\ Adults}$$

Where:

PIT tags Detected as Adults = the number of those PIT tags that were detected in following years at mainstem hydro projects, instream PIT arrays, or were detected as recaptured adult spring Chinook

PIT tags Released = the number of fish within a release group fitted with a PIT tag

To calculate SAR using coded wire tags, the following equation was used:

$$\text{SAR} = \frac{CWTs\ Released}{CWTs\ Detected\ as\ Adults}$$

Where:

CWT Released = the number of fish within a release group fitted with a CWT

CWT Detected as Adults = the number of those CWTs that were recovered in following years on the spawning grounds, hatcheries, and harvest

Coded Wire Tag Analysis

Coded wire tags 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 2017 to February 2018. Snouts were interrogated for the presence of a CWT by using a V-reader or T-wand (Northwest Marine Technology, Inc.; nmt.us). After positive detection, the snout was cut bilaterally into symmetrical portions keeping the half that indicated detection and discarding the other half. This process was then repeated until only a small piece of tissue containing the CWT remained. 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, read and recorded. 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 magnetic pencil (Northwest Marine Technology, Inc.) and inserted into a jig to be read under an LCD microscope with the aid of an illuminator. Biological data was transcribed from the snout card to a final CWT datasheet. The CWT was attached to this datasheet with tape after the six-digit code was read. Information from the datasheet was then transferred to an excel workbook which contained all applicable CWT code combinations.

CWT count data were expanded to account for tag loss and sample rate to estimate total catch contribution to a specific fishery. For each fishery, every decoded CWT was grouped according to their recovery code with the total number of CWT recovered from each release group. Mark rates are typically high (~99%) for most Upper Columbia River release groups. However, several mark groups of CJH spring and summer Chinook were tagged with coded wire at a rate of 20-25%. Therefore, adult returns without a CWT or an adipose fin were presumed to be from the CJH segregated program. We assigned these fish as CJH segregated "no wire" fish. To adjust for the number of "no tag" recoveries, the sum of "no tags" are subtracted from the sum of adjustment for missing tags. This value is then added to all expanded numbers to calculate total catch contribution.

$$CWTadjustment =$$

$$\frac{\left[\left(\frac{CWTrecovered}{Total\ tags}\right) * \ (Lost\ and\ scratched\ tags) + CWTrecovered\right] * \ Tag\ loss\ rate + cwt\ recovered}{Sample\ rate}$$

Where:

CWT recovered = Number of tags recovered for single unique tag code within a fishery or recovery location

Total tags = Number of tags recovered for a single fishery or recovery location

Lost & scratched tags = Sum of CWTs which were either lost or scratched (unreadable) in the CJHP coded wire tag Laboratory during processing

Tag loss rate = Rate of CWT loss as estimated by www.rmpc.org for single unique tag code

Sample rate = Rate of sampling for a single fishery or recovery location

Results

Rotary Screw Traps

The rotary screw trap was operated for the primary purpose of collecting summer Chinook from the mainstem Okanogan River (see Pearl et al 2021 for methods and results from the 2018 operation season). No natural-origin fish were captured that were likely yearling Chinook, therefore no tissue samples were collected in 2018.

Spring-Chinook Presence and Distribution

Several tributaries have produced consistent annual detections of Chinook eDNA going back to 2012, including Salmon Creek and Omak Creek. Results of eDNA surveys also show that Chinook have been present in Shingle and Vaseux creeks in most years. In 2018, we expanded our eDNA surveys to include two temporal sampling events, one in March to target juvenile production in tributaries and another in September to target spawning adults. Our goal with this expanded sampling strategy is to help determine which tributaries are providing habitat for successful spring-Chinook spawning, as evidenced by positive detections in March – when no adult spring Chinook would be present in the basin. We did not detect any Chinook eDNA during the March sampling event. Chinook were detected in many of the tributaries in the fall of 2017 and again in the fall of 2018 (Table 3). Based on the lack of detection during the March sampling event, if would appear that natural juvenile production in the tributaries is minimal, as detection rates for Chinook using eDNA have been determined to be quite high (0.98), especially during low flow periods (Laramie *et al* 2015).

Table 3. eDNA results for sampling conducted in Okanogan basin tributaries from 2012-2018.

Site	Jun 2012	Aug 2012	Oct 2013	Sep 2014	2015	Sep 2016	Sep 2017	Mar 2018	Sep 2018
01. Aeneas Creek			-	-		-	+	-	-
02. Antoine Creek			-	+		+	-	-	+
03. Bonaparte Creek	-	+		-		-	+	-	+
04. Inkaneep Creek	-	+		-		-	-	-	
05. Johnson Creek								-	+
06. Loup Loup Creek			-	+		+	+	-	+
07. Ninemile Creek	-	-		-		+		-	
08. North Fork Salmon Creek	-	-		-			-		-
09. Okanogan River (at Oroville boat launch)									
10. Okanogan River (above Salmon Cr.)	+	+		+			+		+
11. Okanogan River (at Inkaneep Cr.)	+	+		+			+		
12. Okanogan River (at Shuttleworth Cr.)	-	-		+					
13. Okanogan River (near Bonaparte Cr.)	+	+		+					+
14. Okanogan River (near mouth)	+	+		+			+		+
15. Okanogan River (near Omak Cr.)									+
16. Omak Creek (above falls)	-	-				+	+	-	+
17. Omak Creek (near mouth)	+	+		+		+	+	-	+
18. Omak Creek (Mission bridge)									
19. Salmon Creek (RKM 0.6)				+		+	+	-	+
20. Salmon Creek (RKM 2.9)									
21. Salmon Creek (RKM 7.1)	+	+		+		+	+	-	+
22. Salmon Creek (RKM 17.3)									
23. Salmon Creek (RKM 21.9)									
24. Salmon Creek (RKM 25.5)									
25. Shatford Creek								-	
26. Shingle Creek (Lower)	-	+		+		-	+	-	
27. Shingle Creek (Upper)								-	
28. Shuttleworth Creek	-	-		-		-		-	
29. Similkameen River			+	+			+		+
30. Siwash Creek			+					-	
31. Tonasket Creek			+			-		-	
32. Tunk Creek			-			+	+	-	+
33. Vaseux Creek	-	+		+		+	+	-	
34. Wanacut Creek			-			-	+	-	
35. West Fork Salmon Creek	-	-		-			-		-

+	Chinook DNA Detected
-	Chinook DNA Not Detected

Spring Chinook Run Escapement

In 2018, WDFW estimated the run escapement above Wells Dam consisted of 4,962 adult spring Chinook (Figure 5). This estimate does not include those fish who travelled above Wells Dam only to eventually reverse course and return downstream. This was the third consecutive year in which spring Chinook run escapement upstream of Wells Dam approximated 5,000 fish and was the first year with substantial returns from Chief Joseph Hatchery Program-released hatchery-origin spring Chinook. Although PIT tags had revealed a low level of historical occupancy and utilization of the Okanogan River basin by spring Chinook (Figure 5), in 2018 a much higher proportion of returning adult spring Chinook entered the Okanogan River and its tributary streams than had been the historical norm. The detection efficiency of the OKL PIT array was estimated to be 82%, based on 271 adult spring Chinook PIT detections in the Okanogan basin with 41 that were not detected at OKL but were detected at an array upstream of OKL. Run escapement estimates generated for specific PIT array locations and Okanogan River tributary streams are presented in Table 4.

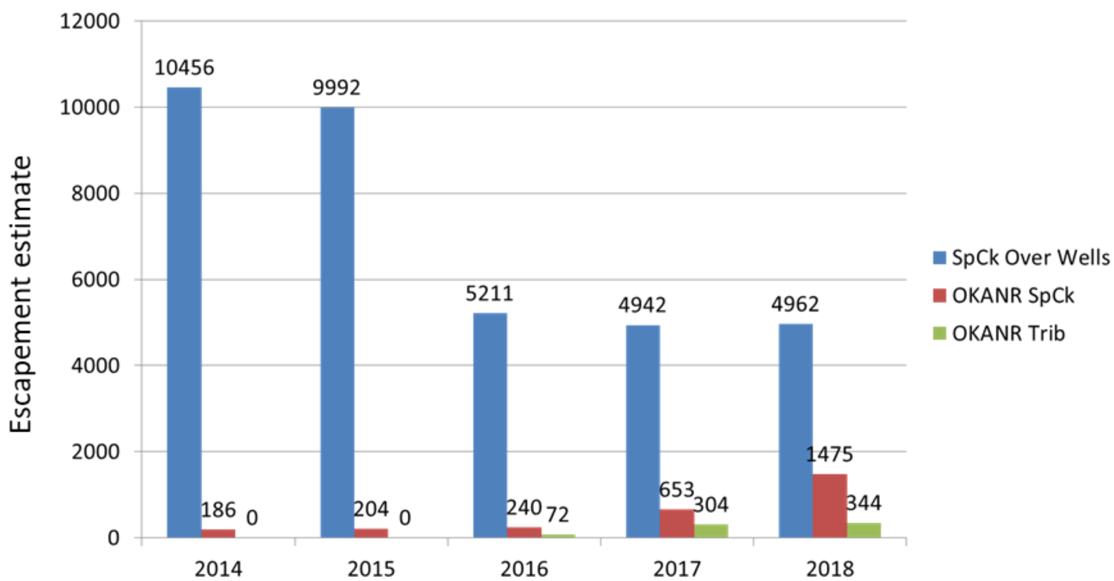

Figure 5. Annual Spring Chinook (SpCk) run escapement above Wells Dam, estimate provided by WDFW. OKANR SpCk is the estimated spring Chinook salmon run escapement estimate to the Okanogan River basin. OKANR Trib is the total run escapement estimate for spring Chinook to Okanogan River tributary streams.

Table 4. 2018 Run escapement estimates for specific Okanogan River locations and tributary streams. Note that there is not a PIT array within the Similkameen River, whose estimate was generated through carcass recoveries.

Stream	2018 Run Escapement Estimate	
	Hatchery	Natural-origin
Okanogan and Similkameen Mainstem[3]	1,089	68
Loup Loup Creek	100	0
Salmon Creek	29	0
Omak Creek	73	0
Johnson Creek	93	0
Bonaparte Creek	0	0
Antoine Creek	0	0
Zosel Dam	8	0
Okanagan Mainstem[4]	145	5
Vaseux Creek	6	0
Skaha Dam	11	0
Shingle Creek	0	0
Total	1,401	73

Escapement into Canada

Methodological uncertainties have limited our confidence in Chinook escapement estimates into the Canadian portion of the Okanogan basin. To date, estimates were primarily based on video counts of fish ascending the passageway at Zosel Dam. However, due to the variations in dam operations, we were uncertain of the proportion of fish that were passing by the video system, and thus, available for counting. Additionally, fish fallback and re-ascension was known to occur, as indicated by limited PIT tag data, though the frequency of occurrence was poorly understood. With these uncertainties in mind, 2017 was the final year for the Zosel video project. A run escapement is provided from the WDFW PIT tag group based on final detections in the Canadian portion of the Okanogan basin (Table 4).

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[3] Okanogan and Similkameen Mainstem captures spring Chinook with a final detection at the OKL PIT array, near Malott, WA.
[4] Okanagan Mainstem captures spring Chinook with a final detection at the OKC PIT array, near Oliver, BC, Canada

Redd Surveys

In 2018, walking surveys occurred from 15 August until 25 September.. Float surveys in the Similkameen River occurred weekly from July 24 through August 22, until they ended due to staffing constraints. Streams were surveyed between 1 and 5 times. Surveyed streams, barriers to anadromy, and locations of detected redds are shown in (Figure 6).   Omak Creek was the only stream in which we found Chinook redds, although we also found live Chinook in Johnson and Salmon creeks (in addition to Omak Creek). Additional results from the 2018 spring Chinook spawning ground surveys are presented below in Table 5 and Table 6.

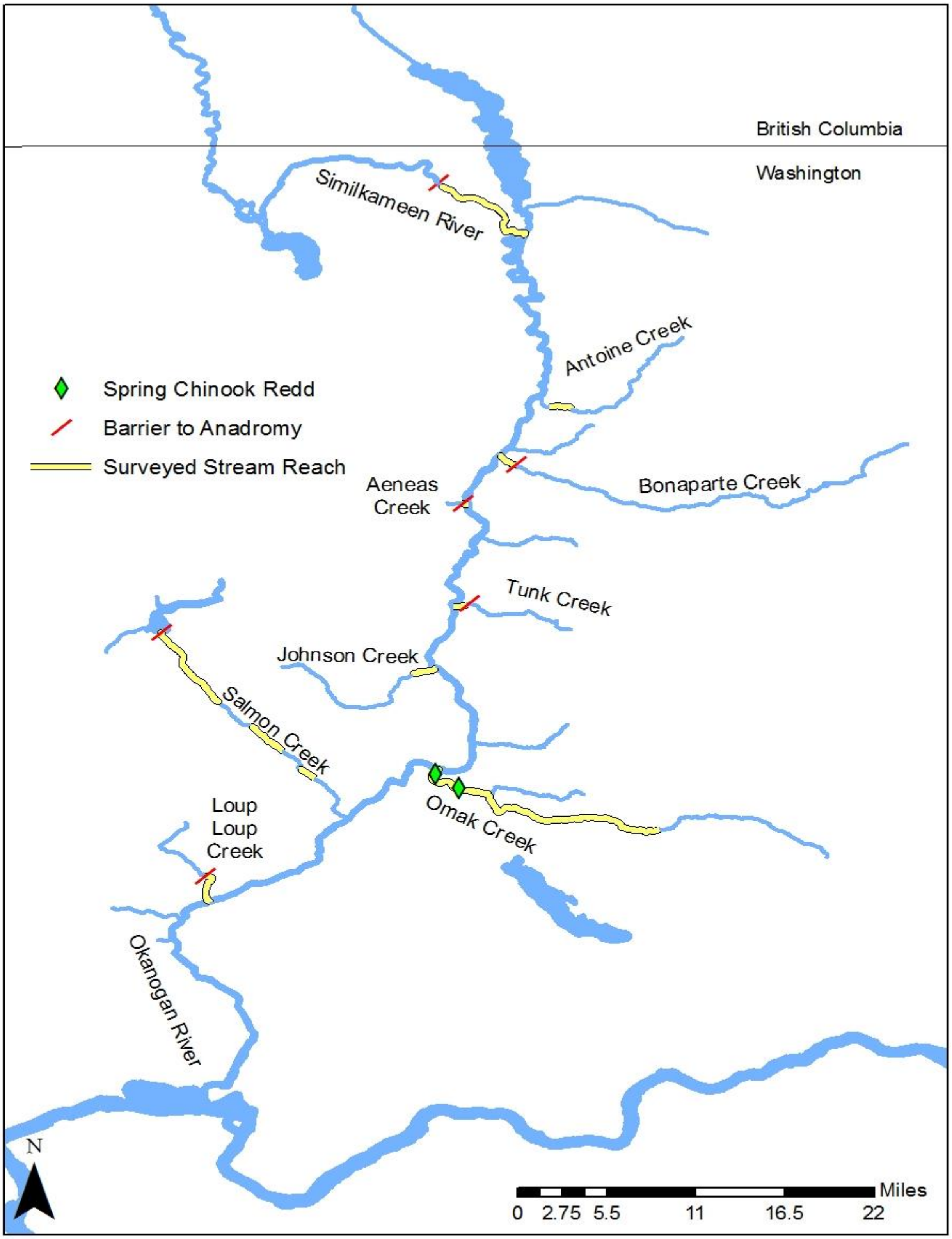

Figure 6. Map of the Okanogan River basin spring Chinook redd survey area. All spring Chinook redds detected in 2018 are marked by green diamond symbol.

Table 5. Total number of redds, live fish, and carcasses detected in the Okanogan River basin streams.

Stream	Number of surveys	Redds Detected	Live Fish Detected	Carcasses Detected
Loup Loup Creek	2	0	0	0
Salmon Creek	4	0	1	0
Omak Creek	4	2	2	0
Johnson Creek	1	0	1	0
Tunk Creek	1	0	0	0
Aeneas Creek	1	0	0	0
Bonaparte Creek	1	0	0	1
Antoine Creek	1	0	0	0
Similkameen River	5	0	N/A	17*

*Both summer and spring Chinook carcasses detected in the Similkameen River, and carcass assignment to a particular run could not be completed with 100% confidence. 17 carcasses were detected, of which 6 contained PIT tags characterizing them as spring Chinook. One of the six PIT-tagged carcasses that had been designated a spring Chinook upon tagging at Wells was later determined, by extracting and reading its coded wire tag, to be a summer Chinook.

Table 6. Number and timing of spring Chinook redd counts in tributaries of the Okanogan River basin in 2018.

Tributary	Aug. 12-18	Aug. 19-25	Aug. 26-Sept. 1	Sept. 2-8	Sept. 9-15	Sept. 16-22	Sept. 23-29	Redd Count	%
Antoine Creek	0	0	0	0	0	0	0	0	0%
Aeneas Creek	0	0	0	0	0	0	0	0	0%
Bonaparte Creek	0	0	0	0	0	0	0	0	0%
Johnson Creek	0	0	0	0	0	0	0	0	0%
Loup Loup Creek	0	0	0	0	0	0	0	0	0%
Omak Creek	0	0	0	0	0	2	0	0	100%
Salmon Creek	0	0	0	0	0	0	0	0	0%
Tunk Creek	0	0	0	0	0	0	0	0	0%
	0	***0***	***0***	***0***	***0***	***2***	***0***	***0***	100%

Carcass Surveys

Coded wire tags were recovered from 11 carcasses recovered during spawning grounds surveys. Of these tags, one was scratched, and three belonged to hatchery-origin summer Chinook pre-spawn mortality carcasses that were recovered in the Similkameen River during spring Chinook spawning ground surveys. Table 7 provides data on coded wire tags recovered from spring Chinook.

Table 7. Coded wire tags recovered in 2018 Okanogan spring Chinook spawning grounds surveys

CWT	Brood Year	Fresh/Salt Age	Rearing Hatchery	Release Location	Recovery Location	Carcasses Recovered	10(j) Release?
200117	2014	1.2	Chief Joseph Hatchery	Okanogan River	Similkameen River	6	Yes
055239	2014	1.2	Winthrop NFH	Methow River	Similkameen River	1	No

All recovered carcasses that were ultimately determined to be spring Chinook are included in Table 8 A total of 18 carcasses were recovered during spring Chinook spawning grounds surveys, one at Bonaparte Creek and the remainder in the

Similkameen River. Of these carcasses, nine were ultimately determined to be spring Chinook – the Bonaparte Creek fish and eight from the Similkameen River. The others were classified as summer Chinook. All recovered carcasses were pre-spawn mortalities.

Table 8. Spring Chinook carcasses recovered in 2018 Okanogan spring Chinook spawning grounds surveys

Recovery Date	Fork Length (cm)	Recovery Location	Origin	Sex
7/31/2018	75	Similkameen River	Hatchery	F
8/8/2018	76	Similkameen River	Hatchery	M
8/14/2018	77	Similkameen River	Hatchery	F
8/14/2018	78	Similkameen River	Hatchery	M
8/14/2018	71	Similkameen River	Hatchery	M
8/14/2018	77	Similkameen River	Hatchery	M
8/14/2018	65	Similkameen River	Hatchery	M
8/14/2018	70	Similkameen River	Hatchery	M
9/6/2018	67	Bonaparte Creek	Hatchery	M

Spawning Escapement

Two redds were detected, both within Omak Creek. All reaches of Omak Creek which are accessible to anadromy and suitable for spring Chinook spawning were surveyed. The fish per redd ratio in 2018 was 2.301. This resulted in a total spawn escapement estimate of 5 spring Chinook[5]. Mark-recapture population estimation efforts were thwarted by low numbers of carcass recoveries. Only one carcass was detected outside of the Similkameen River, and, since there was only a single pass survey of Bonaparte Creek and therefore no opportunity for recapture. Within the Similkameen River, there were no recaptures, so no population estimate or estimate of total pre-spawn mortality could be calculated based on mark-recapture data.

[5] This spawner escapement should be interpreted with care; calculation methodology results in a precise estimate which belies the uncertainty in the estimate generated by an incomplete sample across the basin and relatively few total redds detected.

The only tributary occupied by spawning spring Chinook in the Okanogan river basin in 2018 was Omak Creek (**Error! Reference source not found.**). There was no documented mainstem spawning.

pHOS and PNI

pHOS could not be calculated because not enough redds or carcasses were observed to get a valid estimate. The PIT-based run escapement resulted in an estimate of 5% NORs (n = 73) in the Okanogan basin. PNI was not calculated because it is not a relevant metric for either program.

Hatchery-Origin Stray Rates

CWT Assessment of Brood Year and Return Year Stray Rates

Strays outside the Okanogan— The most recent brood year that could be fully assessed (through age 5) for stray rate of Okanogan 10(j) fish to spawning areas outside the Okanogan was 2013. There were zero carcass recoveries in the target stream (Okanogan), which biased the CWT-based stray/homing rate evaluation because the PIT tag run escapement estimate predicted that 1,401 hatchery spring Chinook returned to the Okanogan and most of them were likely from the 10(j) program. However, using the CWT recovery data for the Okanogan 10(j) program, the 2013 brood year had a stray rate of 15.4% (estimated 32) to non-target streams and 1.3% to non-target hatcheries (Table 9). All of the non-target hatchery recoveries for BY2013 occurred at the Winthrop National Fish Hatchery (WNFH). Returns to CJH comprised 80.7% of the recoveries. The objective of this program is to return fish to the Okanogan River and technically, the fish that return to CJH are considered strays. However, these fish are raised at CJH from egg to fall parr, essentially acclimated to the Columbia River during this early life stage, so a relatively high return rate to that facility should be expected. Despite the high return rate to CJH, the run escapement trend in the Okanogan suggests that the program is successful at reintroducing fish to the Okanogan.

For return year 2018, an estimated 49 Okanogan 10(j) fish strayed to the Methow River basin and represented 11.9% of the Methow total spawning escapement and 80.2% of all recoveries in 2018 (Table 10). There were an estimated 6 (9.9% of all recoveries) fish recovered in the Similkameen River, 5 (8.3% of all recoveries) recovered at the CJH and no recoveries at the WNFH in 2018. CJH segregated spring Chinook had a lower stray rate to non-target streams and hatcheries. For BY13, the stray rate for non-target streams and hatcheries was 2.1% and 0.0%, respectively

Table 11). The homing rate to the Chief Joseph Hatchery was 96.5%.

For return year 2018, an estimated 6 CJH segregated fish strayed to the Methow River basin and represented 1.5% of the Methow total spawning escapement and 4.9% of all recoveries in 2018 (Table 12). There were an estimated 1 (0.9% of all recoveries) fish recovered in the Okanogan River and 115 (92.6% of all recoveries) recovered at the CJH in 2018.

Table 9. Number and percent (%) of hatchery-origin Okanogan 10(j) spring Chinook that were recovered at target spawning areas, and number and percent that strayed to non-target spawning areas and non-target hatcheries, brood years 2013 and 2014. Values are derived from coded wire extractions and expansions. 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						En Route Fish	
	Target Stream		Non-target Streams		Non-target Hatchery		CJH Returns		Wells Hatchery	
	Number	%	Number	%	Number	%	Number	%	Number	%
2013	0	0.00%	32	15.1%	3	1.3%	168	80.7%	6	2.9%
2014	12	12.7%	56	61.1%	0	0.0%	23	25.1%	1	1.1%
Total	***12***	***4.0%***	***88***	***29.2%***	***3***	***1.0%***	***191***	***63.5%***	***7***	***2.3%***

Table 10. Number and percent (%) of total spawning escapements that consisted of hatchery-origin Okanogan 10j spring Chinook within other non-target basins, return years 2017-2018.

Return Year	Wenatchee		Methow		Entiat	
	Number	%	Number	%	Number	%
2017	0	0.0%	6	1.8%	0	0.0%
2018	0	0.0%	49	11.9%	0	0.0%
Total	***0***	***0.0%***	***55***	***6.9%***	***0***	***0.0%***

Table 11. Number and percent (%) of Chief Joseph Hatchery spring Chinook that were recovered at target spawning areas, and number and percent that strayed to non-target spawning areas and non-target hatcheries, brood years 2013 and 2014. Values are derived from coded wire extractions and expansions. 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				En Route Fish	
	Target Hatchery		Non-target Streams		Non-target Hatchery		Wells Hatchery	
	Number	%	Number	%	Number	%	Number	%
2013	268	96.5%	6	2.1%	0	0.0%	4	1.4%
2014	134	94.2%	8	5.8%	0	0.0%	0	0.0%
Total	***402***	***95,4%***	***14***	***4.0%***	***0***	***0.0%***	***4***	***0.6%***

Table 12. Number and percent (%) of total spawning escapements that consisted of hatchery-origin Chief Joseph Hatchery spring Chinook within other non-target basins, return years 2017- 2018.

Return Year	Wenatchee		Methow		Entiat	
	Number	%	Number	%	Number	%
2017	0	0.0%	6	1.8%	0	0.0%
2018	0	0.0%	6	1.5%	1	6.3%
Total	***0***	***0.0%***	***12***	***1.7%***	***0***	***3.1%***

PIT Tag Assessment of Return Year Stray Rates

Fourteen PIT tags from the CJH segregated spring Chinook program were detected at Bonneville Dam as returning adults in 2018. Nine of these fish had a final detection at an dam ladder and were excluded from the analysis. The remaining five fish all returned to CJH, resulting in a 100% homing rate and 0% stray rate (Table 13). The results of this assessment are highly uncertain based on the small sample size.

Twenty-eight PIT tags from the Okanogan 10(j) spring Chinook program were detected at Bonneville Dam as returning adults in 2018. Ten of these fish had a final detection at an dam ladder and were excluded from the analysis. For fish homing to the Okanogan, an adjustment for detections at OKL was applied to account for the 82% detection efficiency of that site, resulting in the addition of one fish estimated to have entered the Okanogan. The homing rate to the Okanogan was 58% and the stray rate was 42% (Table 14). Notably, 100% of the strays had returned to the CJH, where they had been reared from egg to fall parr.

Table 13. Summary of strays and homing for segregated spring Chinook released from Chief Joseph Hatchery for adult return year 2018.

Destination	Number	Percent	H:S %
Homing	5	36%	100%
Stray	0	0%	0%
En route dam final detection	9	64%	
Total	14	100%	100%
Destination for strays			
Chief Joseph Hatchery	14	100%	
Other hatchery	0	0%	
Other tributary	0	0%	

Table 14. Summary of strays and homing for Okanogan 10(j) spring Chinook released from Riverside Pond for adult return year 2018.

Destination	Number	Percent	H:S %
Homing*	11	38%	58%
Stray	8	28%	42%
En route dam final detection	10	35%	
Total	29	100%	100%
Destination for strays			
Chief Joseph Hatchery	8	100%	
Other hatchery	0	0%	
Other tributary	0	0%	

*Returns to the lower Okanogan PIT array were adjusted for a detection efficiency of 82%

Smolt-to-Smolt Survival and Travel Time

Apparent survival of spring Chinook yearlings in 2018 to RRJ was 71% for the segregated program released from CJH and 70% for the 10j reintroduction fish released from Riverside Pond (Table 15). Survival to RRJ was slightly less than the nearby program at WNFH (76%) and similar to previous years (Table 15; Figure 7).

Apparent survival of spring Chinook segregated yearlings from CJH to McNary Dam (MCN) was 44%. Survival to McNary Dam was considerably higher for both the 10j reintroduction fish released from Riverside Pond (60%) and the nearby program at WNFH (59%) as well as LNFH (66%) (Table 15). It is unclear why there was lower survival to MCN for the segregated program in 2018. Despite the lower survival compared to other programs in 2018, survival to McNary Dam for segregated CJH spring Chinook was similar to two of the last three previous years (Figure 8).

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

Table 15. Apparent survival estimates to McNary Dam (MCN) and Rocky Reach Dam (RRJ) for PIT tagged spring Chinook Salmon smolts released from Chief Joseph hatchery (CJH), Winthrop National Fish Hatchery (WNFH) and Leavenworth National Fish Hatchery (LNFH) in 2018.

Spring Chinook Release Group	# PIT tags Released	# PIT tags Recap.	Reach	Survival	Survival Standard Error (SE)	Capture Prob.	Capture Prob. (SE)
Yearlings released at CJH	4970	852	Release to RRJ	0.71	0.05	0.24	0.02
		219	Release to MCN	0.44	0.07	0.10	0.02
Yearlings released at Riverside (10j)	4356	650	Release to RRJ	0.70	0.05	0.21	0.02
		251	Release to MCN	0.60	0.10	0.10	0.02
Yearlings released at WNFH	19882	4427	Release to RRJ	0.76	0.02	0.29	0.01
		890	Release to MCN	0.59	0.05	0.08	0.01
Yearlings released at LNFH	19713	1876	Release to MCN	0.66	0.04	0.12	0.01

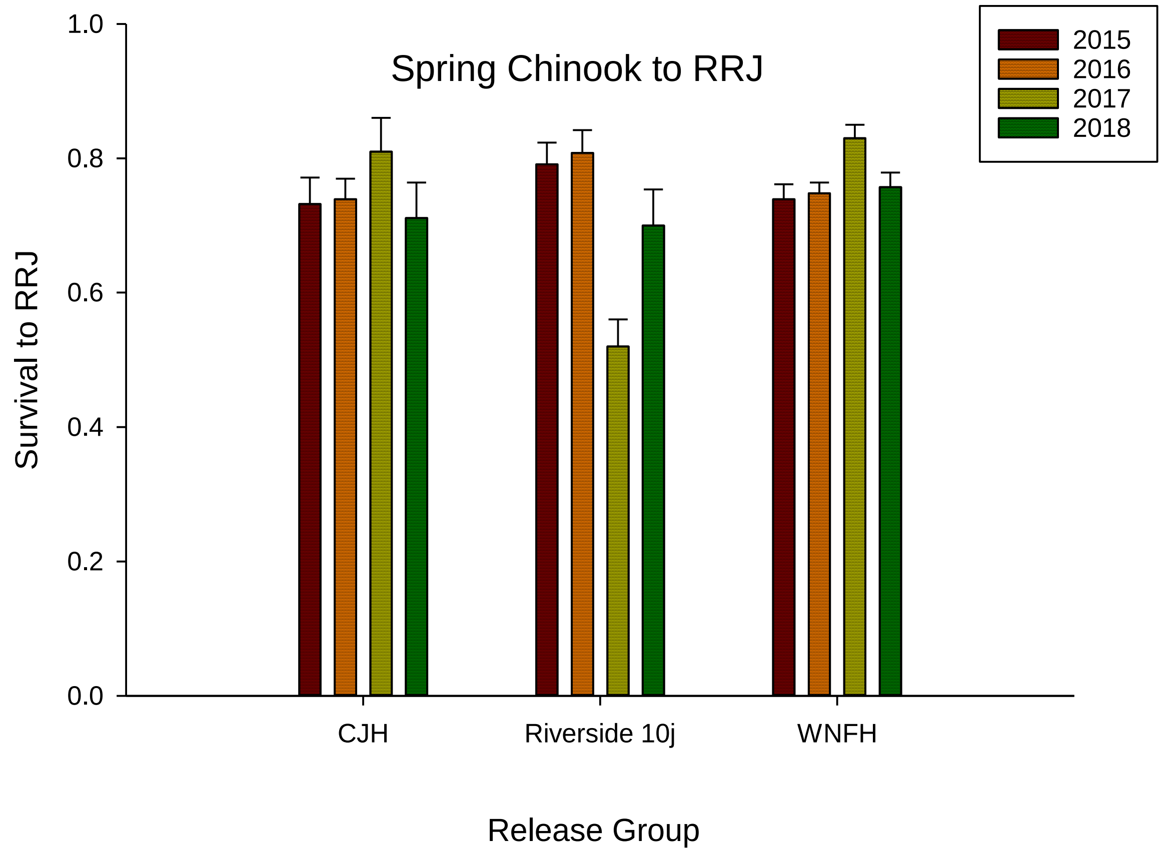

Figure 7. Spring Chinook smolt survival (mean and standard error) from release at Chief Joseph Hatchery (CJH), Riverside Pond and Winthrop National Fish Hatchery (WNFH) to the juvenile collection facility at Rocky Reach Dam from 2015 to 2018.

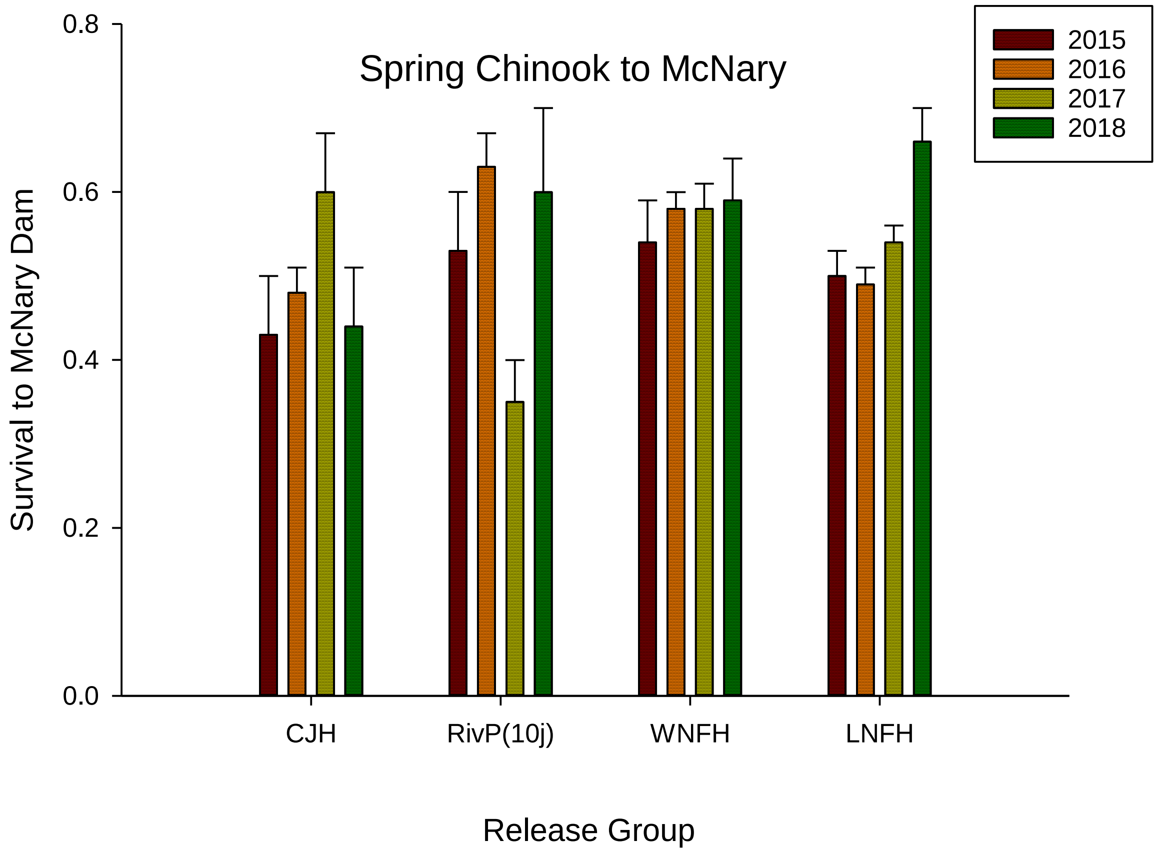

Figure 8. Spring Chinook smolt survival (mean and standard error) from release at Chief Joseph Hatchery (CJH), Riverside Pond (RivP(10j)), Winthrop National Fish Hatchery (WNFH) and Leavenworth National Fish Hatchery (LNFH) to McNary Dam from 2015 to 2018.

Releases of spring Chinook smolts began on April 16, 2018. Of the 4,356 PIT tagged 10j fish released from Riverside Pond (rkm 64), only 14 were detected at the Lower Okanogan PIT detection array. Fifty percent passed OKL within 4 days and 90% passed within 12 days. The mean travel time of spring Chinook released from CJH facilities to RRJ in 2018 was 13.9 days (8.4 km/day) for the segregated spring Chinook released from CJH and 17.4 days (9.3 km/day) for the 10(j) reintroduction fish from Riverside Pond (Table 16). CJH segregated spring Chinook and 10(j) fish from Riverside had similar travel times to McNary (mean 25 days; 90% passage 33-35 days), despite a 46 km shorter journey and a forced versus volitional release strategy. The slower migration rate of the CJH fish was more evident by looking at Bonneville Dam, where the 10(j) spring Chinook from Riverside Pond and the WNFH fish reached Bonneville Dam 2-6 days later on average with a 90% passage date that was 7-10 days slower. The majority of spring Chinook from CJH and Riverside Pond arrived at RRJ from late April to mid-May, with 90% passage dates of May 10 and May 12, respectively (Figure 9). 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. The migration rate in 2018 was similar to the average from 2015 to 2018 for both programs (Table 17).

Table 16. Travel time and migration speed for spring Chinook release groups in 2018.

Release Group	Release timing	Release Strategy	Release to RRJ Mean Travel Time (d)	Release to RRJ 90% Passage (d)	Release to RRJ Travel Rate (km/day)	Release to MCN Mean Travel Time (d)	Release to MCN 90% Passage (d)	RRJ to MCN Travel Rate (km/day)	Release to BON Mean Travel Time (d)	Release to BON 90% Passage (d)	MCN to BON Travel Rate (km/day)
CJH Spring Chk	Apr 16-17	Forced	14	25	8.4	25	35	23.8	32	46	58.3
RivP Spr Chk (10j)	Apr 16-19	Volitional	17	27	9.3	25	33	31.7	30	39	60.9
Winthrop Spring Chk	19-Apr	Forced	11	20	14.6	22	31	24.5	26	36	60.6
LNFH Spr Chk	Apr 17-23	Forced	NA	NA	NA	19	32	17.8 [a]	23	37	54.8

[a] Release to McNary, not Rocky Reach to McNary

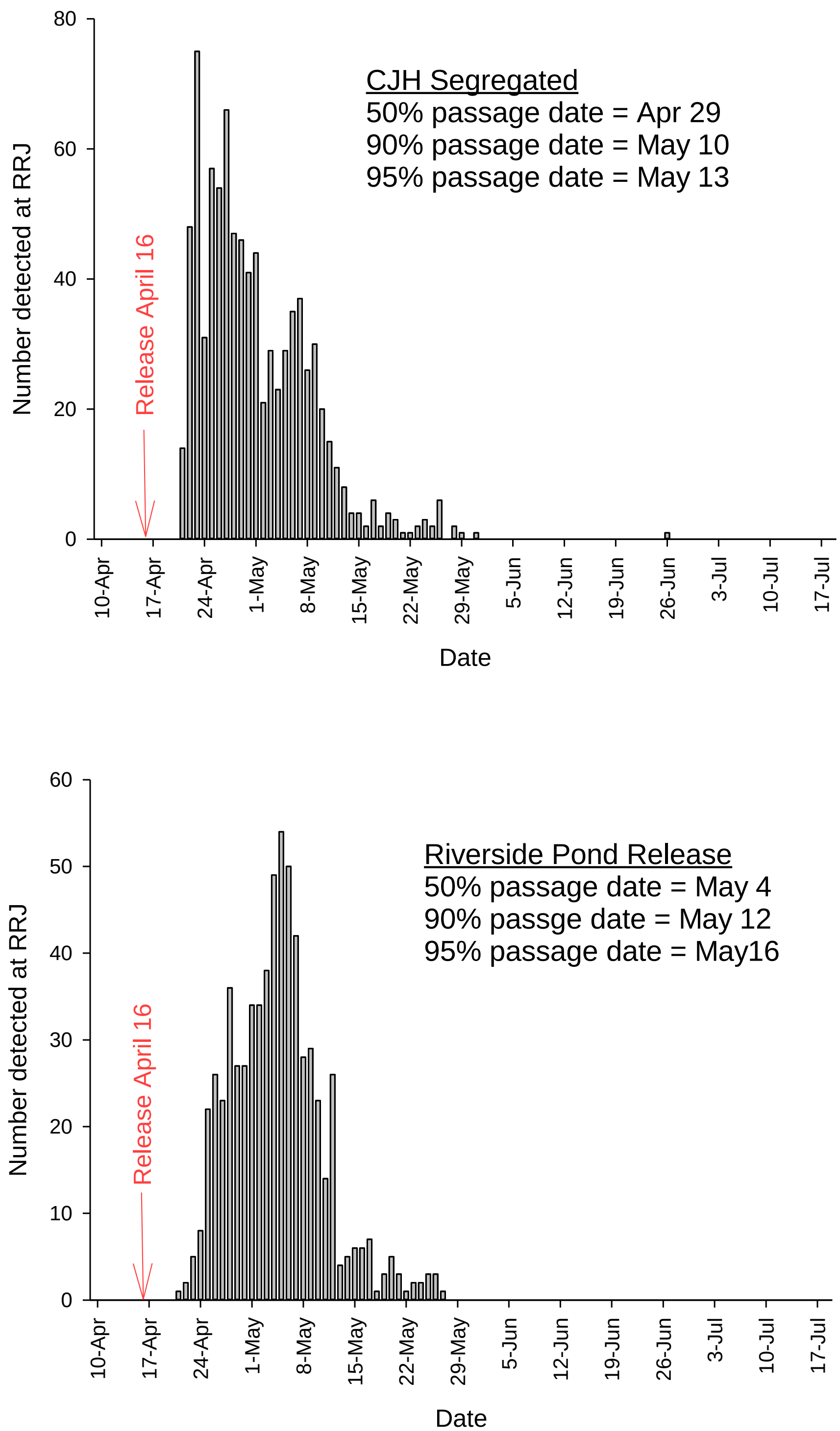

Figure 9. Arrival timing at Rocky Reach Juvenile bypass (RRJ) of PIT tagged spring Chinook released from the Chief Joseph Hatchery (CJH) and Riverside Pond in 2018.

Table 17. Mean travel time and 90% passage time (days) for spring Chinook released from Chief Joseph Hatchery and the Riverside Pond from 2015 to 2018.

		Rocky Reach Dam		McNary Dam		Bonneville Dam	
Release Group	**Year**	**Mean Travel Time (d)**	**90% Passage (d)**	**Mean Travel Time (d)**	**90% Passage (d)**	**Mean Travel Time (d)**	**90% Passage (d)**
CJH Spring Chinook Segregated	2015	31	43	41	54	42	53
	2016	14	27	23	34	26	37
	2017	10	24	18	29	21	35
	2018	14	25	25	35	32	46
	Average	**17**	**30**	**27**	**38**	**30**	**43**
Okanogan 10(j) Spring Chinook Riverside Pond	2015	15	23	27	33	32	39
	2016	12	23	21	30	24	35
	2017	23	34	33	43	35	46
	2018	17	27	25	33	30	39
	Average	**17**	**27**	**26**	**35**	**30**	**40**

Smolt-to-Adult Return (SAR)

The most recent brood year that could be fully assessed (through age 5) for SAR was 2014. We estimated the SAR using two methods, PIT tags and coded-wire tags.

PIT based estimate—SAR from release back to Bonneville and Wells Dam adult fish ladders were assessed, although sample sizes of returning adults were very small, leading to a high level of uncertainty in the results of the PIT-based estimate. CJH specific harvest rates were not available for the fisheries below Bonneville Dam (Zones 1-5), therefore the average harvest rate on all spring Chinook below Bonneville Dam was used to estimate the harvest rate on CJH fish.

For CJH segregated spring Chinook from brood year 2014 (outmigration year 2016), 14 adult fish (age 4&5) returned to Bonneville Dam with a PIT tag, resulting in SAR estimates of 0.28% before harvest and 0.30% with harvested fish added back in (Table 18).

For the 10j reintroduction program released from Riverside Pond, 24 adult fish (age 4-5) returned to Bonneville Dam with a PIT tag, resulting in SAR estimates of 0.48% before harvest and 0.49% with harvested fish added back in (Table 18). An important difference in the SAR estimates between the two groups was that, starting in brood year 2014, the 10j reintroduction fish were adipose present, and therefore were excluded from harvest in the non-treaty sport fishery. Therefore, harvest on this group was limited to incidental mortality from catch and release and the treaty fisheries between Bonneville and McNary dams.

Table 18. PIT-based SAR estimates for spring Chinook released from the Chief Joseph Hatchery (segregated) and Riverside Pond (10j reintroduction). Jacks were not included in the SAR calculation. The upriver spring Chinook harvest rates reported by the Technical Advisory Committee of US v. Oregon were used to adjust PIT return numbers and estimate total 'with harvest SAR'.

CJH Segregated Spring 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		Without Harvest SAR	With Harvest SAR
2013	4970		1	3	8	0	0		0.16%	0.17%
2014	4967		0	0	12	2	NA		0.28%	0.30%
2015	4970		5	1	11	NA	NA		0.22%	0.23%
			PIT Tag Detections at Wells Dam							
2013	4970		0	3	5	0	0		0.10%	0.12%
2014	4967		0	0	8	2	NA		0.20%	0.23%
2015	4970		1	1	8	NA	NA		0.16%	0.18%
Riverside Pond 10j reintro. Spring Chinook			PIT tag Detections at Bonneville Dam							
Brood Year	Number of PIT tags		Age 2 Mini-Jack	Age 3	Age 4	Age 5	Age 6		Without Harvest SAR	With Harvest SAR
2013	4902		0	9	26	0	0		0.53%	0.57%
2014	4959		6	6	23	1	NA		0.48%	0.49%
2015	5036		3	5	9	NA	NA		0.18%	0.18%
			PIT Tag Detections at Wells Dam							
2013	4902		1	8	18	0	0		0.37%	0.42%
2014	4959		0	6	18	1	NA		0.38%	0.42%
2015	5036		0	5	4	NA	NA		0.08%	0.09%

CWT-Based Estimate—Based on expanded CWT's, the 2013 brood year for the Okanogan 10j spring Chinook had a SAR of 0.16%. BY14 had an SAR of 0.05%, however, this number may change as more adult captures from BY14 are uploaded to the RMIS database, and this table changes in the coming years to reflect those data (Table 19). For the BY13 CJH spring Chinook the SAR was 0.17% (Table 20). BY14 had an SAR of 0.14%, however, this number may change as more adult captures from BY14 are uploaded to the RMIS database.

Table 19. Smolt-to-adult return rate (SARs) for Okanogan 10j spring Chinook, brood years 2013-2014.

Brood Year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
2013	195,145	309	0.16%
2014	191,112	96	0.05%
Total	***386,257***	***405***	***0.10%***

[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.

Table 20. Smolt-to-adult return rate (SARs) for Chief Joseph Hatchery spring Chinook, brood years 2013-2014

Brood Year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
2013	201,090	349	0.17%
2014	188,455	248	0.13%
Total	***389,545***	***597***	***0.15%***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).
[b] Includes estimated recoveries (spawning grounds, hatcheries, all harvest - including the ocean and Columbia river basin, etc.) and observed recoveries if estimated recoveries were unavailable.

Spring Chinook Harvest

The Chief Joseph Dam Tailrace and mainstem Columbia River fishery opened to tribal fishermen following the commencement of the First Salmon ceremony held on May 25th, 2018. This is an annual ceremony hosted by The Confederated Tribes of the Colville that marks the return of spring Chinook to the region and is a tradition that has been practiced for many years. Upon completion, tribal fishermen were allowed to use selective gear to target non-ESA listed, hatchery-origin, Carson stock spring Chinook returning to CJH as adults and jacks. Hook and line fishing, along with dip and hoop net are the only authorized gear types in these areas. This fishery is regulated to avoid significant take of ESA-listed spring Chinook as well as summer steelhead which are included in the Upper Columbia River Evolutionary Significant Units (ESUs).

Tribal fishermen may retain spring Chinook that do not have an adipose fin, as well as Sockeye that do not have a Floy tag, however all Steelhead, Bull trout and Sturgeon must be released. All fish that show external markings such as: Floy, radio and tail-punches must be released as well. An expanded, 97.5 ad-absent spring Chinook were harvested with release mortality on ad-present spring Chinook assessed at 2.5, for a total harvest of 100.0 spring Chinook (Table 21). All ad-present Chinook released were assessed at a 5% mortality rate which is added to the harvest total. All angler effort came from the hook and line gear type. This fishery was closed on June 27, 2018 to allow for the collection of broodstock via the CJH ladder.

Table 21. Expanded tribal harvest of ad-clipped spring Chinook at the Chief Joseph Dam tailrace and Columbia River mainstem fisheries.

	Ad-Absent Harvest	Incidental Mortality	Effort Hours	Harvest Per Unit Effort (HPUE)
2017	79.3	0.5	908.8	0.087
2018	97.5	2.5	407.3	0.252

DISCUSSION

Spring-Chinook Run Escapement

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

PIT tags have been another important tool for monitoring the progress of reintroduction efforts. Since 2016, 5,000 spring Chinook have escaped above Wells Dam, but 2018 was the first year with substantial returns from CJH releases. A much higher proportion of these returns entered the Okanogan basin. The majority of the run escapement (65%) occurred in the mainstem Okanogan River, followed by Loup Loup Creek (7%), Johnson Creek (6%) and Omak Creek (5%). The WDFW mark-recapture study at Wells Dam will continue to provide valuable information for returns from the reintroduction program to the Okanogan basin

Escapement into Canada

Approximately 11% of the run escapement into the Okanogan basin was estimated to be in Canada, based on the PIT detection mark recapture methodology. Coordination with Okanagan Nation Alliance (ONA) regarding monitoring of Chinook returns will be important because it is apparent that the returning 10(j) fish are going to Canada and that the streams in Canada show good potential to support spring Chinook production.

Spawning Escapement

Despite the relatively high run escapement estimates, spring Chinook spawning ground surveys from July through September 2018 showed very little evidence of spawning. It is unclear why there was such a large discrepancy between run escapement and spawning escapement. The difference may be due to high pre-spawn mortality (although we did not find many carcasses), survey deficiencies, poor spawning habitat conditions, including limited areas of suitable substrate, poor flow, and warm water temperatures. However, 2018 was the first year of "boots on the ground" spawning grounds surveys. It would be premature to form any sweeping conclusions. In future years, greater coverage of potential spawning areas, stronger returns of adult fish, or refined methodologies could all potentially result in greater total spawning escapement estimates.

Hatchery-Origin Stray Rates

The homing and straying results for the 10(j) program should be interpreted cautiously. Recovery of spring Chinook carcasses in the natural environment is difficult, and constrained by environmental conditions, access to locations where carcasses may be present, and carcass recovery efforts. Due to the general lack of success in recovering spring Chinook carcasses in the Okanogan River basin (see Spawning Grounds), the homing and straying data based on CWT for the 10(j) program is biased. Therefore, the accuracy of straying and homing rates reported in the results are highly uncertain, but the observations of Okanogan (10(j) returns to the Methow basin are useful. Given that the origin of the brood for the Okanogan 10(j) program are from the Methow, it was not surprising that some returned there and the risk of these strays to the Methow population is minimal. Further evidence of the inaccuracy of the stray rate is provided by the run escapement estimate to the Okanogan River based on PIT tags. Based on the observed increase in spring Chinook run escapement to the Okanogan following the reintroduction of the 10(j) program, it is apparent that a high percentage of 10(j) spring Chinook are returning to the Okanogan. Both the CWT and PIT tag assessments indicated that Okanogan 10(j) fish also commonly return to the CJH. This result is understandable considering that these fish were reared from egg to fall parr at that facility. Although the fish that return to CJH would fail to meet the objective of the reintroduction program, they pose relatively little risk to other tributary populations. The return of Okanogan 10(j) fish to the CJH is likely an unavoidable consequence of the necessary rearing practices. Considering the positive trend in run escapement to the Okanogan, it is apparent that the program is successfully providing returning adults to the Okanogan, despite some straying to CJH and the Methow basin.

The CWT and PIT data for the segregated program suggest a high fidelity for homing back to CJH. For the CWT assessment, this result may have been biased high in the Okanogan due to the low carcass recoveries, but the observation of a low stray rate to the other downstream tributaries is encouraging.

The PIT tag assessment of straying and homing had limited utility due to small sample size, but it did provide a useful supplement to the CWT assessment. In future years with better ocean survival we anticipate more confidence and utility of the PIT tag assessment of straying and homing.

Smolt to Smolt Survival and Travel Time

The survival results for each release group provide a useful index of annual survival for comparison between release groups and, in the future, between years. Statistical tests were not conducted to determine if observed differences were statistically valid because we believe this should be done with a multi-year dataset and the few total years for which we currently have results. Targets for post release survival have not been established, but it was encouraging to see that the 2018 estimates of CJH programs were similar to previous years and nearby programs. In the future, with more years of smolt migration data, the program should develop a statistical framework for evaluating smolt-to-smolt survival and establish targets that could be used to help adaptively manage the release strategies, if it is determined that survival or travel time are not adequate to meet program goals. This analysis may also be useful for adjusting pre-season forecasts based on higher or lower than normal outmigration survival. Similar to previous years, the hatchery fish migrated out of the system relatively quickly in 2018, with no detections of migrants in the Okanogan after April 29. 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.

This assessment of year 2018 performance suggests that the program was successful at releasing actively migrating smolts. This analysis did not attempt to account for detection probability at OKL. It is likely that the detection rate was different throughout the time period when smolts were detected. However, detection rates at large river arrays generally increase with decreasing flow, so late arriving fish would have a better chance of being detected at OKL than fish outmigrating during high flows from April to June. Therefore, it is not likely that a meaningful number of late migrating smolts or residual hatchery fish would have crossed OKL when compared to what was detected during peak migration. Although the OKL PIT detection site is 25 km from the confluence with the Columbia River, it is very close (~2km) to the inundated zone of Wells Pool. Therefore, we can assume that smolts crossing OKL do represent fish leaving the Okanogan River system, or at least that they are entering a more reservoir-like environment where interspecific competition for food and space is likely to be less than in the river.

Smolt-to-Adult Return

SAR could only be calculated for two complete brood cycles, 2013 and 2014. Both brood years experienced bad ocean conditions, which is reflected in the low SAR values. Although the program does not have a specific target for SAR, the PIT based estimates were only about 0.25% for the segregated program, which was barely enough fish to collect broodstock. The Okanogan reintroduction programs SARs were approximately twice as high as the segregated program. The reintroduction program did have higher smolt outmigration survival to RRJ and McNary for both years, which could explain some of the differences in SAR. Additionally, the 2014 brood year fish were adipose present, which reduced a portion of the harvest mortality for returning adults due to a mark-selective sport fishery below Bonneville Dam. With additional years of data, future efforts should evaluate the mechanisms that may be contributing to lower survival of the segregated program to identify management actions that could help improve survival.

We also calculated a CWT-based estimate for BY13 and BY14. SARs for the segregated program were similar for both brood years but still low at 0.15%. The Okanogan reintroduction programs SARs were similar for BY13 but substantially lower for BY14 with an SAR of 0.05%. Because BY13 releases were ad-clipped, there were more recoveries in the sport fishery compared to BY14, which were not ad-clipped. The low SAR may also be a result from the low number of recoveries on the Okanogan spawning grounds (<10) for both brood years. It is also likely that the SAR estimate is biased low because some recovery efforts were not expanded within RMIS, and also because some fish likely have yet to return. We had no way to obtain information necessary to do these expansions or to even speculate about the magnitude of the potential error introduced due of it. With the difficulty of recovering Okanogan spring Chinook carcasses on the spawning grounds, PIT tag analysis will provide additional information on the distribution and returns to the basin. We will continue to use PIT tags as an independent, additional estimate of SAR.

ADAPTIVE MANAGEMENT AND LESSONS LEARNED

The Annual Program Review

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 Annual Program Review (APR) was convened in March 2019 with the purpose of reviewing data collection efforts and results from 2018 and developing the hatchery implementation and monitoring plan for 2019 (Figure 10). 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 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, and hatchery ladder operations to achieve biological targets for 2019. 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 trends of the naturally-spawning population in terms of VSP parameters[6]
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 hatchery origin returns (HOR) met?
6. Are there negative effects of the hatchery on the natural population?
7. Are assumptions about natural production potentially valid?

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

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

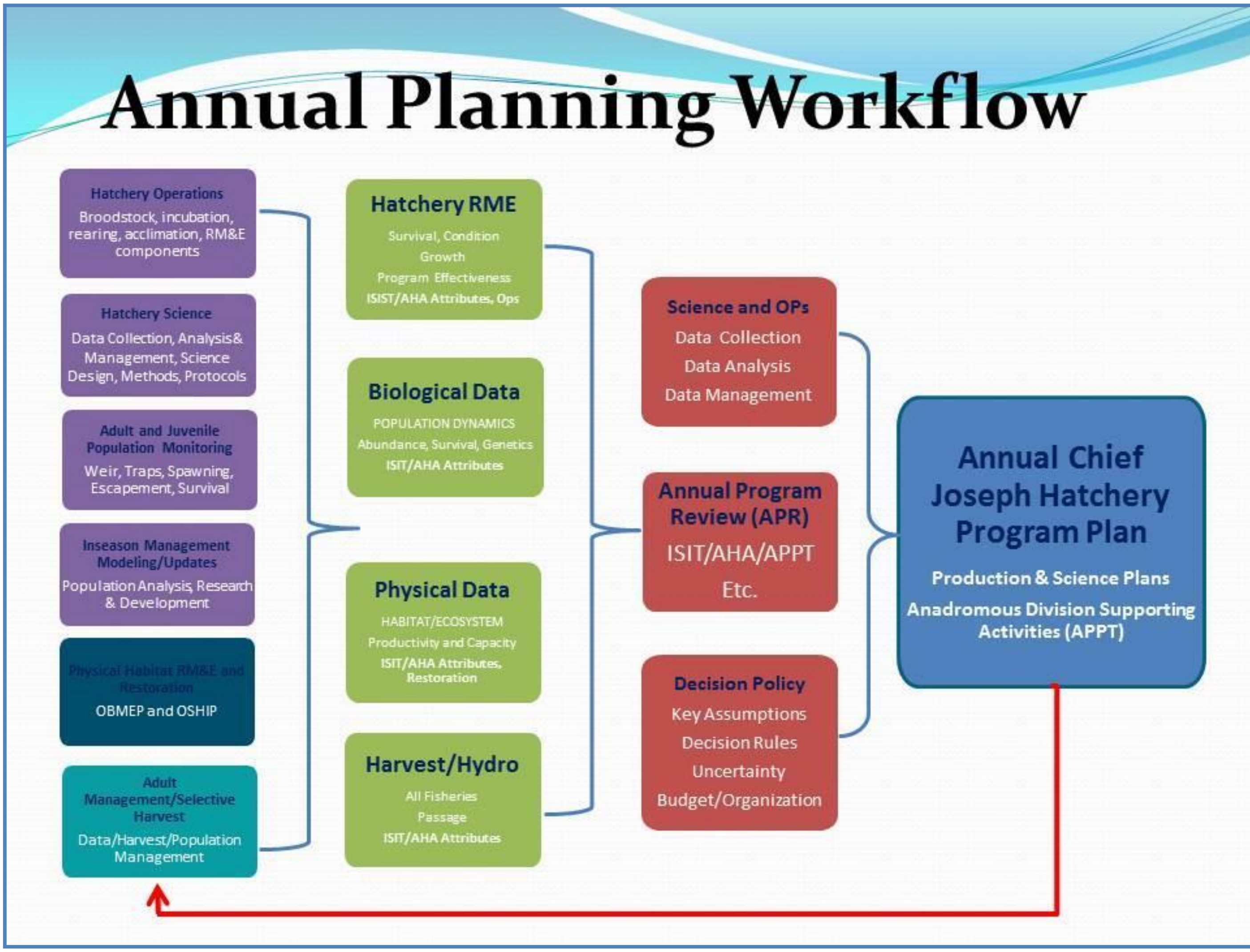

Figure 10. The Chief Joseph Hatchery's annual planning process and workflow.

2019 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 In-season Implementation Tool (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 (https://wdfw.wa.gov/fishing/management/columbia-river/reports). As the season nears, this information is supplemented with return data from downstream dam counts. The pre-season forecast for Upper Columbia spring Chinook Salmon was 11,200 which, if realized, would be the second lowest return of spring Chinook to the Upper Columbia since 2000. Given the low pre-season forecast we anticipate it will be a difficult year to collect broodstock and local fishery opportunities will be limited. The CJH spring Chinook programs lack a history of returns and therefore there is no predictive model for estimating program specific returns. Therefore, we adapted the LNFH return model to estimate returns for the CJH segregated program. This was accomplished by adjusting the predicted returns to LNFH to the release numbers of the CJH. We did not apply additional mortality to CJH smolts based on their different release location, but there would certainly be some differences that would affect the accuracy of our adapted forecast model. The LNFH used three models (DLM Pred, Eco Pred, and TAC) to forecast a return for LNFH of between 665 and 831 spring Chinook. For brood years 2014-2016 the releases at CJH averaged 48% of the LNFH releases. Multiplying the LNFH forecasts by 48% resulted in a prediction of CJH returns between 320-399 adults. The CJH has a broodstock collection target of 640 adults, therefore if the forecast is accurate the program would not be able to meet its goals and managers should anticipate a shortfall in the program. Fishing opportunity will be negligible and ladder operations should be maximized to meet broodstock needs. Managers should also consider taking additional spring Chinook brood during the summer Chinook time period (post July 1), when spring Chinook individuals can be positively identified.

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. Extent, fate, timing, and location of spawning Chinook in the Canadian portion of the Okanogan basin.
2. 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 × natural-origin, and natural-origin × natural-origin crosses of these various life-history types.
3. 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.
4. 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.
5. Design for testing fish tagging rate assumptions. PIT, radio and genetic tagging emphasis.
6. Post-release mortality for the hatchery ladder

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APPENDIX A

Hatchery Operations and Production

The CJH's central facility is a 15-acre facility located immediately below Chief Joseph Dam along the right bank of the Columbia River at rkm 872 near Bridgeport, WA. There is one CJH acclimation facility on the Okanogan River, Riverside (rkm 64) acclimation pond.

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 900,000 spring Chinook. The spring Chinook program includes a segregated program (700,000 smolts) supported by Leavenworth National Fish Hatchery (LNFH) broodstock and a re-introduction program (200,000 smolts) supported by WNFH broodstock (Met Comp stock) to reintroduce spring Chinook to the Okanogan under section 10(j) of the ESA.

In 2018, the segregated spring Chinook program did not meet full production goals due to higher than expected pre-spawn mortality, in addition to the elevated egg loss due to a failing chiller. The 10(j) spring Chinook reintroduction program was initially at full program with the number of eyed eggs received, though because of the chiller issues, there was approximately 90% mortality of those eyed eggs.

Spring Chinook Salmon

BY 2017 Leavenworth Spring Chinook Rearing and Release

Pre-spawn mortality was average and BKD prevalence was low, resulting in the program meeting its goal for egg take. However, green to eyed egg survival was only 48.7%, resulting in fewer ponded fry than anticipated. A total of 280,536 fish were ad-clipped, with a total of 200,029 also receiving a CWT. This group also received 4,815 PIT tags, with a total of 4,778 released (208 detected at release). During the month of April, reservoir water temperatures increased steadily, triggering a good smolt response. Feeding rates were increased for final grow out. A volitional release began on April 15, 2019 with the last of the fish being pushed out April 16, 2019.

Cumulative egg to smolt survival

The cumulative egg to smolt survival for the 2017 brood Leavenworth stock spring Chinook was 78.2%, with the fry to smolt survival being 92.75% (Table A 1). This includes ponding loss, rearing loss, and subtracting the shortage realized at marking. This overall survival metric will be a critical assessment of the hatchery's performance each brood year. The target egg to smolt survival identified in the original spring Chinook HGMP was 77% (CCT 2008a).

Table A 1. Chief Joseph Hatchery BY 2017 spring Chinook rearing summary, April 2019.

Month	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
5/31/2018	366,759	10,153	411	378	97.31%
6/30/2018	361,567	5,192	1,044	212	95.93%
7/31/2018	280,536*	2,300	1,434	84	94.08%
8/31/2018	280,456	80	482	79	94.06%
9/30/2018	280,053	403	748	69	93.92%
10/31/2018	279,362	691	1,408	47	93.69%
11/30/2018	278,072	1,290	1,584	34	93.26%
12/31/2018	277,166	906	1,584	26	92.95%
1/31/2019	276,666	500	1,100	29	92.78%
2/28/2019	276,591	75	484	29	92.76%
3/31/2019	276,572	19	1,056	29	92.75%
4/16/2019	276,560	18	352	20	92.75%
Cumulative:	**276,560**	**21,627**	**11,687**	**20**	**92.75%**

**Population adjusted after marking*

Volitional release began on 4/15 with all being forced out on 4/16.

BY 2017 10J MET COMP SPRING CHINOOK REARING AND RELEASE

On October 13, 2017, CCT staff transported 218,288 MetComp spring Chinook eyed eggs from the WNFH for rearing at CJH. On October 25, 2018 fish were transferred to the Riverside Acclimation Pond. Under Permit No. 18928, issued by the National Marine Fisheries Service, this group is designated as an (10j) experimental population, for the reintroduction of spring Chinook into the Okanogan basin.

Temperatures at both Omak and Riverside dropped dramatically during December, and both ponds iced over. Over the course of the spring, temperatures rose steadily, and the fish growth stayed on target for release. These fish were forced released on April 18, 2019. Table A 2 illustrates feed fed, feeding rate, and mortality. After subtracting mortality and shed tags, a total of 4,946 PIT tags were released (3,566 were detected at release.)

Table A 2. Riverside Acclimation Pond BY 2017 integrated spring Chinook rearing summary, April 2019.

Month	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
10/31/2018	211,903	46	528	32	99.98%
11/30/2018	211,588	315	924	32	99.83%
12/31/2018	211,486	102	-	30	99.78%
1/31/2019	211,418	68	-	30	99.75%
2/28/2019	211,170	248	-	30	99.63%
3/31/2019	210,892	243	924	26	99.52%
4/18/2019	210,582	310	1,232	20	99.37%
Cumulative:	**210,582**	**1,332**	**3,608**	**20**	**99.37%**
Volitional release began on 4/15 with all being forced out on 4/18.					

BY 2018 CJH/Leavenworth Spring Chinook

2018 Brood Collection

The segregated spring Chinook production goal for the 2018 brood is a release of 700,000 yearlings in April of 2020. The calculated number of brood needed to meet this production was 640 adults, based on a 50/50 ratio of males and females. This includes 10% pre-spawn mortality, up to 20% culling for BKD management, 10% egg loss, and rearing mortality of 15%. The mortality per life stage benchmarks were based on historical performance at LNFH. As with any new facility, baseline data collected during initial production years will be the basis for adjusting broodstock requirements in future years.

The ladder was opened on May 31st and 118 HOR were collected for brood. The remainder of the brood was collected in June. Broodstock consisted of ad clipped fish only, which were scanned for PIT tags, sexed, and inoculated prior to separating them into raceways by sex. The adult pond had a flow rate of 500 gpm, and an exchange rate of 54 minutes, representing a Flow Index (FI) of 0.70 for both ponds #5 and #6 during peak population. Since collection, both adult ponds have been on 100% well water to maintain proper temperature profiles and alleviate the risk of Columnaris. Both ponds #5 and #6 were treated a minimum of 3 day/week with formalin to control fungus, at a concentration rate of 1:6000, for one exchange. Pre-spawn mortality was exceptionally high due to an outbreak of copepods that were not detected prior to the first spawn (Table A 3).

Table A 3. Chief Joseph Hatchery spring Chinook broodstock holding and survival summary for 2017. (M= adult males, J = jacks, and F = adult females). The survival standard for this life stage was 90%.

	Beginning of Month			End of Month			Mortality			Monthly Survival (%)			Cumulative Survival (%)		
Month	M	J	F	M	J	F	M*	J	F*	M	J	F	M	J	F
June	56	0	62	310	22	349	1	0	14	99.7%	NA	96.1%	99.7%	NA	96.1%
July	310	22	349	308	22	349	2	0	0	99.0%	100.0%	100.0%	99.4%	100.0%	96.1%
August	308	22	349	0	0	0	210	21	220	31.5%	4.5%	37.0%	31.8%	4.5%	35.5%
Total	**310**	**22**	**349**	**0**	**0**	**0**	**213**	**21**	**234**				**31.3%**	**4.5%**	**35.5%**

*13 of the 14 female morts and the 1 male mort in June were "jumpers" and not normal prespawn mortality.
Mortality in the month of August was mostly after the 2nd spawn and due to excessive copepods on their gills.

Spawning

Spawning began on August 15 and concluded on August 29, 2017. The spawn consisted of 109 females, 111 males and 1 jack, with 5 non-viable (green) females killed resulting in an estimated green egg take of approximately 414,200.

Spawning occurred inside the spawning shed adjacent to the adult holding raceways, and gametes were then transported to the main facilities egg entry room for processing. Each individually numbered female was fertilized with a primary male initially, and then a backup male was added to ensure fertilization. Each female's eggs were then placed in the corresponding numbered tray. The eggs from 1 female were culled due to high ELISA results (culled eggs from ELISA results are not included in Table A 4.). This was approximately 0.9% of the females spawned and is less than what is planned for (up to 20%).

Broodstock origin

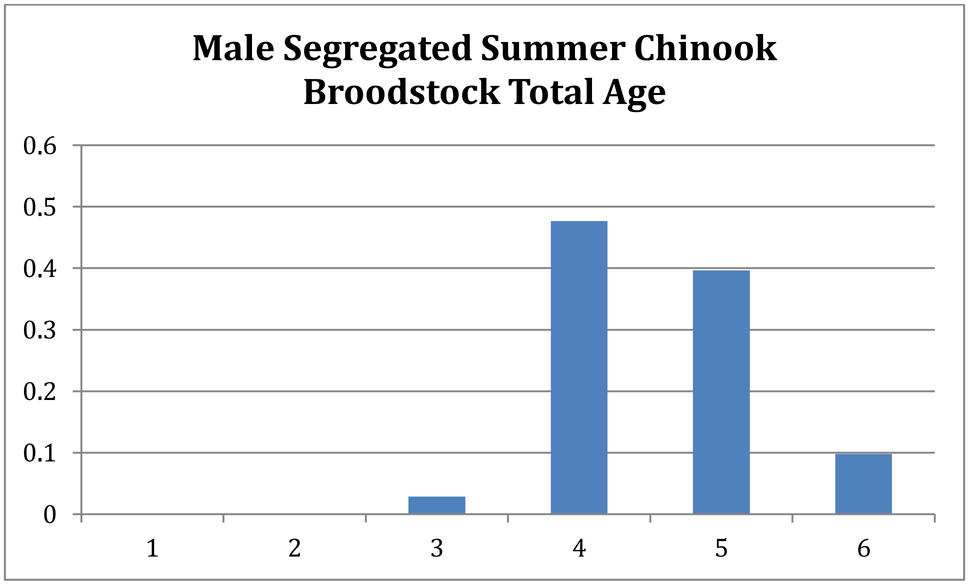
Broodstock were interrogated for coded-wire tags on three different spawning events in August (August 15, 22, and 29). When a coded wire was detected, the snout was collected for extraction and later examined in the laboratory. Results indicate that 99 percent of all broodstock collected for the spring Chinook program either came from the CJH segregated or integrated program with 1 percent of broodstock coming from Winthrop NFH. The CJH segregated program was the largest contributor to brood with 97% (n=576) of adults coming from the Chief Joseph Hatchery, followed by 2% (n=10) from Riverside Pond and 1% (n=7) from the Winthrop NFH (Table A 4). A large portion of snouts (n=454) were examined in the lab and determined to not have a wire. Release data indicates that, on average, 31% of CJH segregated Chinook, brood year 2013-2015 were ad-absent and received a CWT. Based on this data and the sample size of brood stock collected via the CJH ladder, a minimum of 410 ad-absent, "no tag" Chinook should be represented in the sample.

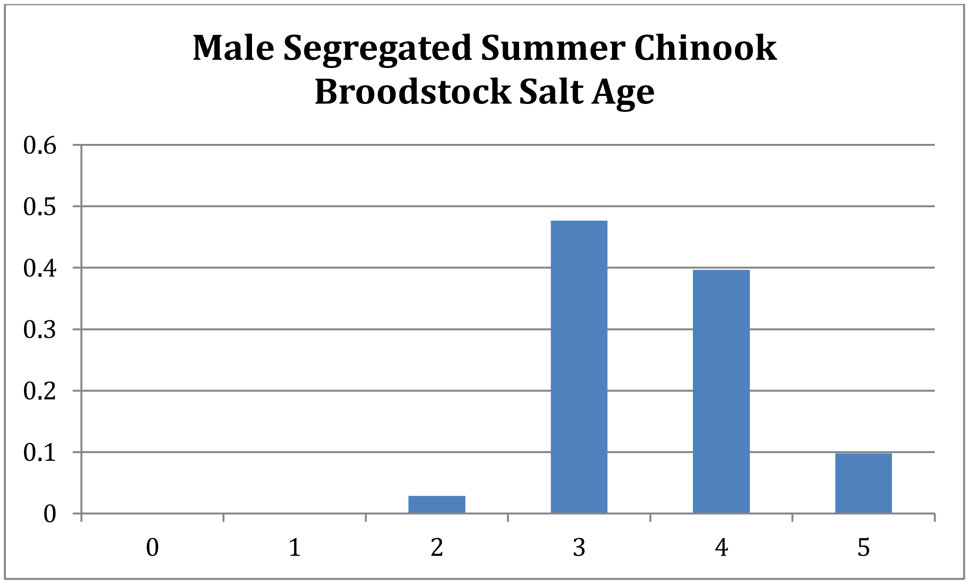
Table A 4. Composition of hatchery-origin brood, by program, collected for the CJH spring Chinook program in 2018.

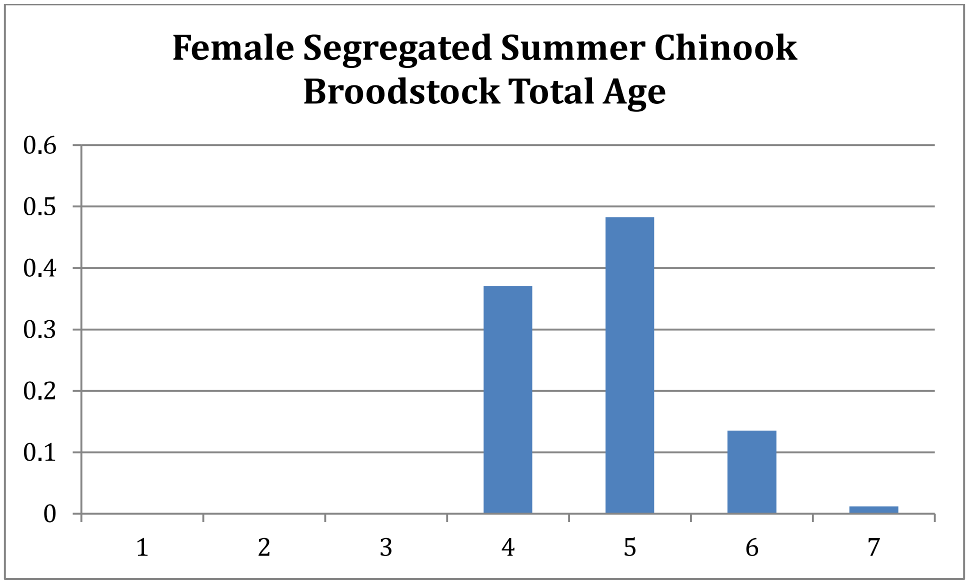
Category	Hatchery Program	# tags	% of brood	
Okanogan Integrated	Riverside Pond	10		2%
CJH Segregated	Chief Joseph	122	20%	97%
	Chief Joseph (non-tagged)	454	77%	
Other UCR summer/fall Chinook hatchery	Winthrop	7		1%
Total		593	100%	

Segregated Program Broodstock Age Structure

Coded wire tags are extracted from summer Chinook segregated program broodstock and later read to determine the age of successfully spawned fish (Figure A 1).







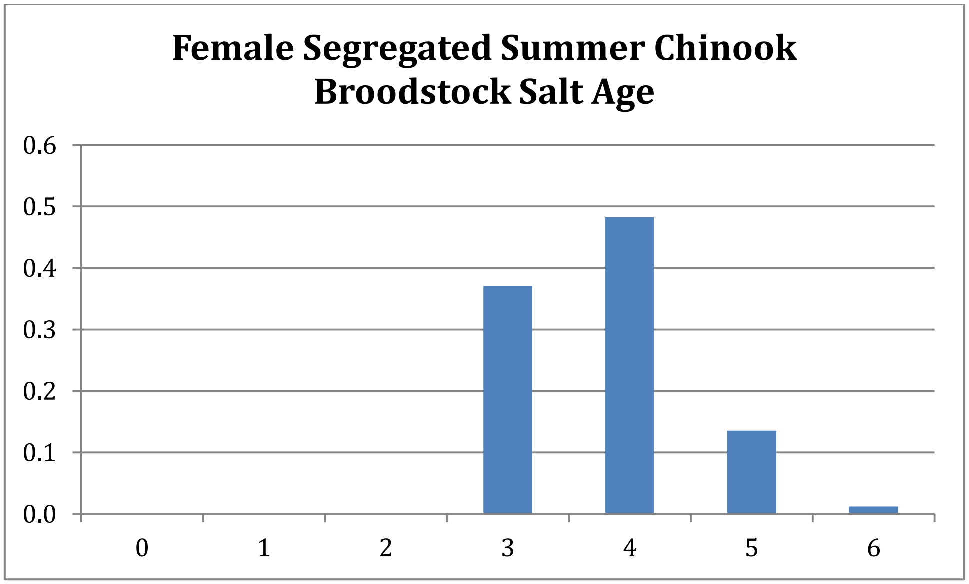


Figure A 1. The total and salt ages of the 2018 broodstock, males and females, collected for the Chief Joseph Hatchery segregated program.

Incubation

Each female's eggs were initially incubated separately to facilitate culling based on ELISA results. Once eyed, egg mortality was removed and remaining eyed eggs were enumerated and put back into their original trays. All spring Chinook eggs were initially placed on chilled water.

The water temperature was gradually dropped, on the first egg take, to 46° F degrees, as this was as low as the chilled water would get. This process was done over a several hour period four days after spawning. The second egg take was left on well water (60° F) until such time as the total numbers of temperature units (TUs) were earned to equal the first egg take, then the same procedure was used to lower water temperature to 46° F.

This process provided the ability to control when, and how many, fish are brought out of the incubators and placed into early rearing.

Green egg to eyed egg survival was 90.6% (Table A 5). This survival was right at the key assumption of 90%. However, premature hatching was observed, prompting more extensive monitoring of temperature and dissolved oxygen. It was determined that DO was low in the incubators due to a malfunctioning chiller, causing premature hatching resulting in higher-than-normal eyed egg to ponded fry survival.

Table A 5. Chief Joseph Hatchery spring Chinook spawning and egg survival summary for 2018 (M = adult males, J = jacks and F = adult females). The target survival standard for this life stage was 90%.

Spawn Date	Total Adults Spawned			Green Eggs On Hand	Eyed Eggs On Hand	Mortality (Pick off)	Culled eggs	Adjusted Total Egg Take	Cumulative Survival (%)
	M	J	F						
8/15/2018	42	0	42	157,800	120,265	9,617	-	129,882	92.6%
8/22/2018	51	1	52	191,800	139,770	17,200	3,871	160,841	89.0%
8/29/2018	18	0	15	56,000	34,050	3,754	-	37,804	90.1%
Total:	111	1	109	405,600	294,085	30,571	3,871	328,527	90.6%

Overall average fecundity was 3,014

Eggs were shocked and picked between 9/11 and 9/20.

**Mortality does not include the 3,871 eggs culled for high ELISA values.*

Rearing

The BY 2018 spring Chinook ponding began in December, with fry initially estimated at 469,994. On January 2 the last of the fish were ponded. Initial loss during ponding was elevated due to recent chiller issues. Early rearing has been normal, with no fish health issues detected. Fish will be adipose fin-clipped in May, with some receiving both a clip and CWT. See Table A 6 for rearing details.

Table A 6. Chief Joseph Hatchery brood year 2018 spring Chinook rearing summary, May 2019.

Month	Total on hand	Mortality	Feed Fed	Fish per pound	Cumulative Survival (%)
12/31/2018	469,994	6,289	167	1,181	98.68%
1/31/2019	490,533	35,957	651	214	92.07%
2/28/2019	488,080	2,453	349	202	90.62%
3/31/2019	486,359	1,721	349	161	90.25%
4/30/2019	485,110	1,249	552	110	89.99%
Cumulative:	**485,110**	**47,669**	**2,068**	**110**	**89.99%**

Chief Joseph Hatchery Ladder

The CJH ladder was operated from May 31 to June 29 to collect brood for the segregated program. During this time frame when the weekly broodstock collection reached its goal, the ladder was closed immediately for the season. All steelhead and ad-present Chinook were returned to the river via a water-to-water transfer. A total of

674 hatchery origin adults (311 males and 363 females) and 22 jacks were taken from the ladder and used as broodstock. A total of 109 natural-origin spring Chinook, 4 ad present steelhead and 10 ad-absent steelhead were trapped, handled and released back to the Columbia River (Table A 7 and Table A 8). The encounter/handling and release of 4 NOR steelhead represents 36% of the allowable incidental take provided in the Biological Opinion (BiOp) for Chief Joseph Hatchery collection facilities (NMFS 2008). There were no observed immediate steelhead mortalities during the ladder operations in 2018.

Table A 7. Chief Joseph Hatchery adult spring Chinook, Sockeye, and steelhead ladder operations from June to August 2018.

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
June	6	0	0	77	23	0	0	0
July	1	0	0	6	2	0	0	1
Aug	10	7	2	27	2	3	4	9
Total	**17**	**7**	**2**	**110**	**27**	**3**	**4**	**10**

RTS= Return to stream

Table A 8. Chief Joseph Hatchery spring Chinook collected during ladder operations in 2018.

Date	HOR Chinook surplussed	HOR Chinook Jacks surplussed	NOR Chinook RTS	NOR Chinook Jacks RTS	HOR Chinook RTS	HOR Chinook Jacks RTS	HOR Brood
May	0	0	7	1	0	0	118
June	0	0	69	22	176	80	556
July	0	0	6	2	0	0	0
August	7	2	27	2	10	3	0
Total	**7**	**2**	**109**	**27**	**186**	**83**	**674**

RTS= Return to stream

The ladder was closed and dewatered on August 31, 2018 for the season. The protocol was to sample 20% (one of five) of the adipose-clipped spring Chinook for coded-wire tags (CWT). Snouts with positive CWT detection were held frozen until December 2018 when CWT extraction and reading took place in the Chief Joseph Hatchery lab. Recovery data is expanded by the tag loss 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 are presumed to be from the CJH segregated program.

Spring Chinook CWT recovery data from the CJH ladder represents spring Chinook encountered during Chinook ladder operations (May 25-October 16). Seven spring Chinook were captured during the month of August and sampled for a CWT (Table A 9). These seven fish are the only spring Chinook encountered and sampled during ladder surplus events for 2018. Results show that only one of these fish had a CWT and it is from the CJH segregated program, however due to the large amount of no-wire, adipose-clipped fish returning to the hatchery ladder, it is presumed that the other six fish are from the CJH segregated program.

Table A 9. Percent of CJH ladder surplus spring Chinook each year estimated to be from various facilities based on CWT assessment of spring Chinook. Estimated number of annual spring Chinook coded wire tag recoveries, by release hatchery, from Chief Joseph Hatchery ladder operations in June to October.

	# Surplus Fish	Facility/Program						
		Riverside Pond	CJH	Winthrop	Leavenworth	Chiwawa Pond	Methow Hatchery	Other[a]
2013	3	0%	0%	0%	0%	100%	0%	0%
2014	46	0%	0%	0%	91%	7%	2%	0%
2015	24	0%	0%	4%	75%	17%	0%	4%
2016	17	13%	43%	6%	13%	13%	6%	6%
2017	127	25%	75%	0%	0%	0%	0%	0%
2018	7	0%	100%	0%	0%	0%	0%	0%
Avg.	**37**	**6%**	**36%**	**2%**	**30%**	**23%**	**1%**	**2%**

[a] Releases from Out of ESU hatcheries include Parkdale and Nez Perce hatcheries

APPENDIX B

2019 Production Plan

Table B 1. Spring Chinook – Met Comp (Riverside Pond Release)

Chief Joseph Hatchery Production Plan											
Brood Year:	2019							**Planting Goal:**	200,000		
Species:	Spring Chinook							**Pounds:**	13,333		
Stock:	Met Comp										
Origin:	Hatchery/Wild										
Egg Take Goal:	326,800							**Adult Goal:**	190		
Estimated Release Data:											
Start Date:	**End Date:**	**Num Released**	**fish per lb.**	**Wt. grams**	**Total weight (lb.)**	**Total weight (kg)**	**Life Stage**	**Release Site**	**Mark Type**	**Tagged**	
04/15/21	04/30/21	200,000	15.0	30.2	13,333	6,048	Yearlings	Riverside Ponc	None	100% CWT	
Notes:	Egg take goal includes 20% for culling.										
	Adult Goal includes 10% pre-spawn mortality										
	10% Green to Eyed egg mortality										
	Rearing mortality is 10.5%										
Rearing Summary:											

Species	Source	Date	Number Green Eggs	Number Eyed Eggs	Number Ponded	Fed Fry	Released	Location
Spring Chinook	Winthrop NFH	April	261,440	235,296	223,531	212,355	200,000	Riverside

Table B 2. Spring Chinook - Leavenworth (CJH Release)

Chief Joseph Hatchery Production Plan

Brood Year:	2019						**Planting Goal:**	700,000		
Species:	Spring Chinook						**Pounds:**	46,667		
Stock:	CJ Hatchery									
Origin:	Hatchery									
Egg Take Goal:	1,094,400						**Adult Goal:**	640		
Estimated Release Data:										
Start Date:	**End Date:**	**Num Released**	**fish per lb.**	**Wt. grams**	**Total weight (lb.)**	**Total weight (kg)**	**Life Stage**	**Release Site**	**Mark Type**	**Tagged**
04/15/21	04/30/21	700,000	15.0	30.2	46,667	21,168	Yearlings	CJ Hatchery	Ad Clipped	200k CWT
Notes:	Egg take goal includes 20% for culling.									
	Adult Goal includes 10% pre-spawn mortality									
	10% Green to Eyed egg mortality									
	Rearing mortality is 6.5%									
Rearing Summary:										
Species	**Source**	**Date**	**Number Green Eggs**	**Number Eyed Eggs**	**Number Ponded**	**Fed Fry**	**Released**	**Location**		
Spring Chinook	CJH Ladder	April	875,520	787,968	748,570	711,141	700,000	CJ Hatchery		

APPENDIX C

Technical Memorandum: Minijack Rates for 2018 Chief Joseph Hatchery Integrated and Segregated Chinook Releases

Date: 2 May 2018

From: John Rohrback; john.rohrback@colvilletribes.com (509) 634-1068

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

CC: Kirk Truscott

Subject: Minijack rates for 2018 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 April 2018 and provide estimates for the rate of early maturation ("minijack rate") from each yearling group released in 2018 (brood year 2016).

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 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. The CJHP did not have the budget to implement the 11-KT method and therefore 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 2018 CJH release group for dissection and examination. The release groups are:

- Segregated spring Chinook; released from Chief Joseph Hatchery, hatchery-origin broodstock from Leavenworth National Fish Hatchery
- 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 broodstock from Winthrop National Fish Hatchery
- Integrated summer Chinook; released from the Omak Acclimation Pond, natural-origin broodstock primarily of Okanogan-origin stock
- Integrated summer Chinook; released from the Similkameen Acclimation Pond, natural-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). USFWS staff participated in the first day of sampling (April 9, 2018) with CCT to ensure consistency with the USFWS protocol. 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) 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 low rates of early maturity (0.00%-4.52%, Table 1). However, a distinct separation in Log10 GSI between immature and mature fish was not apparent in any of the sampled groups. Because of this, a cutoff value and for classifying sampled fish as mature or immature, and therefore a minijack rate, could not be calculated by the model for any group except for segregated spring Chinook (Figure 1). Histograms that display the distribution of Log10 GSI for each sampled release group are presented in Figures 1-5.

Discussion and Recommendations

The data and analyses presented herein suggest there was not a problem with early maturation rate of brood year 2016 Chinook reared at the CJH and its acclimation facilities. The minijack rates for all CJH release groups in 2018 were low relative to many other Columbia River hatchery programs (Harstad et al. 2014). However, the inability to statistically determine a GSI cutoff value for all but one program was disconcerting. Visual determination of maturity state is subjective and is likely only useful when the state of maturity has progressed to the point where observer error or bias can be overcome. Without statistical confirmation, the visual maturity classifications are unsubstantiated, and the uncertainty associated with a purely visual determination of maturation status unresolved. Differentiation in Log10 GSI between immature and mature subpopulations can be increased by holding sample groups post-release and allowing more time for sexual maturation and gonadal development in mature fish prior to sampling. If practicable, CJH fish to be sampled for early maturation should be held for as long as possible to increase the likelihood of statistically determining a cutoff value between immature and mature Chinook. The USFWS holds their sample fish until mid-May (about 1 month post-release) to better determine the GSI cutoff for early maturation. This extra holding period presents a couple of challenges for CCT. First, there are no facilities to hold 300 fish at the Omak and Similkameen acclimation ponds after most fish are released and bringing those fish back to CJH would present a pathogen risk. Second, M&E staff may not be available in mid-to late May to implement the lab work. A recommendation for 2019 is to duplicate the lab effort on 300 fish held for 1 month longer at CJH and determine if the extra month makes a difference in the ability to detect a statistically significant cutoff. CJHP should also consider doing an 11-Ketotestosterone test on one group of fish each year to provide a control group and comparison to validate the visual and GSI approach.

Additionally, staff should receive further training in visual classification of immature and mature individuals. Within the Omak integrated summer Chinook sample group (n=132), no fish was visually classified as mature. However, two fish (1.51% of the sample) had a Log10 GSI of greater than -1.058 - more than three standard deviations away from the mean. This result could be due to a suite of reasons, including variation within the immature population or measurement error. However, it could also be explained by incorrect assignment of mature fish to the immature category. This potential error can be reduced with additional training as to visual classification of maturity stage.

Table C 1. Mini-jack rate for each Chief Joseph Hatchery release group from brood year 2016.

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	155	150	5	3.23%	4.52%
Segregated Summer Yearlings	Chief Joseph Hatchery	163	156	7	4.29%	N/A
Integrated Spring Yearlings	Riverside Acclimation Pond	149	147	2	1.34%	N/A
Integrated Summer Yearlings	Omak Acclimation Pond	132	132	0	0.00%	N/A
Integrated Summer Yearlings	Similkameen Acclimation Pond	134	133	1	0.75%	N/A

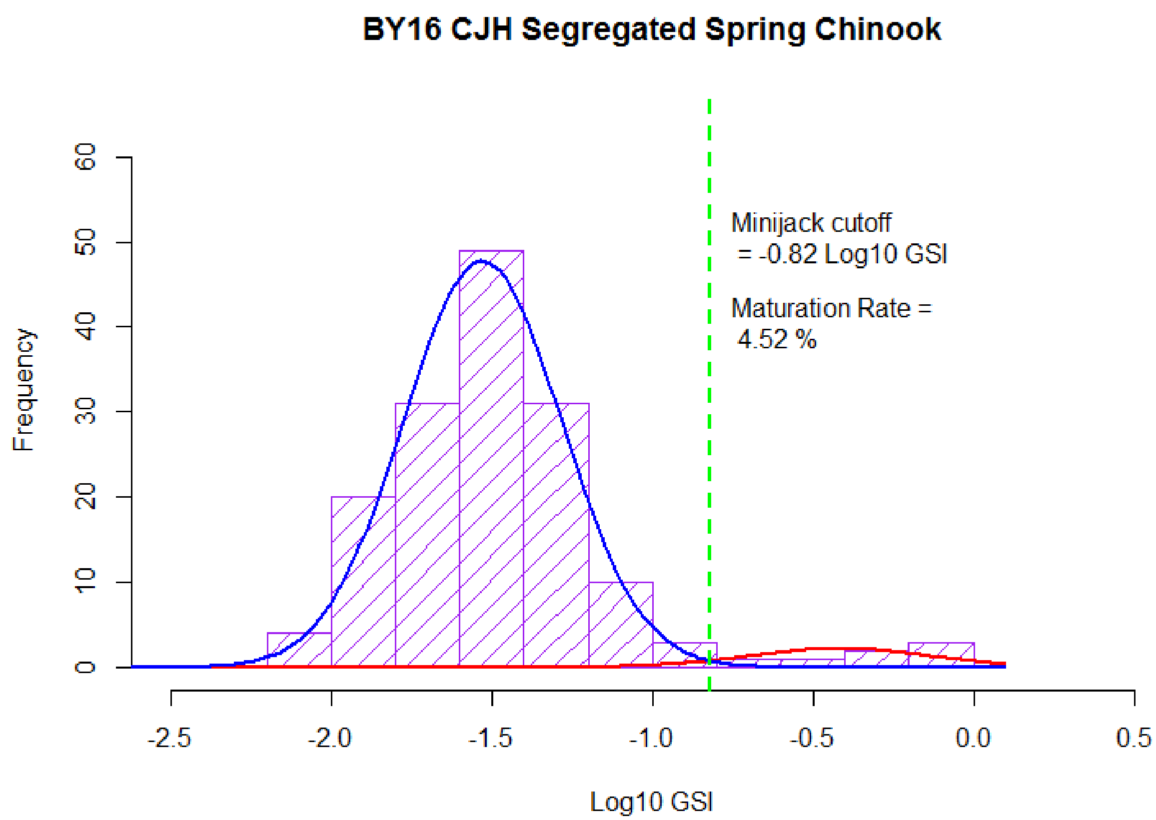


Figure C 1. Distribution of Log10 GSI for segregated spring Chinook released from the Chief Joseph Hatchery. The cutoff value is marked by the vertical green dashed line. It marks the point of differentiation between immature fish (appearing to the left of the cutoff line) and mature fish (appearing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

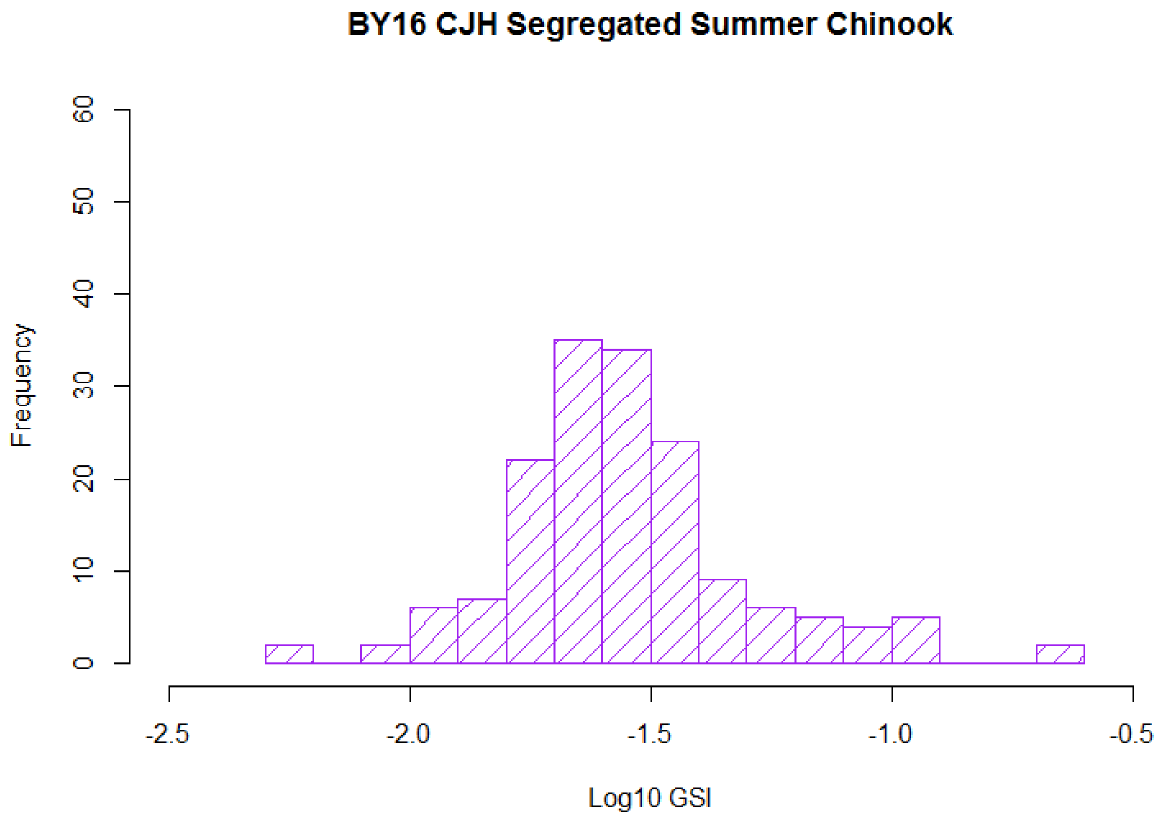


Figure C 2. Distribution of Log10 GSI for the segregated summer Chinook released from the Chief Joseph Hatchery. Since a cutoff value differentiating immature and mature subpopulations was not determinable, subpopulations distribution functions and the cutoff value are not displayed.

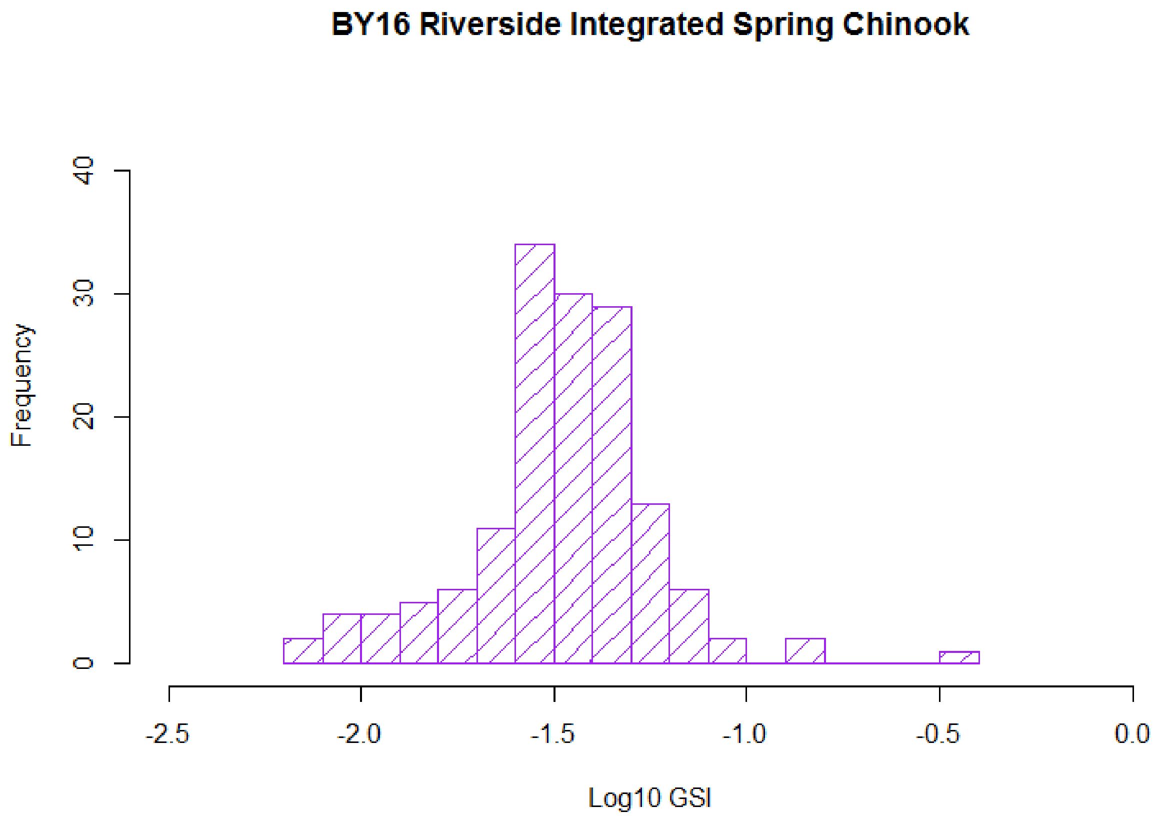


Figure C 3. Distribution of Log10 GSI for the integrated spring Chinook released from the Riverside Acclimation Pond. Since a cutoff value differentiating immature and mature subpopulations was not determinable, subpopulations distribution functions and the cutoff value are not displayed.

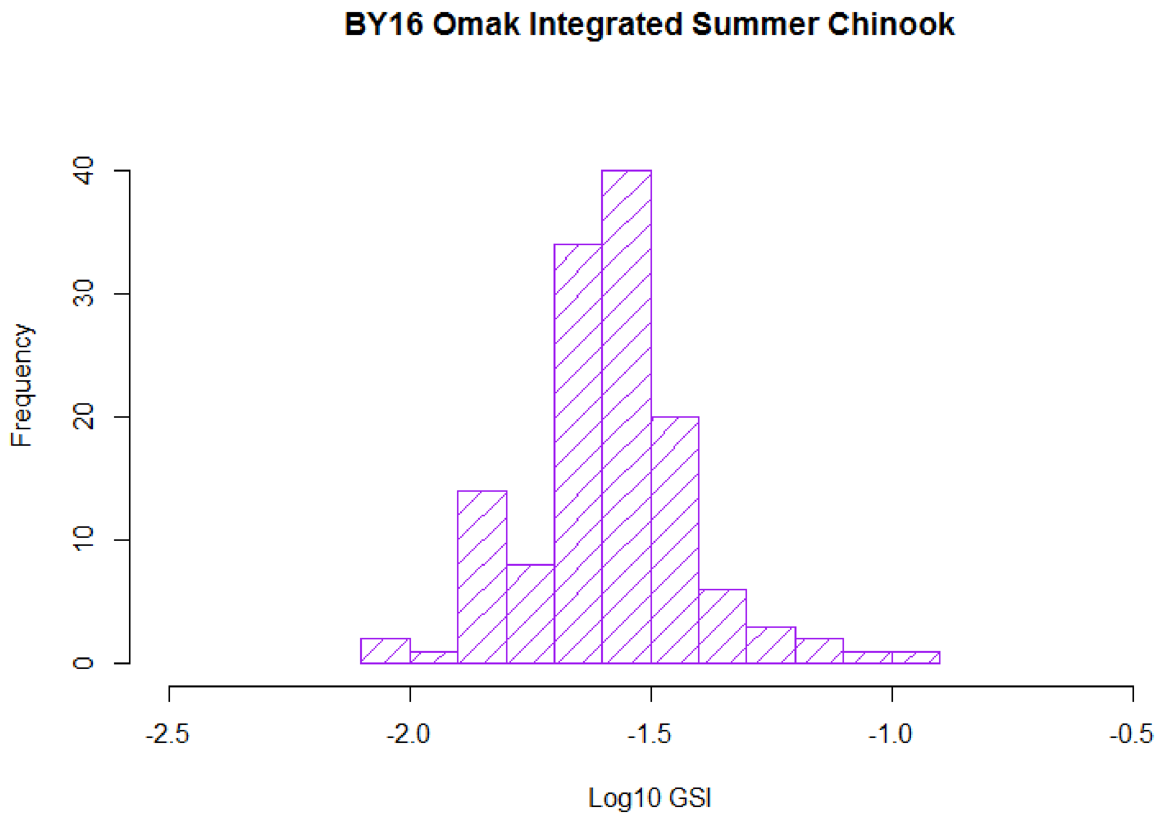


Figure C 4. Distribution of Log10 GSI for the integrated summer Chinook released from the Omak Acclimation Pond. Since a cutoff value differentiating immature and mature subpopulations was not determinable, subpopulations distribution functions and the cutoff value are not displayed.

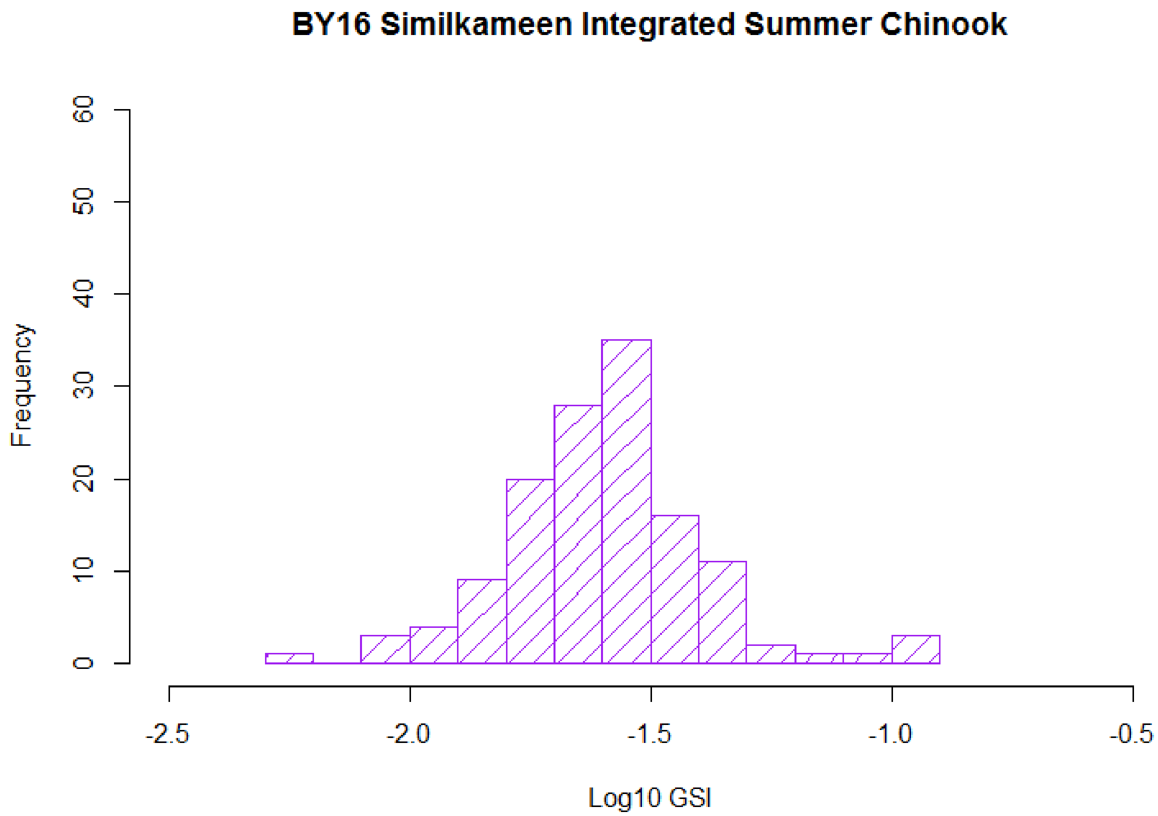


Figure C 5. Distribution of Log10 GSI for the integrated summer Chinook released from the Similkameen Acclimation Pond. Since a cutoff value differentiating immature and mature subpopulations was not determinable, subpopulations distribution functions and the cutoff value are not displayed.

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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), 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

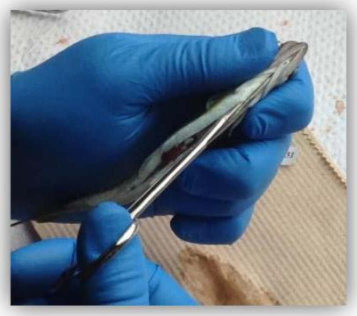
2. Collect fish from hatchery ponds. Random sample? Keep different ponds separate? CWT? Pit Tag?

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

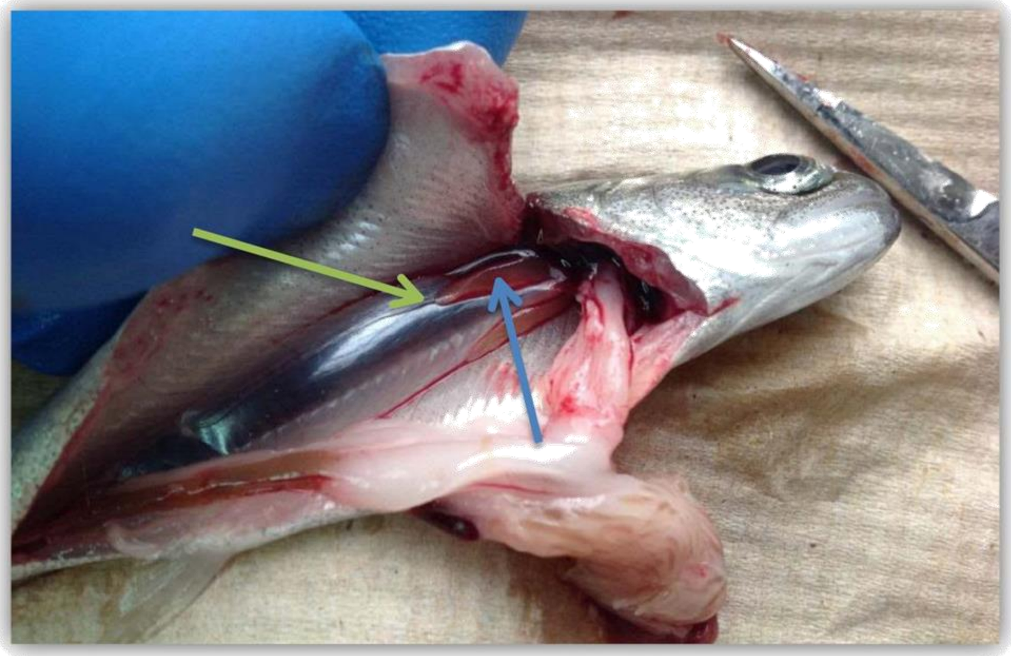
4. Smolt index: 1. Parr, dark marks (bottom fish), 2. Transitional, faded marks (middle fish), 3. Smolt, silver, no marks (top fish)

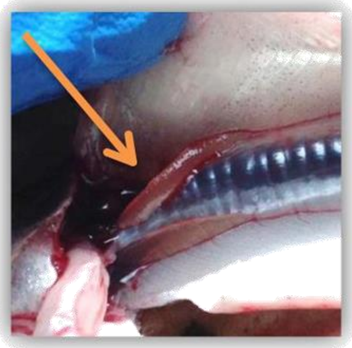
5. Set out 15-20 fish in a row on the sponges. Add number tags to fish. Assess smolt index while all fish are in the line. Obtain weights and lengths, place on paper towel to pass to the dissecting crew.

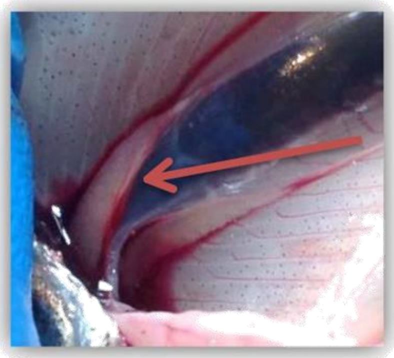
6. Fish dissection: Cut open belly from vent (shallow incision), cut behind gill, open fish and gently remove guts to expose air bladder. Both male and female gonads are located on the top/edge of the air bladder (orange arrow on mature male).

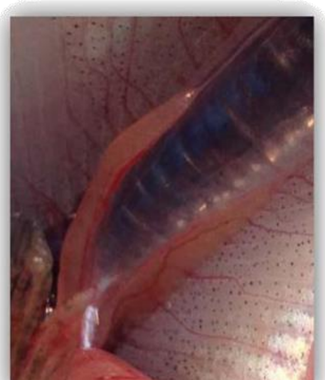


7. Female identification: 1. Ovary forms a point and then narrows to oviduct – thread like (green arrow) 2. Ovary is angular, has ridge (blue arrow), 3. Granulated (orange arrow), 4. Color (red arrow) is not a good indicator as it can vary from pink to white.







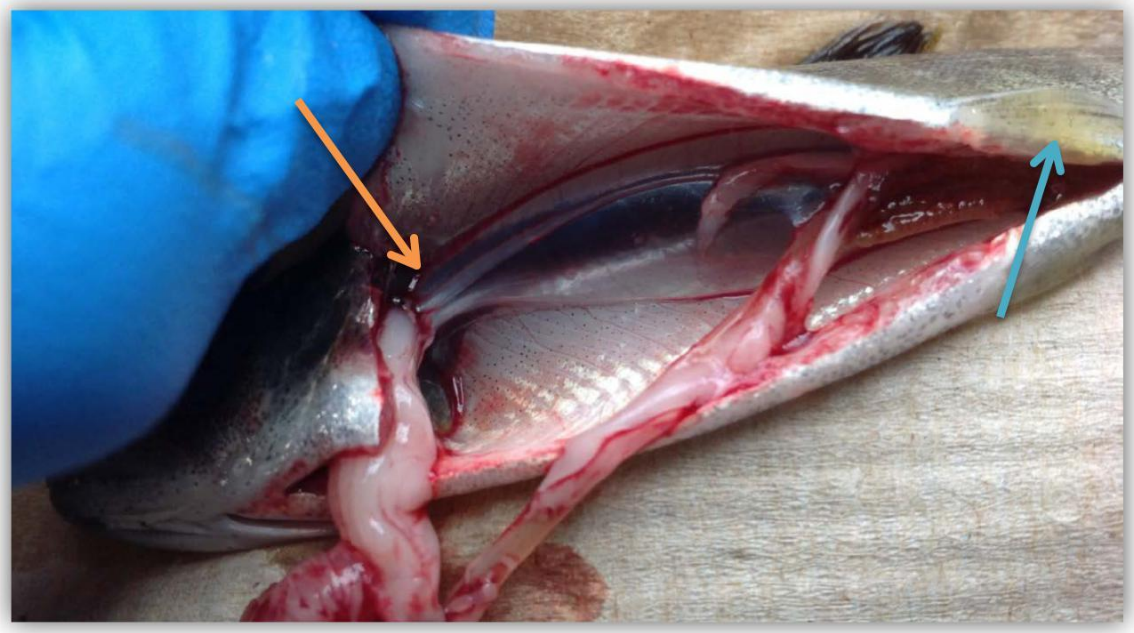


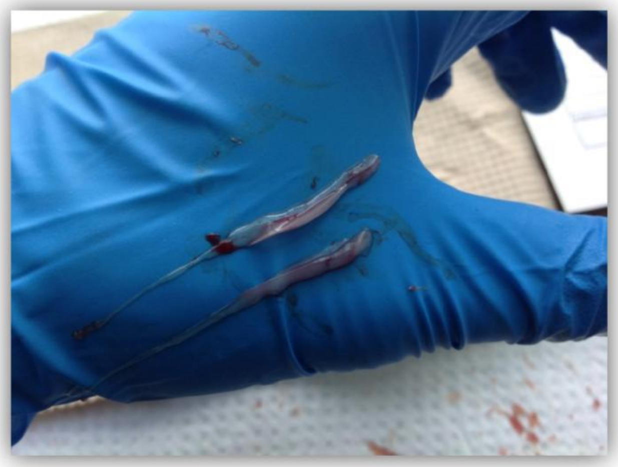
8. Immature male identification: Testes are thready throughout, smooth and round, no development or thickness (green arrows).

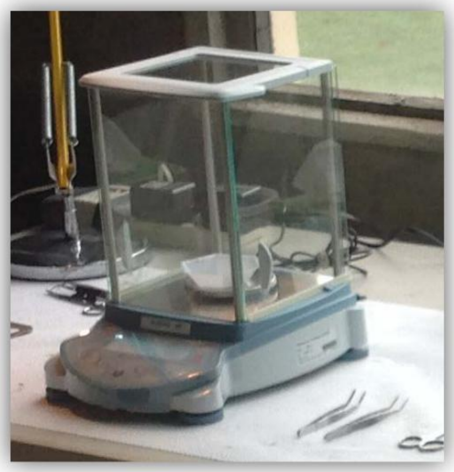
9. Mature male identification: Testes thicken, become white/translucent, smooth, tapers to tail.

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.





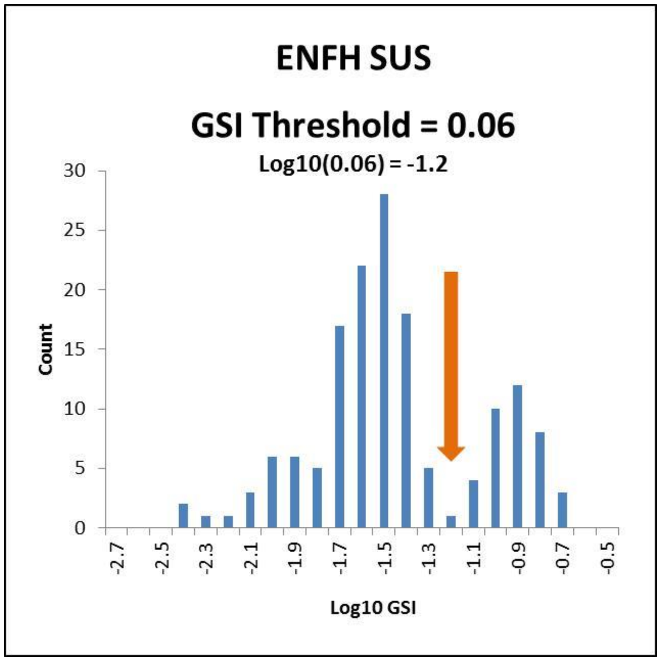


12. To use the scale: Close all doors, zero balance, open door, place ‘nads in weight boat, close doors, wait for number to stabilize. ‘Nads will evaporate and become lighter in a short period of time.

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 ($K=(10^5)*weight/length^3$).
- Calculate the Log10(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, weigh 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)" ))
```