Hood River Production Program Monitoring and Evaluation

Annual Progress Report

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EXECUTIVE SUMMARY

An estimated 379 (±402) adult wild winter steelhead returned to the mouth of the Hood River during the 2018 – 2019 run year, which is below the escapement objective of 656 established by the Revised Master Plan for the Hood River Production Program (HDR|FishPro 2008). Hatchery winter steelhead escapement to the Hood River was an estimated 483 (±293), which fell below the Master Plan objective (n=1,000) for the first time in several years. Sport harvest of hatchery winter steelhead was not directly measured using creel survey methods, however the Cormack Jolly-Seber model output suggested that within-basin prespawn mortality (due to harvest, or other) equated to 111 (±31) adults. A total of 106 hatchery winter adults were removed and either utilized as broodstock or transferred to an offsite impoundment leaving approximately 266 adults available to spawn, inferring a pHOS rate of 0.472.

The 2019 adult sampling year was characterized by a limited number of captures in the weeks after the installation of the East Fork Weir (EFW) in January, followed by a high flow event occurring in early April that rendered the weir inoperable for the remainder of the season. Efficiency of the weir was 17.4% based on the detection probability generated by the CJS model for hatchery winter steelhead. Despite additional complications with the supplementary East Fork Irrigation Diversion ladder trap (i.e. diversion panels lowered, attraction flow limitations), wild broodstock collection goals were nearly met (desired pNOB = 1.0, actual 0.87). This year marks the third time since the removal of Powerdale Dam in 2010 that the EFW has been compromised resulting in difficulties collecting wild broodstock. The other two challenging collection years (2014, 2017) resulted in pNOB values of 0.380 and 0.347 respectively and, along with pHOS values above 0.5, resulted in PNI values well below the HSRG guideline of 0.67 for integrated hatchery populations. For 2019, wild broodstock collections were sufficient to somewhat negate the estimated pHOS rate, ultimately producing a PNI value of 0.648. Fishery managers will likely continue to face concerns regarding undesirable pHOS rates so long as the EFW performs as inconsistently as it has during the past nine years.

Below average returns of adult hatchery winter steelhead likely stemmed from a combination of poor ocean conditions and limited apparent survival of hatchery outmigrants during release year 2017. Typically, 2-salt returning adults comprise the majority (mean = 71.3%) of the run class. The average fork length of hatchery winter steelhead released during 2017 (181.7mm) was significantly less than the recent 5-year moving average (206.3mm), and the 2017 release group also consisted of a relatively large proportion (14.3%) of potentially non-migratory (FL<150mm) individuals. Additionally, apparent survival from release at the East Fork Sandtrap acclimation site (RM 21) to the mainstem RST—a metric potentially indicative of non-migratory behavior—was only 0.60 compared to the 5-year moving average of 0.88. As a result, the SAR rate of hatchery steelhead released in 2017 appears to mirror that of the 2015 outmigration class, where SARs were among the lowest on record (<1.0%, PIT-tag based SAR) due to drought conditions and the warm ocean offshore "blob."

Apparent survival of returning adult winter steelhead from Bonneville Dam to the mouth of the Hood River was slightly above average for hatchery fish (77.4%, mean = 76.6%) and above average for wild fish during 2019 (88.9%, mean = 72.8%). A multitude of factors likely influence the survival rate through the Bonneville pool, however we suspect the number of fallbacks may play a significant role in the apparent survival estimate. During run years 2012 – 2018, 4.0% of wild adult winter steelhead and 5.1% of hatchery winter steelhead exhibited a PIT tag detection history characteristic of fallback behavior (i.e. successfully ascended the ladder but suddenly reappeared at the bottom of the ladder, inferring downstream passage through the spillway or turbines; were immediately detected at downstream migrant PIT-tag interrogation sites; were detected moving downstream through the ladder and exiting). During 2019, no wild winter steelhead appeared to exhibit a fallback detection history

however 4.7% of hatchery winter steelhead were identified as fallbacks. Migration timing for wild and hatchery winter steelhead were nearly identical, with the majority of detections occurring from mid-March to early April. A negative correlation existed between the date a hatchery adult left the Bonneville ladder and survival to the Hood River. While extremely difficult to determine the exact mechanism for decreased survival, the issue may represent a major limiting factor for Hood River steelhead.

Escapement of Hood River wild summer steelhead for the 2018 – 2019 run year (n=167, ±150) did not meet the Revised Master Plan for the Hood River (HDR|FishPro 2008) objective (n=510) and generally reflected the trend for many Columbia River tributaries, as summer runs throughout the basin have been declining, with many populations reporting 25-year lows. The number of hatchery stray summer steelhead captured and removed at adult trapping facilities was minimal during 2019 (n=4), another indicator of poor summer returns throughout many of the Columbia River tributaries. Because of the limited number of previously PIT tagged adults detected at Bonneville Dam and the subsequent low number of recaptures at Hood River adult trapping facilities, refining run estimates of both wild and hatchery summer steelhead in a post-Powerdale Dam environment remains one of the biggest M&E challenges moving forward. Likewise, understanding the impact that stray hatchery summer steelhead have on natural production is also vital towards achieving population recovery.

Escapement, harvest, broodstock and spawning escapement goals as stated by the Revised Master Plan for the Hood River (HDR|FishPro 2008) for adult hatchery spring Chinook salmon were exceeded during 2019. Escapement of hatchery spring Chinook to the mouth of the Hood River was an estimated 808 (±381) adults. Estimated non-tribal harvest of hatchery spring Chinook salmon was 398 (±126) adults and exploitation was 49.3% (mean = 23.2%). Spring Chinook escapement to natural production was somewhat limited (n=105). A total of 243 spring Chinook were collected for broodstock, the majority of which were hatchery origin (97.1%). Although program objectives for adult spring Chinook were met during 2019, managers should adopt a management plan for returning hatchery jacks, as the number of available spawning jacks (n=90) exceeded adults (n=49) during 2019. Model estimates of naturally produced spring Chinook escapement were not available for the 2019 run year due to data limitations. A total of 28 adults and 3 jacks were captured at adult collection facilities. Natural production of spring Chinook continues to be limited based on low numbers of juveniles observed and poor return rates of PIT-tagged individuals.

An estimated 18,569 (±10,607) downstream migrant wild steelhead smolts emigrated from the Hood River subbasin during 2019. Production may have been limited by the previously noted presence of hatchery winter steelhead residuals from the 2017 release group. A potential constraint of wild steelhead smolt production identified by the ISRP (2008) is the presence of residual hatchery steelhead smolts that fail to make an immediate saltwater migration. Production may potentially be primed for an increase in 2020 as efforts to cull undersized hatchery winter steelhead were enacted during 2018 and 2019. Flow conditions during the past two brood years have been conducive for spawning in terms of access to habitat and incubation. Access to potential spawning areas for salmon and steelhead may often be flow dependent where potential barriers can be eclipsed by elevated and/or sustained high flows, allowing temporary access to habitats otherwise unavailable. Given the density-dependent nature of Hood River winter steelhead, such habitats may be of critical importance. Furthermore, there is a positive correlation between the mean daily flow during the spring when winter steelhead are likely to spawn, and the age-1 smolt production observed during the subsequent year's outmigration period. During the fall 2019 trapping period, high numbers of young-of-the-year and age 1+ steelhead were caught. Coupled with a fairly mild 2019 – 2020 winter season conducive to above average growth and survival, and the 2020 outmigration season could represent a strong year class.

Future monitoring and evaluation priorities include refinement of escapement, survival and productivity models, continued development of streamflow-production relationships, and quantification

of species-run specific smolt-to-adult survival rates. Development of apparent survival models for adult wild and hatchery steelhead is also needed, especially considering that pHOS estimates using current methodologies may have inherent uncertainty given the elimination of winter steelhead sport harvest monitoring. The development of sampling designs that can satisfy monitoring uncertainty thresholds (i.e. NOAA criteria where “agencies and tribes should strive to have adult spawner data with a coefficient of variation (CV) on average of 15% or less for all ESA populations”) is needed to evaluate the status and trends of listed populations and is essential for future management and recovery actions.

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LIST OF ABBREVIATIONS

- AUC—Area Under the Curve
- BPA—Bonneville Power Association
- CJS—Cormack Jolly-Seber
- CRITFC—Columbia River Inter-Tribal Fish Commission
- CTWSRO—Confederated Tribes of Warm Springs Reservation Oregon
- CV—Coefficient of Variation
- EDT—Ecosystem Diagnosis and Treatment Model
- EFID—East Fork Irrigation District
- ESA—Endangered Species Act
- FL—Fork Length
- FWP—Fish and Wildlife Program
- HRM—Hood River Mouth PIT tag interrogation station
- HRPP—Hood River Production Program, also referred to as the "Production Program"
- HRRP—Hood River Research Program
- HSRG—Hatchery Scientific Review Group
- IWR—In-stream Water Right
- LCR—Lower Columbia River
- M&E—Monitoring and Evaluation
- MCMC—Markov Chain Monte Carlo
- MFFF—Moving Falls Fish Facility
- NEPA—National Environmental Protection Act
- NPPC—Northwest Power Planning Council
- NWPCC—Northwest Power and Planning Conservation Council
- ODFW—Oregon Department of Fish and Wildlife
- OWRD—Oregon Water Resources Department
- PFF—Parkdale Fish Facility
- pHOS—proportion hatchery-origin spawners
- pNOB—proportion natural origin broodstock
- PIT—Passive Integrated Transponder
- PNI—Proportion Natural Influence
- PNNL—Pacific Northwest National Laboratory
- Production Program—Hood River Production Program
- PTAGIS—PIT Tag Information System
- rb-st—Rainbow-Steelhead
- RM—river mile
- RST—Rotary Screw Trap
- SMU—Species Management Unit
- USACE—United States Army Corps of Engineers
- UCM—Unit Characteristic Model
- USGS—United States Geological Survey
- VSP—Viable Salmonid Population

INTRODUCTION

Viable Salmonid Population (VSP) parameters reported by this project are submitted to ODFW's Coordinated Assessments staff annually. Following internal review, Coordinated Assessments data are made available to the public via ODFW's Salmon and Steelhead Recovery Tracker (www.odfwrecoverytracker.org). As stated on the website, "The ODFW Salmon Recovery Tracker website provides information on the health of Oregon's anadromous salmon and steelhead populations. Website users can explore and download information related to salmon conservation and recovery in Oregon. The Salmon Recovery Tracker was built to make it easier for the public to explore the health of salmon populations and access critical underlying data. It's a first step in helping the state open its information to the public in an easy-to-use medium." VSP parameters specific to the Hood River subbasin can also be found in this report. Additionally, coordinated assessment data are utilized by NOAA's Salmon Population Summary (https://www.webapps.nwfsc.noaa.gov/apex/f?p=261:1:#) database, and StreamNet (https://www.streamnet.org).

Fish Population Status and Trends

The Columbia River was once speculated to produce from 7 to 16 million returning adult salmon and steelhead annually (Chapman 1986, NPCC 1987). In a little over a century those returns have been reduced by nearly 90% due to a variety of anthropogenic influences, including the Columbia River hydroelectric system (Bottom et al 2005). In 1980, Congress passed the Pacific Northwest Electric Power Planning and Conservation Act in an attempt to address economic development, future regional electricity needs, and the effects of the Columbia River hydrosystem on biological resources (NWPCC 2009). As a result of that legislative action, the Northwest Power and Conservation Council (NWPCC—formerly known as the Northwest Power Planning Council) was created to "protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries … affected by the development, operation, and management of [hydroelectric projects] while assuring the Pacific Northwest an adequate, efficient, economical, and reliable power supply" (NWPCC 2009). The NWPCC developed a Fish and Wildlife Program (FWP) for the Columbia River basin that includes management plans for nearly 60 subbasins within the Columbia River watershed, including the Hood River (river mile (RM) 169). In 1987 they recommended that Bonneville Power Administration (BPA) begin to evaluate artificial production facility potential for Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) within the Hood River subbasin. Eventually the Hood River Production Master Plan (O'Toole and ODFW 1991a; O'Toole and ODFW 1991b) was adopted by the NWPCC in 1992, and its overarching goal was to "protect, enhance and restore wild and natural populations of anadromous and resident fish within the Hood River Subbasin" (Coccoli 2000) where production program specific goals included:

- Increasing production of wild summer and winter steelhead trout commensurate with the subbasin's current carrying capacity
- Re-introducing spring Chinook salmon into the Hood River subbasin
- Providing tribal and recreational fisheries for winter and summer steelhead and spring Chinook salmon

BPA also funded a later document which extensively outlined how the various projects identified in the master plans would be structured with respect to administrative organization,

NEPA compliance and implementation as well as monitoring and evaluation. The final document, completed in July 1993, was entitled the "Hood River/Pelton Ladder Master Agreement" (ODFW and CTWSRO Undated*a*). Collectively, these management and planning actions gave rise to what is currently defined as the Hood River Production Program (hereafter referred to as the Production Program) which is co-managed by Oregon Department of Fish and Wildlife (ODFW) and the Confederated Tribes of Warm Springs Oregon (CTWSRO). Both BPA and the Columbia River Inter-Tribal Fish Commission (CRITFC) recognized the need for a strong Monitoring and Evaluation (M&E) component in programs intended to improve natural production in the Hood River subbasin (BPA 1996, CRITFC 1996). The ODFW Hood River Research Program (HRRP) represents one of the six projects under the Production Program umbrella and is the M&E component administered by ODFW.

Since its inception in 1991, the HRRP has focused on evaluating the performance of the Production Program relative to its biological fish objectives for the Hood River subbasin. A set of objectives was established by the original Master Plan (1991), and later revised in 2008 (HDR|FishPro 2008). A summary of those numerical objectives (Table 1) were specified by the Hood River Production Program Master Plan Review (HDR|FishPro 2008).

	1991 Objective by 2016		10 Year Average		Proposed Objective by 2018	
Spring Chinook	**Wild**	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**Hatchery**
Adult Escape to Mouth of Hood R.	1,700		99	399	300	600
Adult Escape to Natural Production	400		98[1]	148[1]	205	8
Broodstock Collection	220		1	108	20	180
Harvest (Tribal & Sport)	1,080		U	83	30	318
Pre-spawning Mortality	NA		U	60	45	90
Smolt production	24,000	250,000	U	120,380	15,000	150,000
Egg-to-Smolt Survival	U	U	U	U	4.4%	78%
Smolt-to-Adult Survival	0.68%	0.68%	U	0.24%	2.0%	0.40%
Pre-Spawn Mortality	10%	10%	15%[2]	15%[2]	15%	15%
Tribal & Sport / Incidental Harvest	63%	63%	1%[1]	21%[1]	10%	53%
HOR Natural Spawn (<5%)	NA	NA	NA	151[1]%	NA	4%
HSRG Rules (>0.70)	NA	NA	NA	0.02[1]	NA	0.73
Summer Steelhead	**Wild**	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**Hatchery**
Adult Escape to Mouth of Hood R.[3]	8,000		300	852	510	NA
Adult Escape to Natural Production	2,400		210	175	408	NA
Broodstock Collection	160		35	3	0	NA
In-Basin Harvest (Tribal & Sport)	5,440		1	110	51	NA
Pre-Spawning Mortality	NA	NA	27[1]	22[1]	51	NA
Smolt Production		40,000	3,921	38,585[4]	7,500	NA
Egg-to-Smolt Survival	NA	NA	0.58%[1]	71.0%	1.0%	NA
Smolt-to-Adult Survival	NA	NA	7.5%	2.1%[5]	5%	NA
Pre-Spawn Mortality	NA	NA	10%[2]	10%[2]	10%	NA
Tribal & Sport / Incidental Harvest	NA	NA	0%[1]	10%[1]	10%	NA
HOR Natural Spawn (5%)	NA	NA	NA	5%[1]	NA	NA
HSRG Ratio (>0.7)	NA	NA	NA	0.67[1]	NA	NA
Winter Steelhead	**Wild**	**Hatchery**	**Wild**	**Hatchery**	**Wild**	**Hatchery**
Adult Escape to Mouth of Hood R.	5,000		662	1,003	656	1,000
Adult Escape to Natural Production	2,400		515	370	465	24
Broodstock Collection	90		68	24	60	0
In-Basin Harvest (Tribal & Sport)	2,510		2	365	66	876
Pre-Spawning Mortality	NA		60[1]	63[1]	66	100
Smolt Production		85,000	8,718	57,286	9,370	50,000
Egg-to-Smolt Survival	NA	NA	0.9%	66.4%	1.0%	75%
Smolt-to-Adult Survival	NA	NA	8.1%	1.1%[6]	7.0%	2.0%
Pre-Spawn Mortality	NA	NA	10%[2]	10%[2]	10%	10%
Tribal & Sport / Incidental Harvest	NA	NA	0%[1]	58%[1]	10%	88%
HOR Natural Spawn (<5%)	NA	NA	NA	75%[1]	NA	5%
HSRG Ratio (>0.7)	NA	NA	NA	0.64[1]	NA	0.95

[1]Computed value; [2] Assumed value; [3]Estimate assumed 10% catch and release mortality; [4]Average for Hood stock releases (1992- 2005); [5] Based on 1998-2002 five year average; [6] Based on 1993-2002 ten year average
U= unknown; NA = Not available

Table 1. Spring Chinook and summer and winter steelhead Production Program objectives reported in the 2008 Revised Master Plan for the Hood River (*Table courtesy of HDR|FishPro 2008*).

Also, as quoted in the program review (HDR|FishPro 2008) was the need for M&E programs to collect the empirical data required to:

- Refine the numerical fish objectives for wild summer and winter steelhead and natural origin spring Chinook to more accurately reflect the subbasin's current and potential species and race specific spawner escapement and smolt production carrying capacities
- Refine the numerical fish objectives for subbasin spawner escapement and harvest of summer and winter steelhead and spring Chinook salmon
- More accurately estimate and monitor species, race, and stock-specific subbasin smolt-to-adult survival rates
- Evaluate existing and proposed acclimation facilities and release strategies
- Monitor the incidental catch/take of wild and hatchery summer and winter steelhead and spring Chinook in mainstem Columbia River fisheries
- Evaluate the existing Pelton Ladder rearing facility, Columbia Gorge rearing facility, and the proposed expanded hatchery at Parkdale Fish Facility (PFF)
- Develop guidelines for implementing the hatchery supplementation program in a manner that will minimize its impact on indigenous populations of resident and anadromous salmonids
- Develop and refine strategies and guidelines for implementing this Master Plan in a manner that will improve program efficiency and benefits

While the HRRP maintains a primary focus on evaluating the goals established by the Production Program, the underlying purpose of the NWPCC FWP to "protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries" should remain superlative, with some emphasis placed on monitoring objectives related to species recovery planning. In 1998 the National Marine Fisheries Service (NMFS) listed Lower Columbia River steelhead as threatened under the Endangered Species Act (ESA), which includes Hood River winter- and summer-run types. As part of the Lower Columbia River sub-domain, recovery goals for Hood River salmon and steelhead identified in the Lower Columbia River Conservation & Recovery Plan for Oregon Populations of Salmon & Steelhead (2010) are to:

- Achieve delisting from the federal ESA threatened and endangered species list
- Achieve "broad sense recovery," defined as having Oregon populations of naturally produced salmon and steelhead that maintain a self-sustaining Species Management Unit (SMU) while providing significant ecological, cultural, and economic benefits.

Developed by ODFW, with participation by NOAA Fisheries, the Oregon Governor's Natural Resources Office, and the Oregon Lower Columbia River Stakeholder Team, the plan serves as a guide to achieve recovery of salmon and steelhead listed under the ESA in the Oregon portion of the Lower Columbia River Basin. Periodically, ODFW issues the Recovery Plan Annual Report which summarizes the current monitoring activities being conducted to assess recovery of ESA listed salmon and steelhead, including several monitoring objectives reported by the HRRP. While many essential biological indicators are currently being addressed, there are several monitoring initiatives identified by the plan as only partially complete or incomplete. Consequently, the HRRP should continue to refine its scope of work whenever possible to include both evaluation of Production Program performance and ESA species recovery.

Additionally, in June 2003 tribal, utility, government, and conservation groups agreed to remove Powerdale Dam, and in the summer of 2010 that initiative was completed. Data collection methods pertaining to both supplemented and non-supplemented species evaluation inherently endured substantial change, and will continue to be evaluated and modified in future years as necessary. The completion of this annual report summarizes the biological data collected during January 1, 2019 – December 31, 2019 and addresses the following objectives:

Adult Salmon and Steelhead Monitoring Objectives (includes summary and analysis of data collected by BPA Project #1988-053-08)

1. Monitor status and trends of steelhead spawning distribution and abundance
2. Estimate escapements of wild, natural and hatchery stocks of anadromous salmonids to the Hood River subbasin
3. Monitor selected life history characteristics of wild, natural, and hatchery stocks of anadromous salmonids escaping to the Hood River subbasin
4. Assess adult collection weir (East Fork, Neal Creek) and ladder/trap (Moving Falls--CTWSRO) capture efficiency and impacts on adult migration
5. Estimate hatchery fraction (pHOS) of steelhead spawning population(s)
6. Identify spatial and temporal spawning patterns for adult winter steelhead
7. Provide background data that can be used for:
   a. Modifications of the numerical fish objectives for the Production Program's hatchery supplementation efforts
   b. Develop models for predicting future run sizes of adult salmonids (CTWSRO)
   c. Federal and state recovery planning
   d. Annual estimates of spawner escapement, age structure, smolt-to-adult ratio, egg-to-smolt survival and smolt-per-spawner ratio

Juvenile Salmonid Summer Rearing Monitoring Objectives

1. Monitor streamflow at selected sites in the Hood River subbasin
2. Model relationships between summer rearing flow conditions, subsequent steelhead smolt production and steelhead spawner escapement
3. Determine survival of naturally produced juvenile spring Chinook
4. Determine life history structure and migration patterns of Hood River spring Chinook parr

Juvenile Salmonid Outmigration Monitoring Objectives

1. Estimate steelhead and spring Chinook (when possible) smolt production at selected sites in the Hood River subbasin
2. Monitor status and trends of Hood River juvenile rainbow-steelhead abundance
3. Evaluate size and condition of outmigrant juvenile salmonids
4. Evaluate age structure of outmigrant juvenile salmonids
5. Determine survival and migration timing of outmigrant salmonids through the estuary

This project supports the Fish and Wildlife (F&W) Program Strategies:

1. Assess the status and trend of natural and hatchery origin abundance of fish populations for various life stages.
2. Assess the status and trend of adult productivity of natural origin fish populations.
3. Assess the status and trend of juvenile abundance and productivity of natural origin fish populations.
4. Assess the status and trend of spatial distribution of fish populations.
5. Assess the status and trend of diversity of natural and hatchery origin fish populations.

This project answers or provides data to answer the F&W Program Management Questions:

1. What are the status and trend of abundance of natural and hatchery origin fish populations?
2. What are the status and trend of adult productivity of fish populations?
3. What are the status and trend of juvenile abundance and productivity of fish populations?
4. What are the status and trend of spatial distribution of fish populations?
5. What are the status and trend of diversity of natural and hatchery origin fish populations?

METHODS: PROTOCOLS, METHODS, AND STUDY AREA

Fish Population Status and Trends

PROTOCOLS:

Hood River non-tribal harvest monitoring (ID: 197)
https://www.monitoringresources.org/Document/Protocol/Details/197

Monitor Abundance of Non-Supplemented Salmonids (ID: 326)
https://www.monitoringresources.org/Document/Protocol/Details/326

Hood River subbasin juvenile and smolt monitoring (ID: 352)
https://www.monitoringresources.org/Document/Protocol/Details/352

Monitor selected physical & environmental variables affecting natural production of Hood River salmonids (ID: 353)
https://www.monitoringresources.org/Document/Protocol/Details/353

Hatchery steelhead pre-release evaluation of relative condition and mark accuracy (ID: 783)
https://www.monitoringresources.org/Document/Protocol/Details/783

Adult and juvenile salmonid scale mounting and age analysis (ID: 784)
https://www.monitoringresources.org/Document/Protocol/Details/784

Hood River subbasin adult abundance monitoring (ID: 2108)
https://www.monitoringresources.org/Document/Protocol/Details/2108

Study Area

The confluence of the Hood River is located 169 miles upstream from the mouth of the Columbia River (USGS river mile data: http://www.ecy.wa.gov/copyright.html). The Hood River watershed covers approximately 339mi^2 (USGS Streamstats) and is comprised of three major subwatersheds—the East, Middle and West Forks (Figure 1).

The East and Middle Forks are glacially fed streams with their source headwaters located on the northeast side of Mount Hood. The West Fork of the Hood River is predominantly spring fed and annually accounts for roughly 40% of the total subbasin discharge during low flow periods and as much as 50% – 60% during high flow periods. The watershed is characterized by a highly variable flow regime that is strongly influenced by precipitation, snowpack and temperature fluctuations. These elements frequently compound upon each other and can produce dramatic results typical of glacially influenced streams. There are approximately 509 total stream miles in the Hood River watershed (USGS Streamstats). HDR|FishPro (2008) determined approximately 100 stream miles are accessible to anadromous salmonids (Figure 2). Land use throughout the basin is diverse and consists of urban, rural residential, agricultural, public and private industrial timber, and National Forest components. To facilitate agricultural and other land use efforts, surface water withdrawals are prevalent throughout the subbasin with three major irrigation districts operating within the Hood River watershed. All maps included in this report were generated using ArcGIS 10.6 and incorporated the World Shaded Relief map and National Geographic physical map provided by the ESRI ArcGIS Services online database (http://services.arcgisonline.com/arcgis/services).

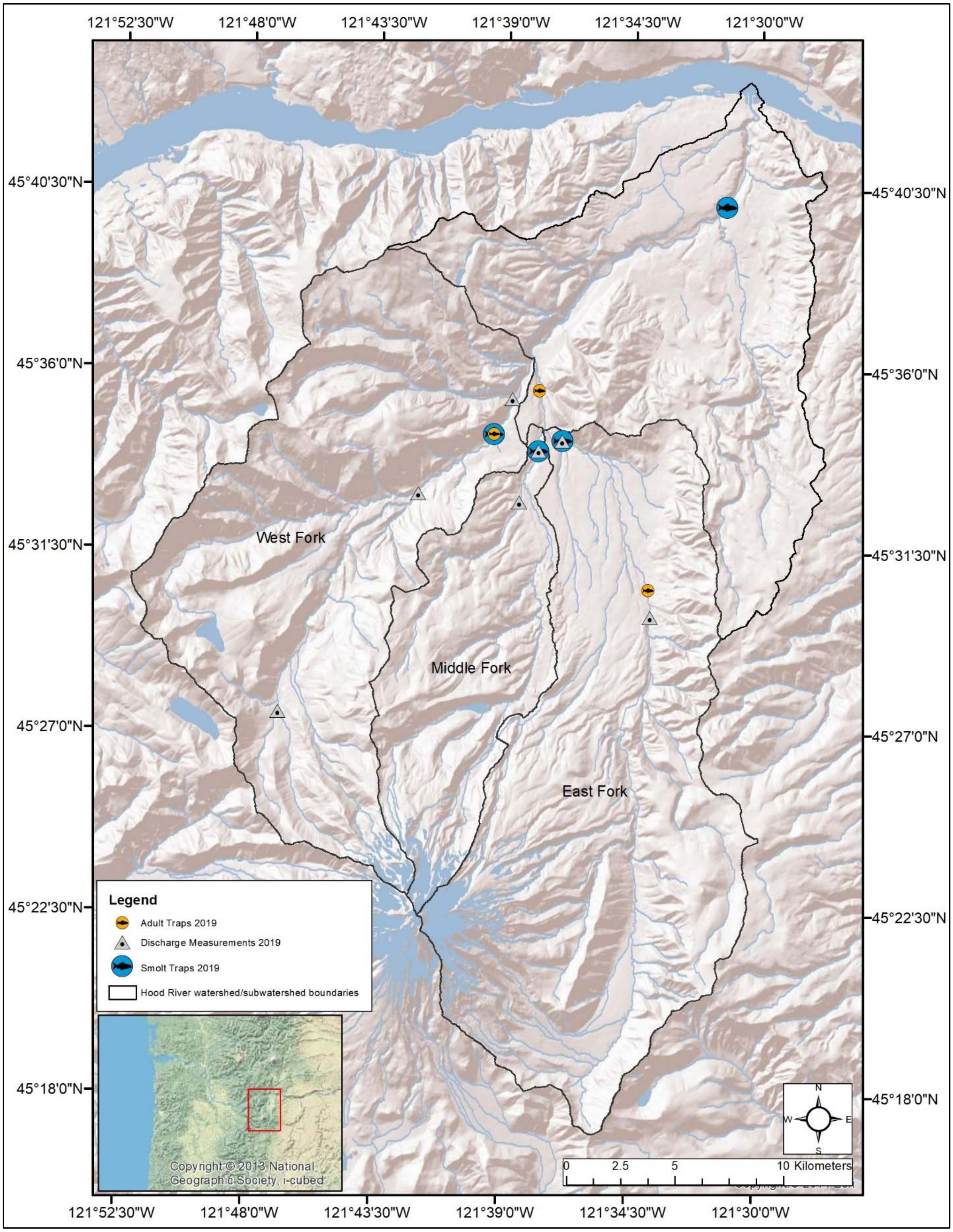

Figure 1. Map of stream discharge and adult and juvenile sampling sites within the Hood River subbasin, 2019.

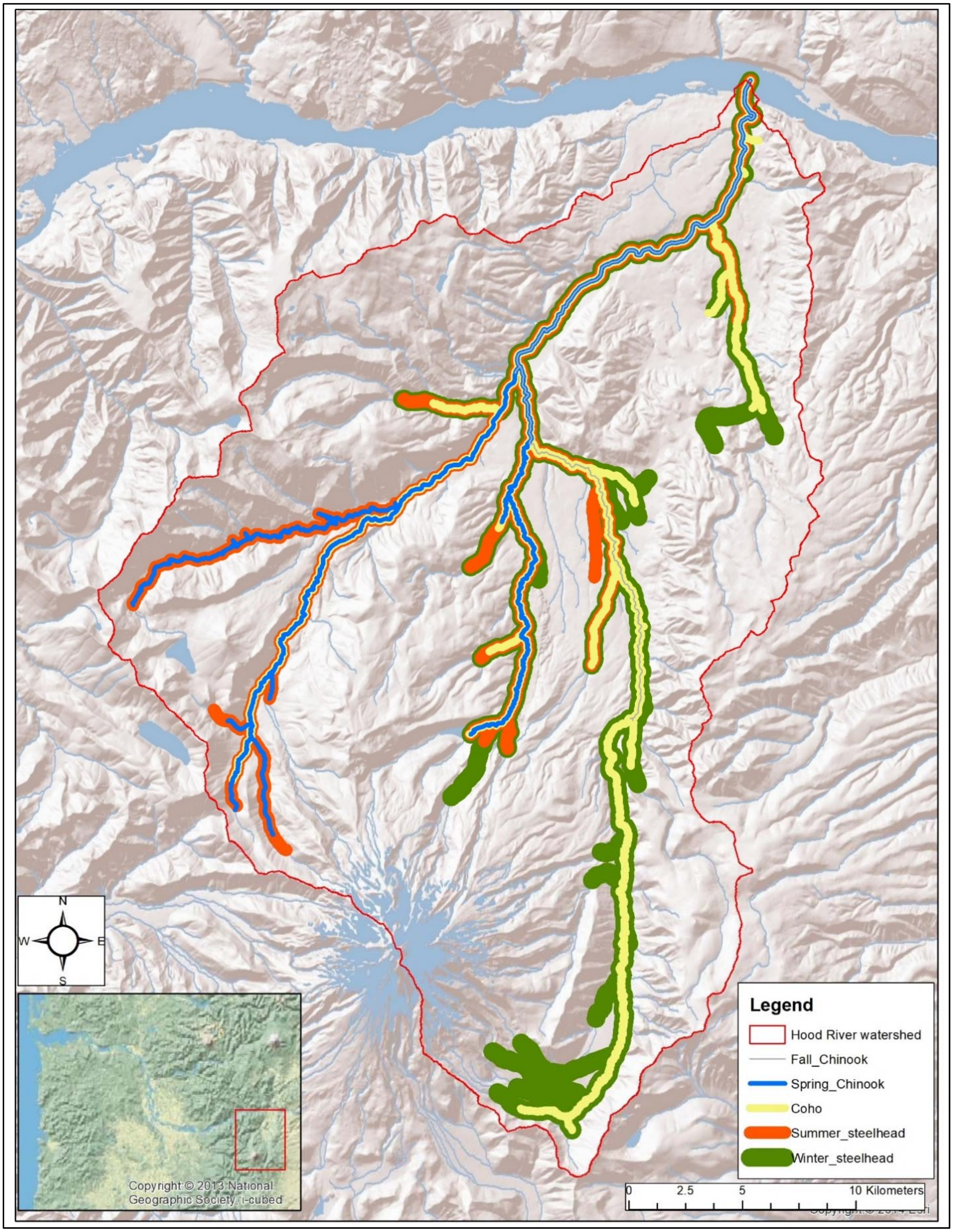

Figure 2. Anadromous salmonid distribution throughout the Hood River watershed (Data source for fish distribution: StreamNet).

RESULTS

Juvenile Abundance—Supplemented Species

An estimated 18,569 (7,962 – 29,176, 95% C.I.) wild rb-st ≥ 150mm FL migrated past the mainstem Hood River RST (RM 4.5) during the 2019 sampling season (Table 2). Figures 3-5 display the annual mean fork length (mm), weight (g), and condition factor for wild steelhead smolts captured at the mainstem RST, by freshwater age.

Year	Number of migrants	95% Confidence Interval Low	95% Confidence Interval High	Age 1	%	Age 2	%	Age 3	%	Age 4	%	Coeffecient of Variation
1994	9,554	4,314	14,794	2,191	22.9%	6,311	66.1%	1,052	11.0%	0	0.0%	28.0%
1995	5,955	0	13,783	1,111	18.7%	3,790	63.6%	1,054	17.7%	0	0.0%	67.1%
1996	8,755	6,188	11,322	738	8.4%	6,423	73.4%	1,570	17.9%	24	0.3%	15.0%
1997	15,972	10,996	20,948	1,834	11.5%	12,208	76.4%	1,930	12.1%	0	0.0%	15.9%
1998	31,035	22,801	39,269	1,463	4.7%	26,989	87.0%	2,583	8.3%	0	0.0%	13.5%
1999	23,942	17,212	30,672	43	0.2%	21,041	87.9%	2,858	11.9%	0	0.0%	14.3%
2000	19,266	15,191	23,341	503	2.6%	12,285	63.8%	6,450	33.5%	28	0.1%	10.8%
2001	6,804	0	14,579	200	2.9%	4,013	59.0%	2,482	36.5%	109	1.6%	58.3%
2002	12,290	8,903	15,677	783	6.4%	8,710	70.9%	2,704	22.0%	93	0.7%	14.1%
2003	14,460	9,835	19,085	218	1.5%	9,700	67.1%	4,522	31.3%	20	0.1%	16.3%
2004	15,042	10,962	19,122	1,612	10.7%	8,810	58.6%	4,566	30.3%	54	0.4%	13.8%
2005	21,484	15,169	27,799	271	1.3%	18,347	85.4%	2,843	13.2%	23	0.1%	15.0%
2006	8,395	5,177	11,613	37	0.4%	4,986	59.4%	3,281	39.1%	91	1.1%	19.6%
2007	4,316	1,478	7,154	226	5.2%	2,857	66.2%	1,151	26.7%	82	1.9%	33.5%
2008	16,080	8,048	24,112	1,521	9.5%	13,183	82.0%	1,376	8.5%	0	0.0%	25.5%
2009	9,317	5,477	13,157	105	1.1%	8,100	87.0%	1,091	11.7%	21	0.2%	21.0%
2010	16,810	11,637	21,983	1,544	9.2%	8,898	52.9%	6,261	37.2%	107	0.7%	15.7%
2011	18,298	14,585	22,011	495	2.7%	14,184	77.5%	3,588	19.6%	31	0.2%	10.4%
2012	16,243	11,370	21,116	715	4.4%	8,657	53.3%	6,725	41.4%	146	0.9%	15.3%
2013	42,220	33,137	51,303	929	2.2%	30,694	72.7%	10,133	24.0%	464	1.1%	11.0%
2014	18,305	13,138	23,472	531	2.9%	11,294	61.7%	6,388	34.9%	92	0.5%	14.4%
2015	26,273	22,544	30,001	3,442	13.1%	15,396	58.6%	7,172	27.3%	263	1.0%	7.2%
2016	22,705	18,514	26,897	1,816	8.0%	16,961	74.7%	3,678	16.2%	250	1.1%	9.4%
2017	17,318	13,528	21,107	1,437	8.3%	13,283	76.7%	2,546	14.7%	520	3.0%	11.2%
2018	16,930	12,903	20,958	660	3.9%	12,156	71.8%	4,080	24.1%	51	0.3%	12.1%
2019	18,569	7,962	29,176									

Table 2. Estimated number of wild downstream migrant rainbow-steelhead (rb-st) greater than or equal to 150 mm fork length to a migrant trap located at RM 4.5 in the mainstem Hood River, by age category.

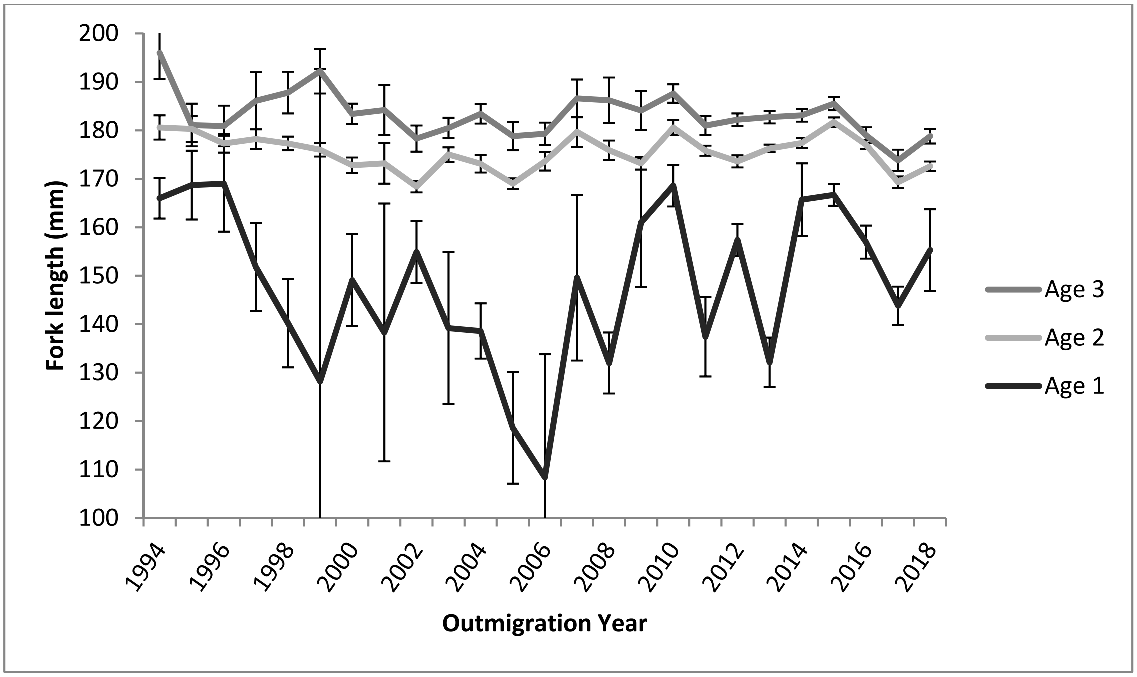

Figure 3. Mean fork length (mm) of downstream migrant wild rainbow-steelhead sampled at a juvenile migrant trap located at RM 4.5 in the mainstem Hood River, by freshwater age class (error bars denote 95% confidence interval).

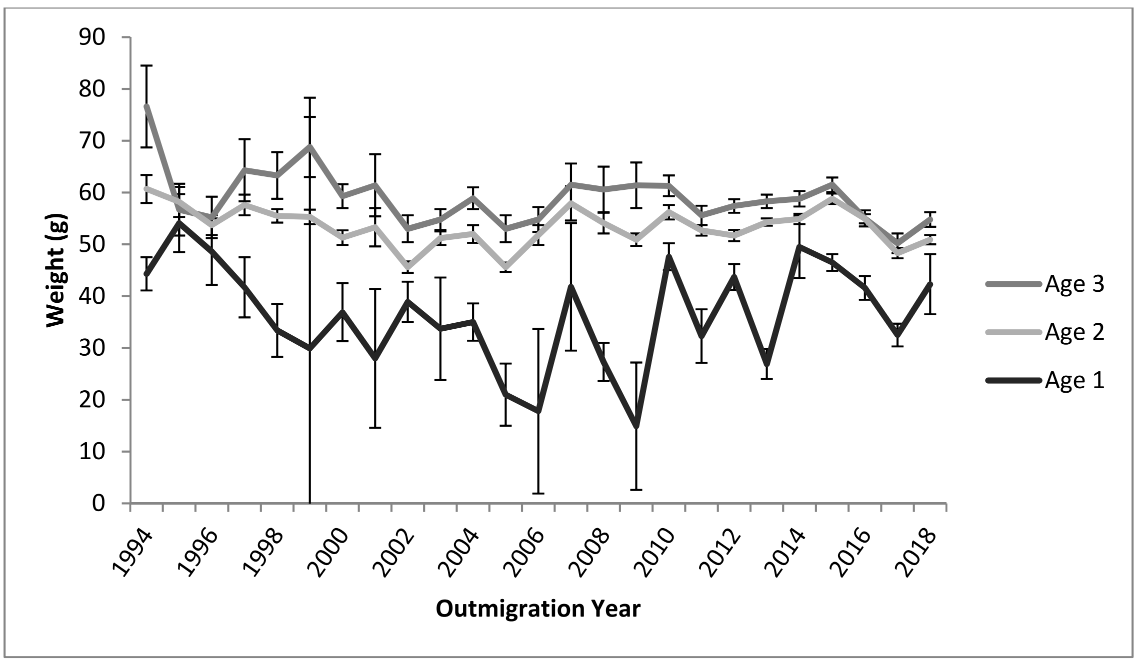

Figure 4. Mean weight (g) of downstream migrant wild rainbow-steelhead sampled at a juvenile migrant trap located at RM 4.5 in the mainstem Hood River, by freshwater age class (error bars denote 95% confidence interval).

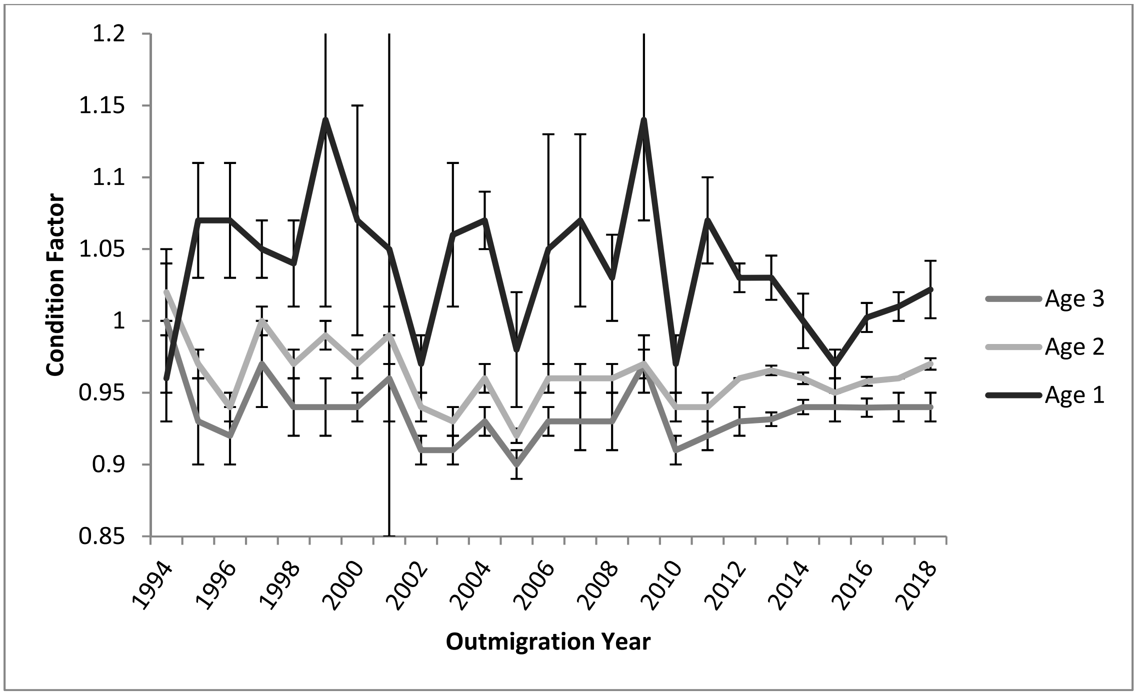

Figure 5. Mean condition factor of downstream migrant wild rainbow-steelhead sampled at a juvenile migrant trap located at RM 4.5 in the mainstem Hood River, by freshwater age class (error bars denote 95% confidence interval).

Apparent survival for wild steelhead smolts from their trapping location to downstream migrant interrogation facilities derived from the CJS model (White and Burnham 1999) for juvenile rb-st (≥ 150mm FL) and associated detection efficiencies are displayed in Figure 6. Apparent survival of juvenile rb-st from the release-after-tagging location upstream of the mainstem RST site to the mouth of the Hood River was 0.915, and apparent survival to downstream interrogation facilities at Bonneville Dam was 0.734.

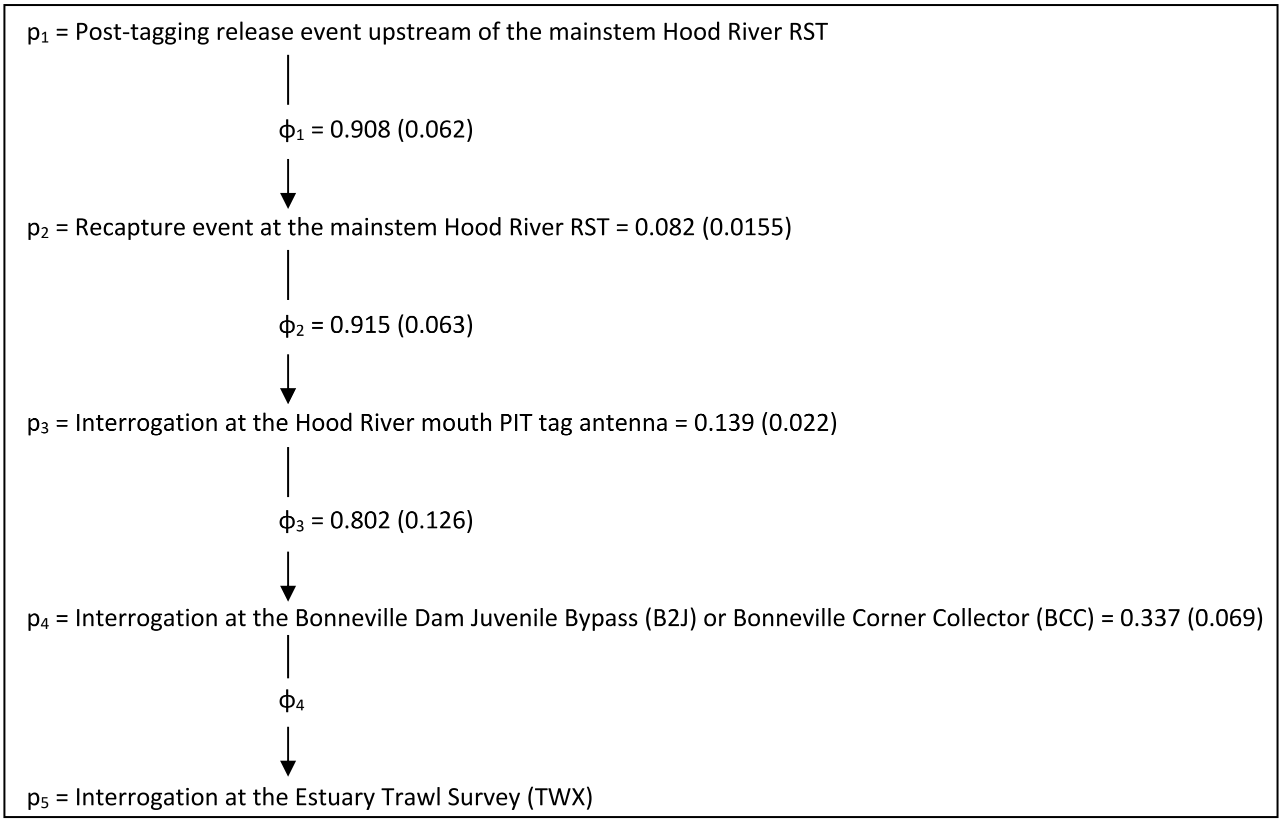

Figure 6. Apparent survival (ϕ) and recapture probability (p) of 2019 wild rb-st (≥ 150mm FL) calculated using the Cormack-Jolly Seber open population model (standard deviation in parentheses).

During 2019, the average number of days for PIT tagged rb-st to be recaptured at a RST after tagging was 5.48 and was 3.71 days for the years 2005 - 2019 (Table 3). Rb-st traveled to the downstream migrant interrogation facilities at Bonneville Dam within 8.21 days of tagging (average of 7.14 days for all data years), and subsequent detections recorded by the estuary trawl survey occurred within 8.44 days (8.85 days for all data years).

Year(s)	INSTREAM	BCC/B2J	TWX
2019 Average	5.48	8.21	8.44
2019 Minimum	1.31	1.51	3.52
2019 Maximum	139.42	49.64	36.38
2005 - 2019 Average	3.71	7.14	8.85
2005 - 2019 Minimum	0.78	1.00	1.00
2005 - 2019 Maximum	163.00	100.00	56.00

Table 3. Average, minimum and maximum migration times in days (from Hood River RST to noted interrogation site) for rb-st tagged during 2019 and combined values from 2005 – 2019.

A summary of juvenile steelhead PIT-tagged during 2019 is provided in Table 4. Nearly 800 juvenile rb-st were tagged during the fall trapping season, a significant increase over 2018 when only 167 juvenile rb-st were tagged (Simpson 2019).

2019, WILD

Month	PIT Tagged	Average fork length (cm)	Minimum fork length (cm)	Maximum fork length (cm)	Average weight (g)	Minimum weight (g)	Maximum weight (g)
April	377	168.0	81	257	50.3	6.5	159
May	1347	170.1	93	255	50.5	7.9	157.7
June	205	141.0	100	305	34.1	9.8	337.0
September	386	145.1	85	220	33.1	5.9	116.8
October	410	145.5	90	216	32.5	7.6	90.5

2019, HATCHERY

Season - Year	PIT Tagged	Average fork length (cm)	Minimum fork length (cm)	Maximum fork length (cm)	Average weight (g)	Minimum weight (g)	Maximum weight (g)
April	9	213.8	178	257	91.3	50.2	162.5
May	801	211.9	108	268	88.9	14.1	199.5
June	168	208.6	119	270	84.1	24.6	192.2
September	7	248.6	205	293	144.0	74.9	241.9
October	9	219.8	166	273	104.3	34.0	211.8

Table 4. Number of juvenile steelhead (by origin) PIT-tagged by month, 2019.

Table 5. Mean fork length (FL; mm) and weight (g) for Hood River stock hatchery winter steelhead smolts sampled at Oak Springs Hatchery prior to being transferred to the Hood River subbasin. (All data shown for late release groups).

Fork Length (mm)

Brood Year	Size Group	N	Mean	Minimum	Maximum	95% C.I.
1996	Small	192	168.2	90	225	± 3.7
1997	Small	205	173.8	89	218	± 3.1
1998	Small	195	194.9	92	268	± 3.6
1999	Small	196	180.6	119	224	± 2.7
2000	Large	195	198.2	134	242	± 3.0
2000	Small	203	182.3	98	244	± 3.4
2001 (G1;L3)	--	200	194.0	109	279	± 4.3
2001 (G1;L4)	--	216	193.0	109	275	± 3.7
2002	--	205	188.7	100	265	± 3.8
2003	--	253	203.8	101	258	± 3.2
2004	--	207	179.8	94	246	± 4.1
2005 (L1)	--	200	179.8	104	237	± 3.6
2006 (L1)	--	228	189.7	104	243	± 3.1
2007	--					
2008	--	204	196.8	107	272	± 3.6
2009 (L1)	--	400	207.3	121	267	± 2.0
2010 (L1;L2)	--	399	198.3	91	273	± 3.0
2011 (L1;L2)	--	406	214.1	129	276	± 2.3
2012 (L1; L2)	--	407	214.6	118	279	± 2.3
2013 (L1; L2)	--	388	202.3	89	272	± 2.6
2014 (L1; L2)	--	400	204.5	103	275	± 3.0
2014 (L3)	--	200	201.4	114	289	± 4.2
2015 (L2; L3)	--	400	197.2	86	267	± 2.9
2016 (L2; L3)	--	400	181.7	97	286	± 3.2
2017 (U1; U3)	--	400	198.4	132	253	± 1.9
2018 (U1; U3)	--	400	200.9	131	260	± 2.1

Table 5, continued.

Weight (g)

Brood Year	Size Group	N	Mean	Minimum	Maximum	95% C.I.
1996	Small	191	53.4	5.7	109.8	± 3.3
1997	Small	202	60.7	7.3	115.8	± 2.9
1998	Small	195	84.1	7.9	190.1	± 4.3
1999	Small	195	62.9	17.4	134.3	± 2.8
2000	Large	192	89.8	26.1	176.0	± 3.7
2000	Small	202	73.4	13.5	164.6	± 3.8
2001 (G1;L3)	--	199	86.2	14.4	282.6	± 6.0
2001 (G1;L4)	--	215	84.0	14.9	262.6	± 5.0
2002	--	205	76.7	12.2	183.3	± 4.2
2003	--	250	95.4	14.9	208.3	± 4.2
2004	--	207	66.1	8.9	166.9	± 4.0
2005 (L1)	--	198	70.6	12.3	151.5	± 3.8
2006 (L1)	--	228	74.0	13.9	147.7	± 3.2
2007	--					
2008	--	204	90.1	13.5	259.7	± 4.9
2009 (L1)	--	400	98.3	17.2	214.4	± 2.8
2010 (L1;L2)	--	399	87.3	8.8	233.0	± 3.6
2011 (L1;L2)	--	406	109.3	22.5	258.0	± 3.6
2012 (L1;:L2)	--	407	111.4	20.3	266.4	± 3.6
2013 (L1; L2)	--	388	92.9	7.2	231.1	± 3.3
2014 (L1; L2)	--	400	97.0	11.5	212.0	± 3.8
2014 (L3)	--	200	97.4	17.2	300.4	± 6.2
2015 (L2; L3)	--	400	90.7	6.7	255.6	± 3.5
2016 (L2; L3)	--	400	71.2	13.4	281.3	± 3.6
2017 (U1; U3)	--	400	88.6	23.7	196.6	± 2.6
2018 (U1; U3)	--	400	91.4	10.8	185.2	± 2.9

Pre-release subsampling at Oak Spring hatchery prior to acclimation of the 2019 hatchery winter steelhead release group indicated that average smolt size was 200.9mm (FL), very close to the 10-year average of 201.3mm. The minimum size recorded during 2019 sampling was 131mm which was similar to the previous year and the second highest minimum length on record. The relationship between apparent survival from release to Bonneville Dam indicates that a larger average size at release translates into a higher smolt conversion rate (Figure 7).

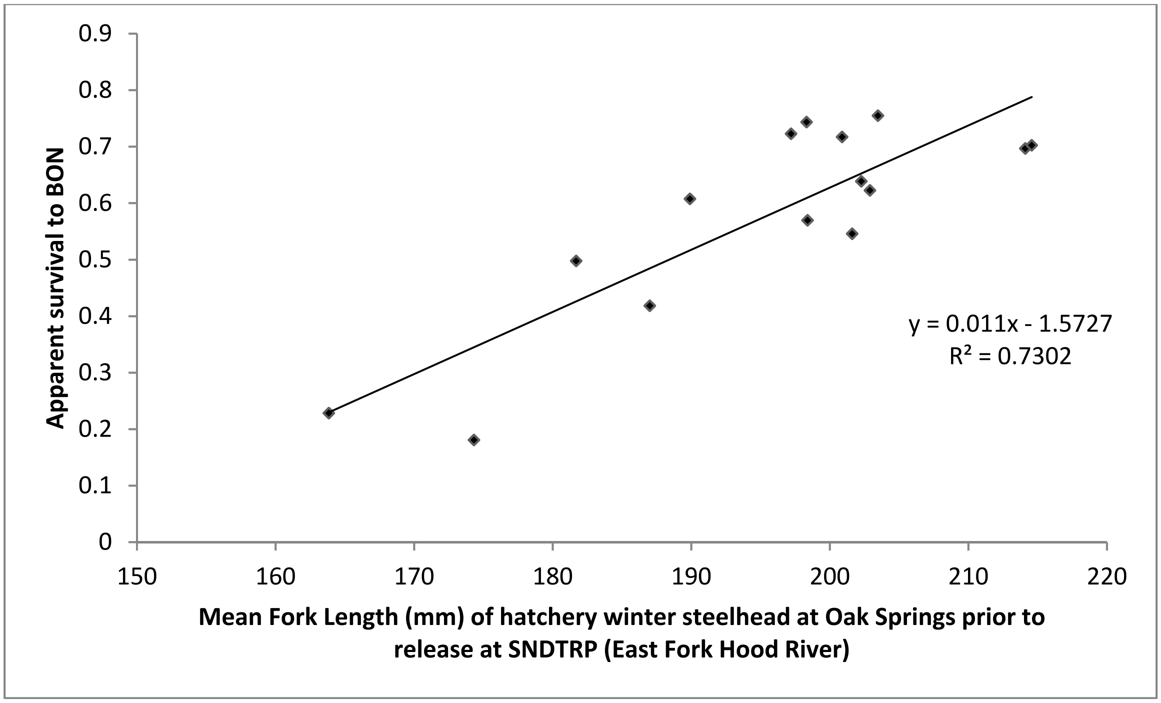

Figure 7. Apparent survival of hatchery winter steelhead smolts to Bonneville Dam relative to average smolt length as determined by subsampling at Oak Springs hatchery prior to transport to the Hood River subbasin (2005 – 2019).

Release Year	Total PIT Tagged in Year *y*	Total Release Group	Proportion of Release Group PIT Tagged	Total Estimated Number of Residuals	Percent Residuals
2005	7,009	83,403	0.08	268	0.32%
2006	15,936	36,819	0.43	80	0.22%
2007	8,023	38,360	0.21	602	1.57%
2008	9,399	66,591	0.14	374	0.56%
2009	8,803	57,461	0.15	1,464	2.55%
2010	6,930	47,347	0.15	684	1.45%
2011	5,660	50,995	0.11	624	1.22%
2012	6,180	54,446	0.11	3,056	5.61%
2013	6,409	55,303	0.12	1,248	2.26%
2014	7,106	51,987	0.14	805	1.55%
2015	9,978	53,235	0.19	626	1.18%
2016	10,733	55,531	0.19	183	0.33%
2017	6,618	46,538	0.14	2,054	4.41%
2018	6,814	54,981	0.12	207	0.38%

Table 6. Estimated number of hatchery winter steelhead residuals exhibiting an age-2 freshwater life history variation during the spring of the year following release for the period 2005 – 2018.

Based on recapture data of hatchery winter steelhead smolts the number of estimated residual hatchery steelhead exhibiting an age-2 freshwater life history variation appears limited, with typically less than 2% (mean = 1.69%, range [0.22% - 5.61%]) of the hatchery release group estimated to survive to detection the year following release (Table 6). Wild age 2 smolt production during year *y* appears limited by the proportion of non-smolt hatchery reared steelhead (FL< 150mm) within release year *y-1* (Figure 8).

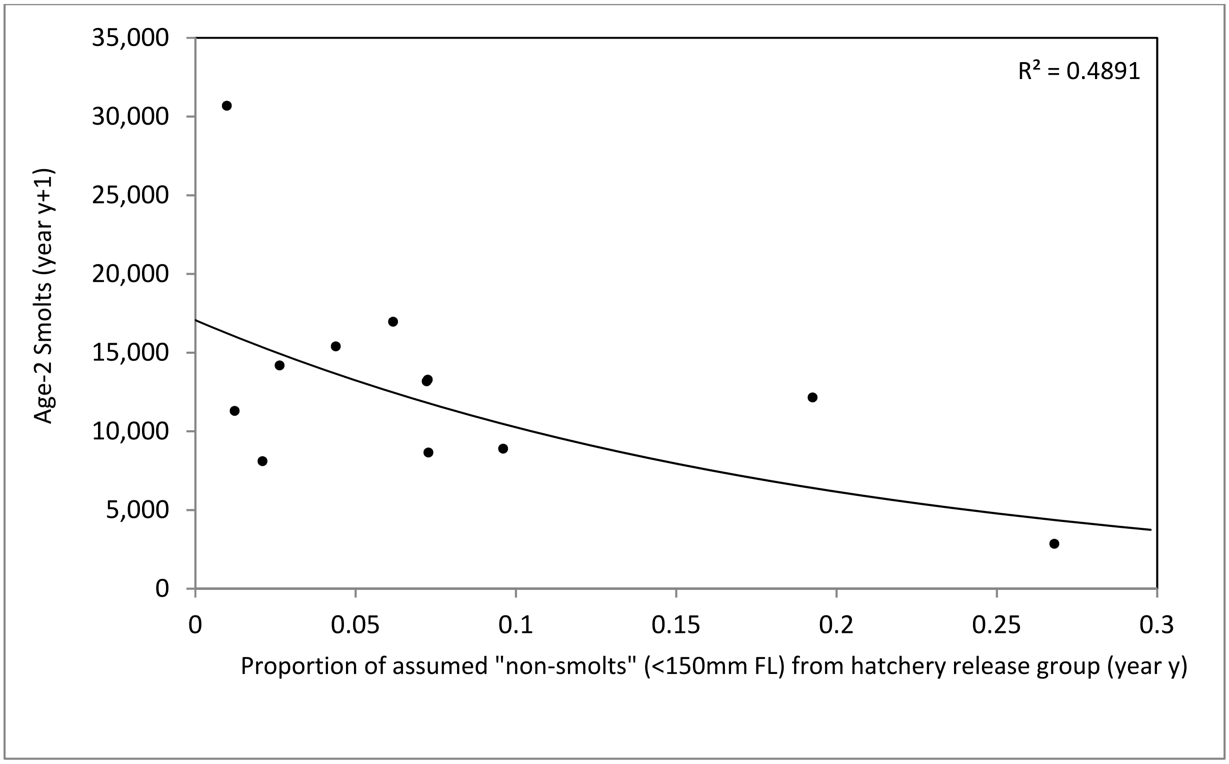

Figure 8. Regression of age-2 smolt production at the mainstem Hood River migrant trap (RM 4.5) during year *y* relative to the proportion of non-smolt hatchery winter steelhead released during year *y-1*.

Naturally produced juvenile Chinook salmon were captured at RST sites during 2019 using the same collection schedule as previously noted for juvenile rb-st. For the year class 2018 – 2019 (brood year 2017), a total of 331 age 0+ juveniles were tagged during the fall 2018 period, and 140 age 1+ Chinook salmon smolts were tagged during the spring 2019 period (Table 7).

Season - Year	PIT Tagged	Average fork length (cm)	Minimum fork length (cm)	Maximum fork length (cm)	Average weight (g)	Minimum weight (g)	Maximum weight (g)
FALL							
2004	319						
2005	489	87.5	69.0	127.0	7.4	3.1	17.4
2006	488	89.1	70.0	145.0	8.8	3.6	38.8
2008	684	86.4	67.0	118.0	7.8	2.2	21.7
2009	756	89.8	66.0	118.0	8.8	3.2	100.0
2010	1211	87.8	60.0	115.0	7.9	3.0	17.0
2011	364	98.1	77.0	124.0	11.3	5.3	22.5
2012	601	102.4	84.0	140.0	13.1	6.2	91.0
2013	2078	100.5	79.0	158.0	12.2	5.4	106.0
2014	190	99.8	78.0	143.0	12.0	5.3	36.7
2015	268	98.3	76.0	138.0	11.0	0.9	29.8
2016	880	96.9	66.0	166.0	10.9	5.2	54.1
2017	1329	98.8	80.0	203.0	11.4	5.7	69.3
2018	331	102.6	80.0	141.0	12.6	5.5	33.1
2019	943	97.5	76.0	154.0	10.7	5.1	36.4
SPRING							
2005	90	79.1	54.0	149.0	6.6	1.6	33.8
2006	79	101.9	60.0	140.0	12.2	2.3	30.0
2007	64	96.3	63.0	160.0	11.2	2.6	47.6
2008	196	100.3	75.0	128.0	11.4	4.9	25.4
2009	120	104.8	70.0	145.0	14.2	3.7	32.0
2010	258	98.0	70.0	129.0	10.6	3.4	22.8
2011	153	105.5	71.0	197.0	14.1	4.0	49.7
2012	260	122.0	82.0	227.0	19.8	6.5	51.4
2013	159	103.8	82.0	198.0	12.9	5.8	33.4
2014	225	122.0	81.0	161.0	21.2	5.3	63.0
2015	573	125.4	81.0	180.0	21.9	3.1	121.6
2016	204	116.4	75.0	151.0	17.9	5.4	35.2
2017	39	103.5	87.0	133.0	12.2	7.2	21.8
2018	243	123.8	89.0	162.0	20.8	7.8	41.5
2019	140	121.0	86.0	155.0	19.5	6.5	43.1

Table 7. Average, maximum and minimum fork length (mm) and weight (g) of juvenile Chinook salmon PIT tagged through fall 2019.

Due to low tagging and recapture rates an expanded population estimate was not produced for naturally produced juvenile Chinook salmon. During the fall 2019 period (brood year 2018), a total of 943 juvenile Chinook were tagged.

The average migration time for the summer and fall tagging groups of juvenile Chinook salmon to the downstream migrant interrogation facilities at Bonneville Dam averaged 70.1 and 128.5 days respectively, although the average migration time for the spring tagging group (age 1+ smolts) was 11.2 days. The average migration time to Bonneville for the summer group was confounded by limited available data. The average migration time to the estuary for the fall group was and 226.0 days and was 31.7 days for the spring group (Table 8).

	INSTREAM	BCC/B2J	HRM	TWX
Fall 2018 - Spring 2019				
Summer Average				
Summer Minimum				
Summer Maximum				
Fall Average	1.4	43.6	10.0	--
Fall Minimum	0.8	2.4	0.5	--
Fall Maximum	9.0	187.2	140.8	--
Spring Average	3.4	6.7	10.3	--
Spring Minimum	0.9	1.5	1.2	--
Spring Maximum	32.0	19.4	48.7	--
Combined 2004 - 2019				
Summer Average	5.3	70.1	22.7	--
Summer Minimum	0.8	2.0	2.3	--
Summer Maximum	60.0	244.0	47.9	--
Fall Average	1.7	128.5	8.3	226.0
Fall Minimum	0.0	1.7	0.2	225.0
Fall Maximum	249.0	256.8	140.8	227.0
Spring Average	2.4	11.2	16.3	31.7
Spring Minimum	0.7	1.0	0.6	3.7
Spring Maximum	40.9	58.3	226.8	326.0

Table 8. Average, minimum and maximum migration times in days (from Hood River RST to noted interrogation site) for Chinook salmon tagged during fall 2018 – spring 2019, and combined values through fall 2019.

The Hood River Mouth (HRM) PIT tag antenna has collected interrogation data on migratory salmonids effectively since 2012. Interrogations of natural production juvenile Chinook salmon tagged during the fall seasons of 2012 – 2019 suggest that a high percentage are potentially leaving the Hood River subbasin shortly after they are tagged and released. Based on PTAGIS interrogation records coupled with CJS model estimates of recapture probability at the HRM antenna, anywhere from 16% - 67% of juvenile Chinook salmon appear to migrate out of the subbasin in the fall in a given year. Sample size limitations often produce antenna efficiency estimates with low precision which makes computing exact numbers difficult, however just based on interrogation data alone, there is evidence that some level of juvenile outmigration occurs during the fall months. Following detection at the HRM, subsequent interrogation data indicated a variety of migratory behaviors were present. A limited number (≈5.0%) of spring Chinook detected at the HRM appeared to exhibit milling behavior (detected

multiple times with at least 7 days between detections). Additionally, interrogations at Bonneville Dam downstream migrant facilities indicated that roughly 40% of the total detections were recorded during September – December while 60% occurred during the spring months. Because of operational constraints at Bonneville Dam during the winter months, the number of downstream migrants during December – February is unknown.

Juvenile Abundance—Non-Supplemented Species

A total of 92 downstream migrant cutthroat trout were PIT tagged in the Hood River during 2019 and the average recorded length and weight of tagged cutthroat in 2019 was slightly less than previous years (Table 9).

Year	PIT Tagged	Average of fork length (mm)	Maximum of fork length (mm)	Minimum of fork length (mm)	Average of weight (g)	Maximum of weight (g)	Minimum of weight (g)	Average of CF	Maximum of CF	Minimum of CF
2005	41	171.6	302.0	103.0	54.0	273.7	9.6	0.93	1.25	0.76
2006	14	175.4	213.0	151.0	55.1	97.3	33.2	0.99	1.10	0.89
2007	19	187.1	253.0	133.0	68.6	166.2	24.4	0.97	1.17	0.87
2008	29	171.5	233.0	120.0	51.9	116.8	20.3	0.98	1.17	0.82
2009	52	179.3	252.0	138.0	55.9	134.1	26.4	0.94	1.14	0.78
2010	53	182.4	310.0	83.0	60.7	203.2	6.4	0.91	1.21	0.68
2011	84	177.3	249.0	96.0	55.2	153.5	7.2	0.96	1.22	0.81
2012	172	178.5	244.0	105.0	54.5	126.8	13.8	0.93	1.19	0.77
2013	208	173.0	228.0	114.0	49.1	113.8	14.3	0.92	1.23	0.71
2014	139	181.5	229.0	145.0	56.7	114.2	27.5	0.93	1.11	0.80
2015	132	181.3	275.0	126.0	57.1	187.2	19.8	0.93	2.92	0.44
2016	118	177.8	266.0	115.0	53.7	166.3	14.5	0.92	1.11	0.78
2017	139	174.7	365.0	136.0	52.1	422.9	22.0	0.92	1.12	0.60
2018	126	175.4	263.0	109.0	52.9	153.9	13.6	0.95	1.10	0.79
2019	92	170.6	225.0	140.0	47.8	109.9	24.1	0.93	1.09	0.71

Table 9. Average, minimum and maximum fork length (mm), weight (g) and condition factor of cutthroat trout PIT tagged through 2019.

A total of 9 bull trout were captured and PIT-tagged during 2019. The majority of bull trout caught in RSTs occur in the Middle Fork of the Hood River, where annual counts ranged from 0 – 22 during 1996 – 2019. Captures of bull trout at downstream migrant traps along with mean FL, weight, and condition factor are summarized in Table 10.

Year	N	Average of fork length (mm)	Minimum of Fork Length (mm)	Maximum of Fork Length (mm)	Average of Weight (g)	Minimum of Weight (g)	Maximum of Weight (g)	Average of Condition Factor	Minimum of Condition Factor	Maximum of Condition Factor
1994	1	243.0	243.0	243.0	136.3	136.3	136.3	0.95	0.95	0.95
1995	--	--	--	--	--	--	--	--	--	--
1996	6	150.5	128.0	165.0	31.5	23.5	41.1	0.95	0.81	1.12
1997	10	177.8	151.0	215.0	61.6	35.5	100.1	1.06	0.96	1.14
1998	26	175.1	105.0	270.0	59.8	13.8	203.8	1.02	0.93	1.24
1999	1	154.0	154.0	154.0	38.5	38.5	38.5	1.05	1.05	1.05
2000	1	222.0	222.0	222.0	102.8	102.8	102.8	0.94	0.94	0.94
2001	1	115.0	115.0	115.0	15.5	15.5	15.5	1.02	1.02	1.02
2002	13	163.2	147.0	181.0	40.4	24.4	57.1	0.91	0.77	0.98
2003	--	--	--	--	--	--	--	--	--	--
2004	--	--	--	--	--	--	--	--	--	--
2005	9	200.6	135.0	375.0	96.2	22.5	363.8	0.93	0.69	1.10
2006	4	173.0	134.0	223.0	40.9	24.5	60.3	1.03	1.02	1.04
2007	--	--	--	--	--	--	--	--	--	--
2008	1	153.0	153.0	153.0	--	--	--	--	--	--
2009	1	381.0	381.0	381.0	564.5	564.5	564.5	1.02	1.02	1.02
2010	2	189.5	144.0	235.0	81.7	25.6	137.8	0.96	0.86	1.06
2011	2	179.5	179.0	180.0	57.5	50.7	64.2	0.99	0.88	1.10
2012	1	156.0	156.0	156.0	39.7	39.7	39.7	1.05	1.05	1.05
2013	3	142.7	135.0	148.0	27.7	19.9	32.8	0.94	0.81	1.01
2014	--	--	--	--	--	--	--	--	--	--
2015	2	212.0	168.0	256.0	103.3	47.9	158.6	0.98	0.95	1.01
2016	1	160.0	160.0	160.0	41.1	41.1	41.1	1.00	1.00	1.00
2017	--	--	--	--	--	--	--	--	--	--
2018	15	164.7	151.0	180.0	47.3	34.9	66.1	1.05	0.99	1.13
2019	9	170.7	125.0	290.0	61.7	19.4	222.2	0.96	0.90	1.01

Table 10. Average, minimum and maximum fork length (mm), weight (g) and condition factor of bull trout captured during 1994 – 2019.

Adult Harvest, Abundance, Diversity and Productivity

Harvest

Non-tribal harvest of hatchery spring Chinook salmon was estimated at 398 (±126) kept subbasin hatchery adult spring Chinook salmon, and 9 subbasin jack spring Chinook salmon (no C.I. available) for the 2019 run year (Figure 9). An estimated 43 natural production spring Chinook salmon were caught and released during 2019 (Table 11). Exploitation of the hatchery spring Chinook adult population escaping to the mouth of the Hood River during 2019 was 49.3%, while the average exploitation rate during the run years 1997 – 2019 was 23.2% (Figure 10). To evaluate the geographical distribution of hatchery spring Chinook harvest, the number of fish sampled was summarized by section (Table 12) since the resolution of the survey data generally does not allow for specific section/location harvest expansions. The majority (42.9%) of spring Chinook were harvested in sections 1 and 4 (lower mainstem, and lower West Fork Hood River) with minimal harvest occurring in sections 2 and 3.

Species-Run-Origin-Stage	For the week ending:	Estimated Number Harvested	Estimated Number Released
Chinook-Spring-Hatchery-Adult		**398**	**0**
	5/12/2019	9	0
	5/19/2019	60	0
	5/26/2019	76	0
	6/2/2019	125	0
	6/9/2019	26	0
	6/16/2019	37	0
	6/23/2019	47	0
	6/30/2019	18	0
Chinook-Spring-Hatchery-Jack		**9**	**0**
	6/23/2019	9	0
Chinook-Spring-Wild-Adult		0	43
	5/12/2019	0	7
	5/19/2019	0	10
	6/2/2019	0	14
	6/9/2019	0	13

Table 11. Weekly spring Chinook non-tribal harvest estimates, 2019.

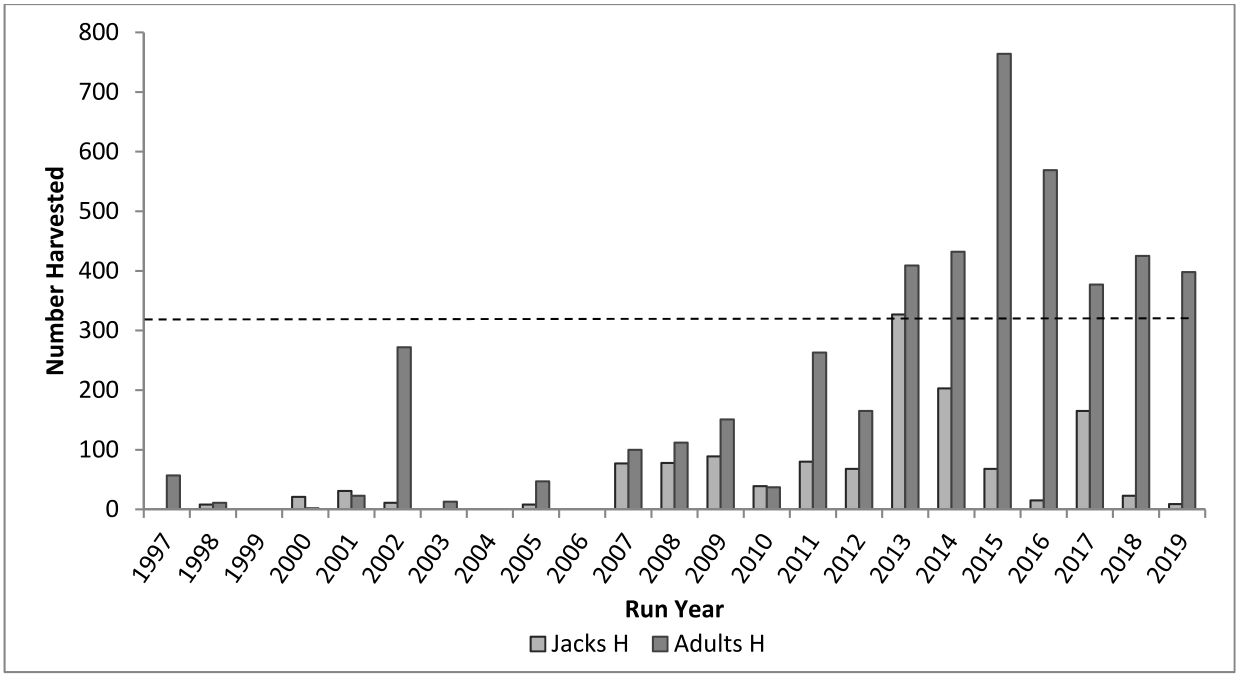

Figure 9. Annual non-tribal harvest of hatchery adult and jack spring Chinook salmon for run years 1997 – 2019. Dashed line indicates the adult numerical fish objective (N = 318) established by the Revised Master Plan for the Hood River Production Program (HDR|FishPro 2008) for combined non-tribal and tribal harvest. No harvest objective currently exists for hatchery jack spring Chinook salmon.

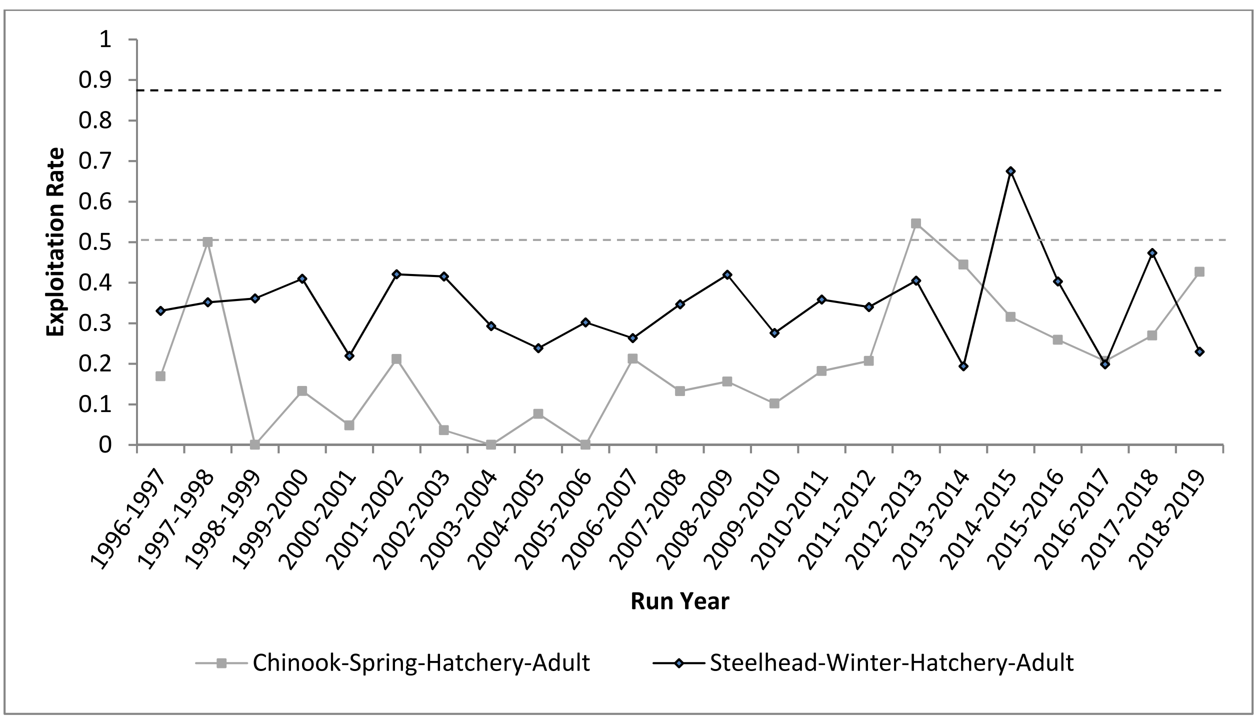

Figure 10. Annual non-tribal exploitation rate for hatchery winter steelhead and hatchery adult spring Chinook salmon for run years 1996 – 1997 to 2018 – 2019 (spring Chinook run year is associated with the latter year denoted by each individual run period). Dashed line indicates the adult harvest objectives (Tribal and sport harvest combined) established by the Revised Master Plan for the Hood River Production Program (HDR|FishPro 2008).

Section	Section Description	Female Adult	Female Jack	Male Adult	Male Jack	Unknown Sex	Grand Total	%
1	River mouth to helicopter hole	6		6		3	15	42.9%
2	Helicopter hole to Neal Creek			2			2	5.7%
3	Neal Creek to the mouth of the West Fork Hood River	2		1			3	8.6%
4	Mouth of West Fork to fishing deadline (200 feet downstream of Punchbowl Falls)	4		9	1	1	15	42.9%
Grand Total		12		18	1	4	35	

Table 12. Total hatchery spring Chinook sampled during non-tribal harvest surveys by section, 2019.

Based on the Cormack Jolly-Seber model real parameter estimates, the estimated apparent survival rate of hatchery winter steelhead from the mouth of the river to the adult collection weir was 0.77 (Figure 11). Although the apparent survival rate may account for pre-spawn mortality and emigration, the assumption is made that up to 111 (±31) adult hatchery winter steelhead were harvested during the 2019 run year (Figure 12).

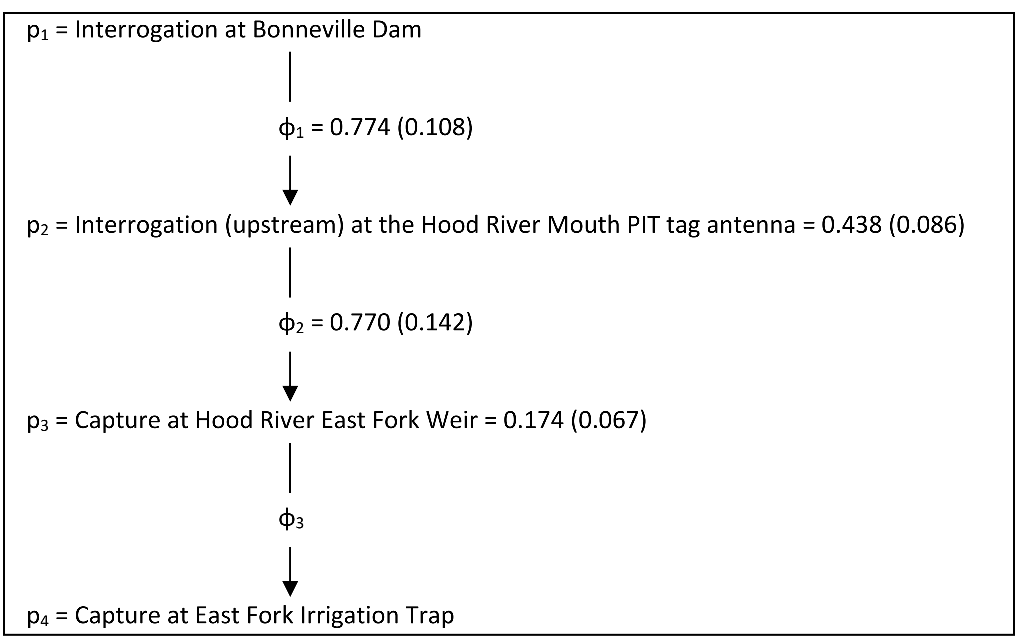

Figure 11. Cormack-Jolly Seber open population model real parameter estimates of apparent survival (ϕ) and recapture probability (p) for adult wild winter steelhead, run year 2019.

Based on escapement estimates to the mouth of the Hood River generated for the 2018 – 2019 run year of 483 (±293) the exploitation rate of hatchery winter steelhead was 23.0% (Figure 10). The average non-tribal exploitation rate for Hood River hatchery winter steelhead based on the run years 1996 – 2019 is 34.4%.

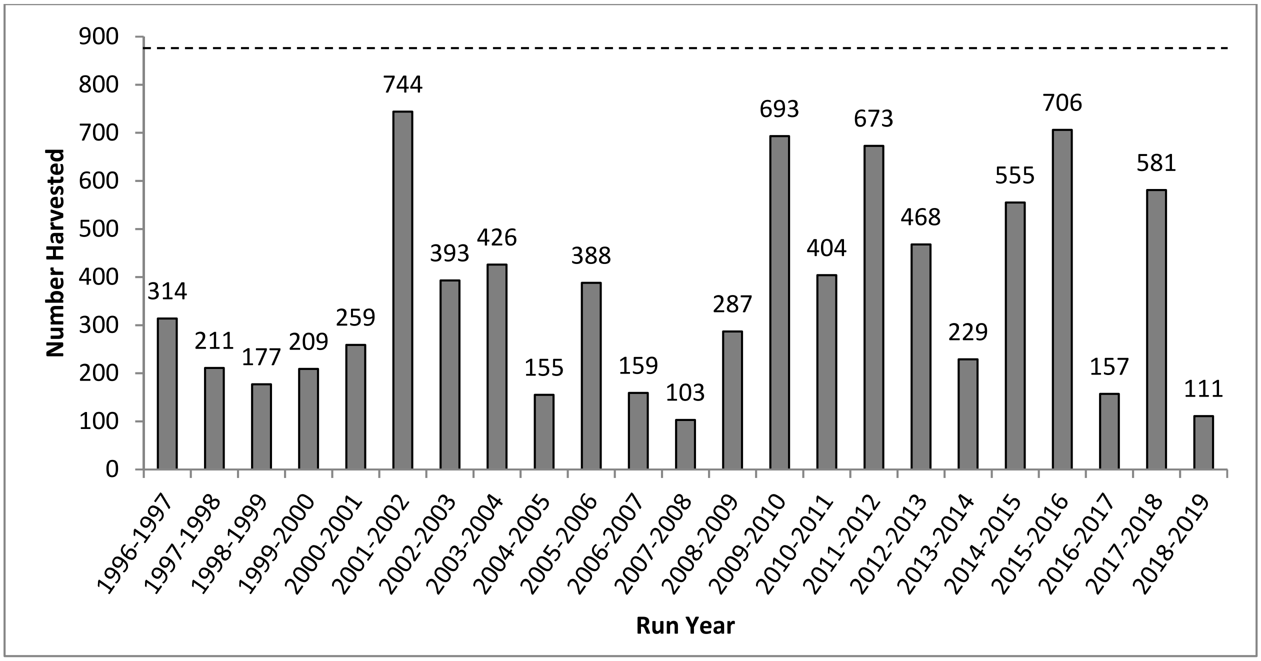

Figure 12. Annual non-tribal harvest of hatchery winter steelhead for run years 1996 – 1997 to 2018 – 2019. Dashed line indicates the adult harvest objective (N = 876) established by the Revised Master Plan for the Hood River Production Program (HDR|FishPro 2008).

Abundance

Total escapement of wild winter steelhead to the mouth of the Hood River (Figure 13) for the run year 2018 – 2019 was 379 (±402). Escapements of hatchery winter steelhead to the mouth of the Hood River (Figure 13) were 483 (±293) based on mark-recapture and survival models (CJS, White and Burnham 1999). After reducing escapement to the Hood River mouth by the total estimated non-tribal harvest (n=111), the total hatchery winter steelhead escaping the fishery was 372. A total of 30 hatchery winter steelhead were collected for broodstock, and 78 were transferred to an off-site impoundment or euthanized leaving 264 escaping to natural production. The proportion of hatchery origin spawners (pHOS) for the 2018 – 2019 run year was 0.472 (Table 15).

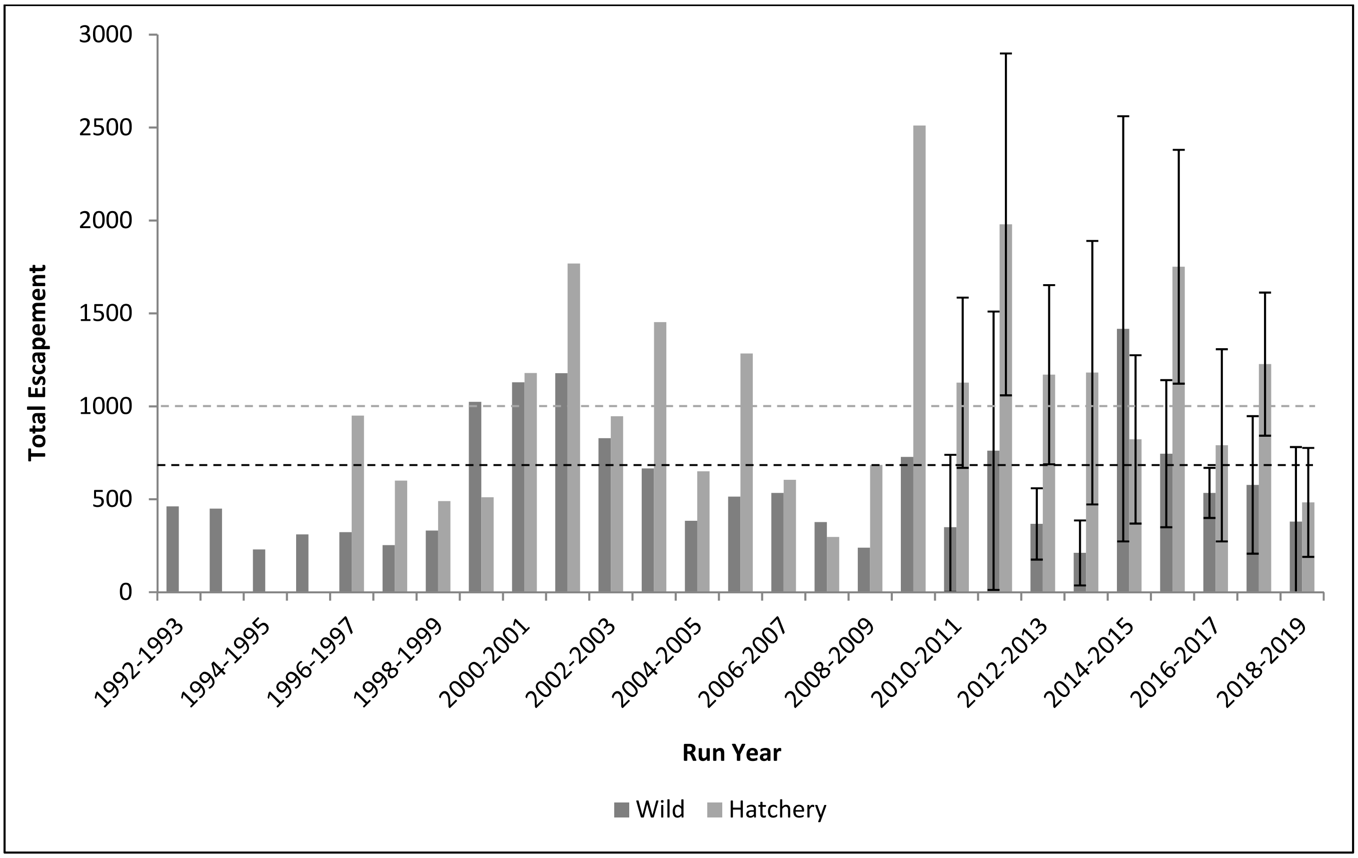

Figure 13. Total estimated wild and hatchery winter steelhead escapement to the mouth of the Hood River for the run years 1992 – 1993 to 2018 – 2019. Dashed line indicates the numerical fish objective (N = 656 wild, N = 1,000 hatchery) established by the Revised Master Plan for the Hood River Production Program (HDR|FishPro 2008). Error bars (95% C.I.) are included for run years where escapement estimates are based on model estimates rather than hard counts (i.e. post-Powerdale Dam removal).

Adult winter steelhead apparent survival from Bonneville Dam to the Hood River averaged 71.4% and 76.5% annually for wild and hatchery fish, respectively (Figure 14). Estimates were not available for wild winter steelhead in 2014 and 2017 due to in-basin sampling constraints. The percentage of fish that exhibited fallback behavior averaged 5.1% annually for hatchery fish, and 4.0% for wild fish.

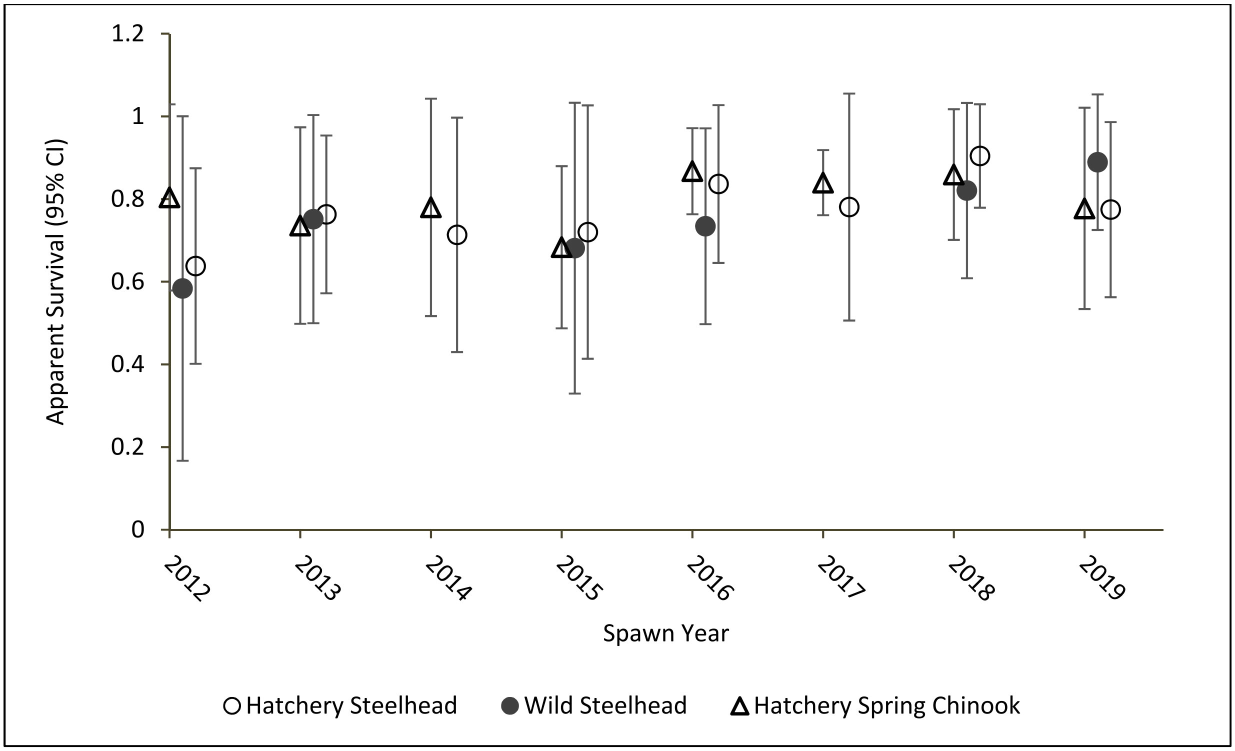

Figure 14. Apparent survival of upstream migrant adult winter steelhead from Bonneville Dam to the Hood River (spawn years 2012 – 2019).

Escapement of wild summer steelhead to the mouth of the Hood River (Figure 15) for the run year 2018 – 2019 was 167 adults (±150) based on mark-recapture and survival models (CJS, White and Burnham 1999; $\phi = 0.812$). After reducing escapement by 10% to account for within-basin pre-spawn mortality the total number of wild summer steelhead escaping the fishery was 151. All captures of wild summer steelhead occurred at MFFF during the 2018 – 2019 run year. A total of 10 hatchery summer steelhead were captured (9 male, 1 female), predominantly at MFFF (90%), and were euthanized.

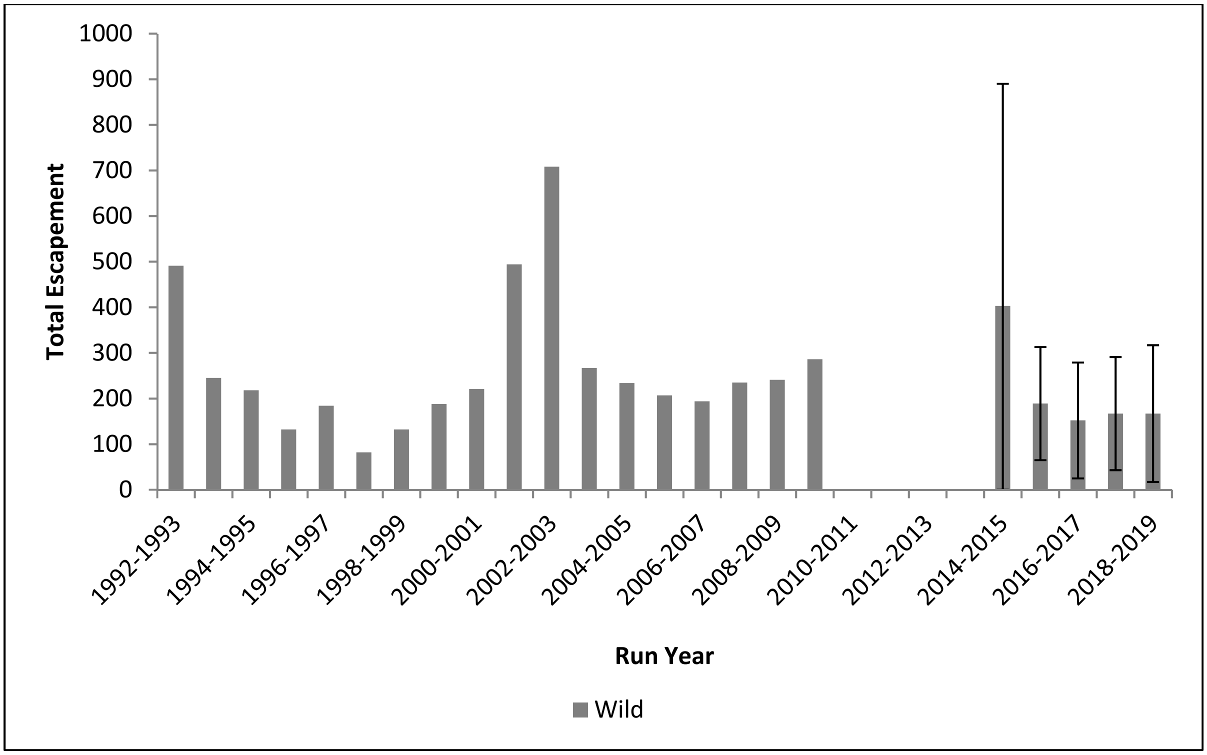

Figure 15. Total estimated wild summer steelhead escapement to the mouth of the Hood River for the run years 1992 – 1993 to 2018 – 2019. Error bars (95% C.I.) are included for run years where escapement estimates are based on model estimates rather than hard counts (i.e. post-Powerdale Dam removal). Estimates for spawn years 2011 – 2014 were unavailable due to data limitations.

Since the removal of Powerdale Dam in 2010, estimates of naturally produced spring Chinook salmon have generally been unavailable due to limited PIT tag interrogation data, however the total captured at adult collection facilities have been reported (Figure 16). Despite comprehensive tagging efforts of naturally produced spring Chinook juveniles, adult returns to the Hood River subbasin of tagged individuals have been scarce and therefore prevent application of mark-recapture methods to estimate adult escapement. During run year 2019, only 28 adults and 3 jacks were recorded at adult sampling facilities. No previously PIT-tagged adult returners were detected at Bonneville Dam, thus any type of mark-recapture analysis could not be conducted. The total known hatchery and natural production spring Chinook released upstream and collected for broodstock during 2019 are displayed in Tables 13 and 14, respectively.

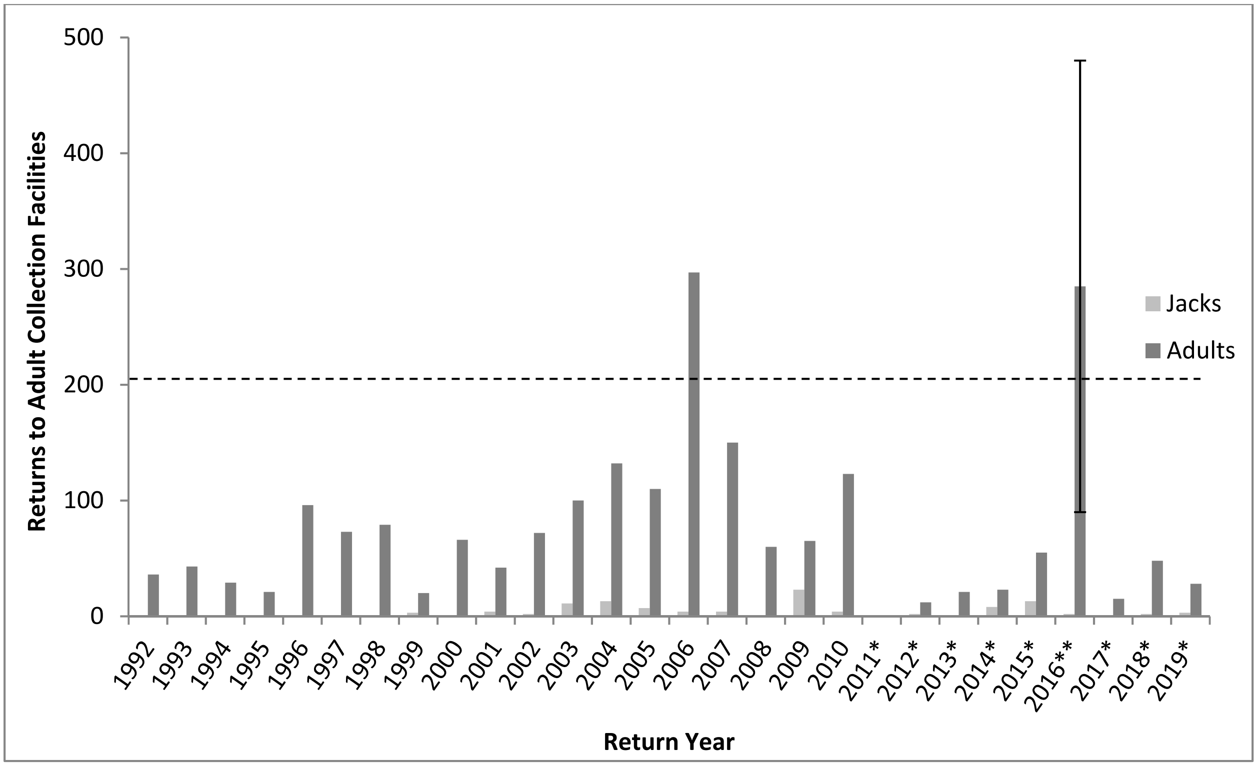

Figure 16. Returns of naturally produced Spring Chinook to Hood River adult collection facilities for the run years 1992 – 2019. Dashed line indicates the adult numerical fish objective (N = 205) established by the Revised Master Plan for the Hood River Production Program (HDR|FishPro 2008). Asterisk denotes samples years following the removal of Powerdale Dam and represent only a portion of total abundance. Double asterisk indicates a basin-wide abundance estimate (error bars denote 95% C.I.) was generated using mark-recapture/survival model methodologies.

Escapements of hatchery spring Chinook to the mouth of the Hood River (Figure 17) were 808 (±381) adults and 146 (±97) jacks, based on mark-recapture and survival models (CJS, White and Burnham 1999; ϕ = 0.771 adults and jacks). After reducing escapement to the Hood River mouth by the total estimated tribal (reported by BPA project 1988-053-03) and non-tribal harvest, the total number of hatchery spring Chinook adults and jacks escaping all fisheries was 338 and 132, respectively. A total of 233 adult and 3 jack hatchery spring Chinook were collected for broodstock (Table 14). Although 24 adult and 90 jack hatchery spring Chinook were physically passed upstream of collection facilities to the spawning grounds (Table 13), model estimates suggest that 105 adults and 129 jacks were available to spawn.

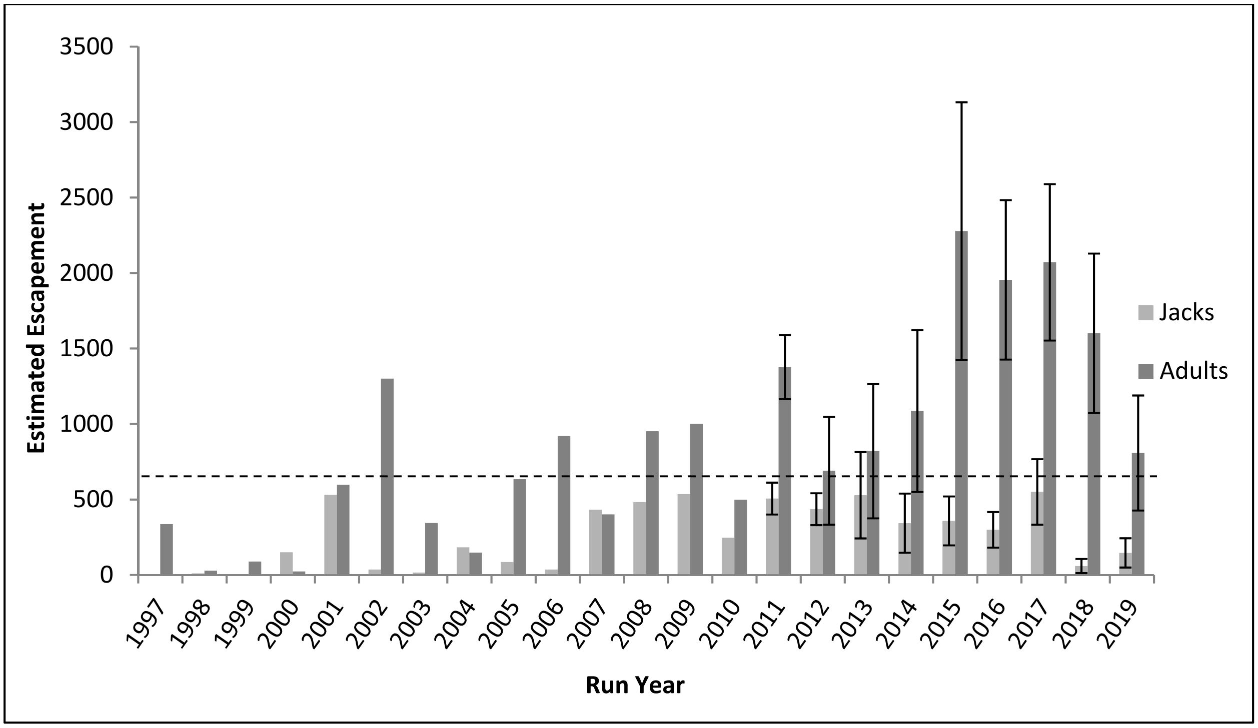

Figure 17. Total estimated adult and jack spring Chinook hatchery escapement to the mouth of the Hood River (run years 1997 – 2019). Dashed line indicates the adult numerical fish objective (N = 600) established by the Revised Master Plan for the Hood River Production Program (HDR|FishPro 2008). No stated numerical fish objective exists for hatchery jack spring Chinook salmon. Error bars (95% C.I.) are included for run years where escapement estimates are based on model estimates rather than hard counts (i.e. post-Powerdale Dam removal).

	Released Upstream					
Life Stage, Origin, Sex	**East Fork Weir**	**EFID Ladder Trap**	**Parkdale Hatchery**	**Moving Falls**	**Fallback Collected for Broodstock**	**Total**
Adult						
Hatchery						
Female	--	--	--	13	--	**13**
Male	--	--	--	14	(3)	**11**
Natural Production						
Female	--	--	--	10	--	**10**
Male	--	--	--	11	--	**11**
Jack						
Hatchery						
Male	--	--	--	90	--	**90**
Natural Production						
Male	--	--	--	4	--	**4**
Total	**0**	**0**	**0**	**142**	(3)	**139**

Table 13. Number of spring Chinook salmon released upstream at adult trapping sites, 2019. Origin for unmarked spring Chinook is preliminary pending completion of scale analysis.

Life Stage, Origin, Sex	Broodstock Collection East Fork Weir	EFID Ladder Trap	Parkdale Hatchery	Moving Falls	Fallback Collected for Broodstock	Total
Adult						
Hatchery						
Female	--	--	--	128	--	**128**
Male	--	--	--	102	3	**105**
Natural Production						
Female	--	--	--	4	--	**4**
Male	--	--	--	3	--	**3**
Jack						
Hatchery						
Male	--	--	--	3	--	**3**
Natural Production						
Male	--	--	--	--	--	**0**
Total	**0**	**0**	**0**	**240**	**3**	**243**

Table 14. Number of spring Chinook salmon collected for hatchery broodstock at adult trapping sites, 2019. Origin for unmarked spring Chinook is preliminary pending completion of scale analysis.

Diversity

During 2019, collections of wild winter steelhead to be utilized for broodstock were somewhat limited due to high flow conditions affecting the trapping efficiency of the EFW (Table 15, also see Table 19 for EFW trapping efficiency). High flow conditions also affected the ability to collect wild brood in spawn years 2014 and 2017, but unlike in those years when pNOB was below 0.50, collections of wild brood were sufficient to produce a pNOB of 0.87. The resulting PNI of 0.648 was close to the desired target of 0.67 set by the Hatchery Scientific Review Group, whereas in 2014 and 2017 the PNI was well below the HSRG guideline.

Run Year	NORs at adult collection facility (actual)	NORs at adult collection facility (estimate)	HORs at adult collection facility (actual)	HORs at adult collection facility (estimate)	NOR broodstock collected	NOR broodstock Spawned	HORs collected	HORs spawned	Total brood spawned	pNOB	pHOS	PNI
1997	290	N/A	636	N/A	52	32	37	22	54	0.590	0.514	0.535
1998	227	N/A	389	N/A	45	22	41	20	42	0.520	0.471	0.527
1999	298	N/A	313	N/A	43	35	35	27	62	0.560	0.423	0.572
2000	921	N/A	301	N/A	56	24	47	15	39	0.620	0.206	0.749
2001	1,015	N/A	920	N/A	138	58	4	4	62	0.940	0.428	0.686
2002	1,059	N/A	1,024	N/A	109	43	1	0	43	1.000	0.418	0.705
2003	745	N/A	553	N/A	91	43	3	1	44	0.980	0.386	0.717
2004	597	N/A	1,027	N/A	90	45	8	1	46	0.980	0.529	0.649
2005	345	N/A	495	N/A	72	23	18	6	29	0.790	0.474	0.626
2006	460	N/A	896	N/A	118	49	44	1	50	0.980	0.466	0.678
2007	476	N/A	445	N/A	53	31	5	3	34	0.910	0.463	0.663
2008	340	N/A	194	N/A	76	37	2	0	37	1.000	0.296	0.772
2009	216	N/A	397	N/A	46	38	35	0	38	1.000	0.510	0.662
2010	667	N/A	1,818	N/A	99	46	0	0	46	1.000	0.498	0.668
2011	131	314	333	723	43	32	70	0	32	1.000	0.592	0.628
2012	210	685	453	1,306	32	21	76	20	41	0.510	0.566	0.475
2013	176	330	305	702	32	19	31	22	41	0.460	0.559	0.453
2014	54	190	154	952	13	15	44	25	40	0.380	0.818	0.314
2015	305	1,275	283	267	42	42	26	5	47	0.890	0.005	0.995
2016	286	670	404	1,045	52	41	20	0	41	1.000	0.504	0.665
2017	31	534	100	633	21	19	35	24	43	0.440	0.510	0.464
2018	238	519	406	646	63	41	34	0	41	1.000	0.347	0.743
2019	91	341	114	372	43	39	30	6	45	0.870	0.472	0.648

Table 15. Annual pNOB, pHOS, and PNI values based on broodstock collection and available number of natural origin and hatchery origin spawners. (The actual number of adult winter steelhead was recorded at adult sampling facilities (Powerdale Dam (1997 – 2010), East Fork Weir (2011 – 2019), East Fork Irrigation Diversion trap (2014 – 2019), Moving Falls Fish Facility (2014 – 2019), and Neal Creek Weir (2011 – 2015)). The estimated number of available spawners for run years 2011 – 2019 was based on mark-recapture and CJS survival models used to calculate total escapement.)

The first wild winter steelhead capture at an adult collection facility occurred March 30 and the first hatchery capture March 14. The final wild winter steelhead sampled occurred on May 17, and the last hatchery winter steelhead was collected May 20. The median migration date for both wild and hatchery steelhead was April 19 (Figure 18). Although typically winter steelhead runs encompass two calendar years, adult sampling limitations do not allow for capture of early run returnees. As described in the materials and methods, there is a high likelihood that winter steelhead entered the Hood River subbasin prior to the installation of adult collection weirs based on PIT tag return data, past observations at Powerdale Dam, and creel survey data (Simpson et al. 2015). Migration time from Bonneville Dam to the Hood River adult collection weir averaged 48 and 56 days for hatchery and wild winter steelhead, respectively, although the migration timing was highly variable (Table 16). Wild winter steelhead exhibited protracted migratory behavior where the minimum migration time between Bonneville Dam and the adult weirs was 4.9 and the maximum was 182.3 days (Table 16).

Migration time delays were commonly observed as steelhead migrate through Bonneville Dam, as fish may holdover in the ladder complex for several months in some cases, depending on the environmental conditions. The majority (≈75%) of winter steelhead migrated through the Bonneville Dam adult ladder complex in under 2 days, however during December – February, average migration time increased to 9.6 – 16.9 days (Figures 19 – 20). The average ladder ascension time gradually decreased as ladder entry time approached April 1. Holdover times in the Bonneville pool of migrants successfully ascending the ladder prior to reaching the Hood River mouth averaged over 40 days during November and December, and gradually decreased to 1-2 days by April. Comparatively, the majority (98.6%) of Hood River summer steelhead migrated through the fish ladder in less than one day.

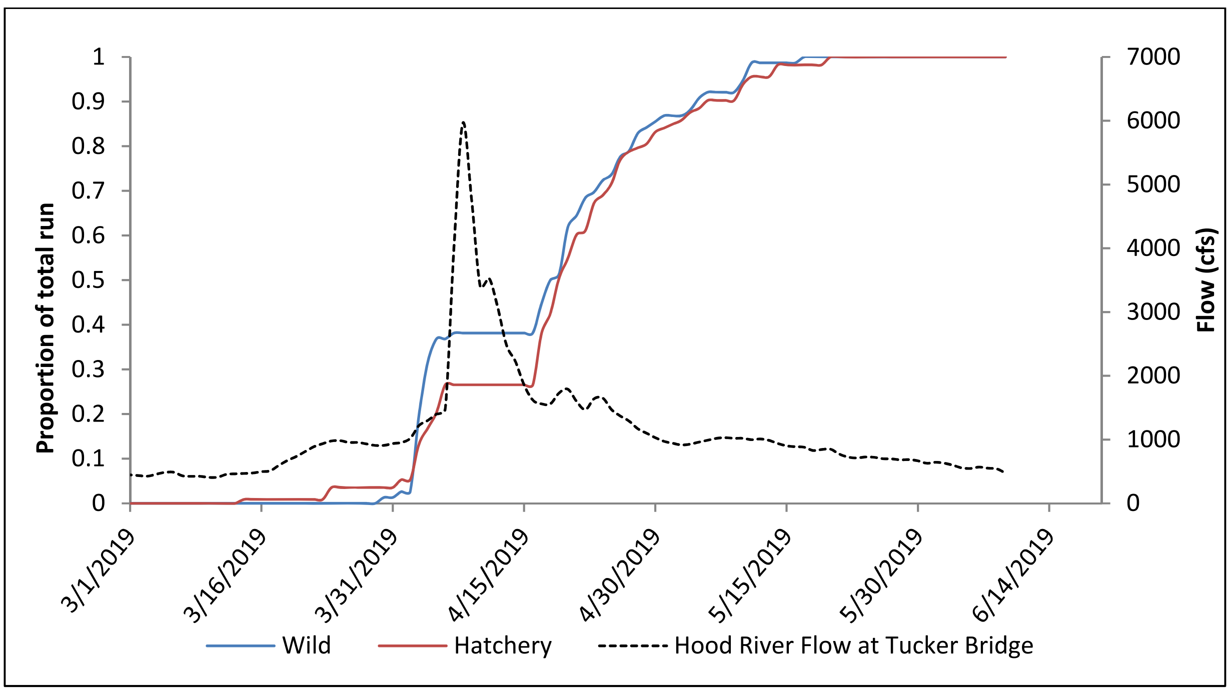

Figure 18. Run timing of returning adult winter steelhead to Hood River adult collection sites relative to discharge at Tucker Bridge (cfs), 2019.

Hatchery Winter Steelhead 2018 - 2019

	BON to HRM	HRM to Weir	BON to Weir
Average	13.1	32.0	48.0
Minimum	0.7	7.2	8.2
Maximum	104.3	88.6	117.7

Wild Winter Steelhead 2018 - 2019

	BON to HRM	HRM to Weir	BON to Weir
Average	5.6	25.8	56.3
Minimum	1.4	25.8	27.3
Maximum	17.9	25.8	85.2

Wild Summer Steelhead 2018 - 2019

	BON to HRM	HRM to Weir	BON to Weir
Average	30.1	11.7	15.3
Minimum	1.0	11.7	15.2
Maximum	120.1	11.7	15.4

Hatchery Winter Steelhead 2007 - 2010

	BON to HRM	HRM to Weir	BON to PWD
Average	--	--	38.0
Minimum	--	--	4.0
Maximum	--	--	220.0

Wild Winter Steelhead 2007 - 2010

	BON to HRM	HRM to Weir	BON to PWD
Average	--	--	50.9
Minimum	--	--	4.0
Maximum	--	--	168.7

Table 16. Migration time (days) for hatchery winter steelhead and wild winter and summer steelhead from Bonneville Dam to the Hood River mouth and to the adult collection weir (run year 2018 – 2019), and migration time for hatchery and wild winter steelhead from Bonneville Dam to Powerdale Dam (run years 2007 – 2010).

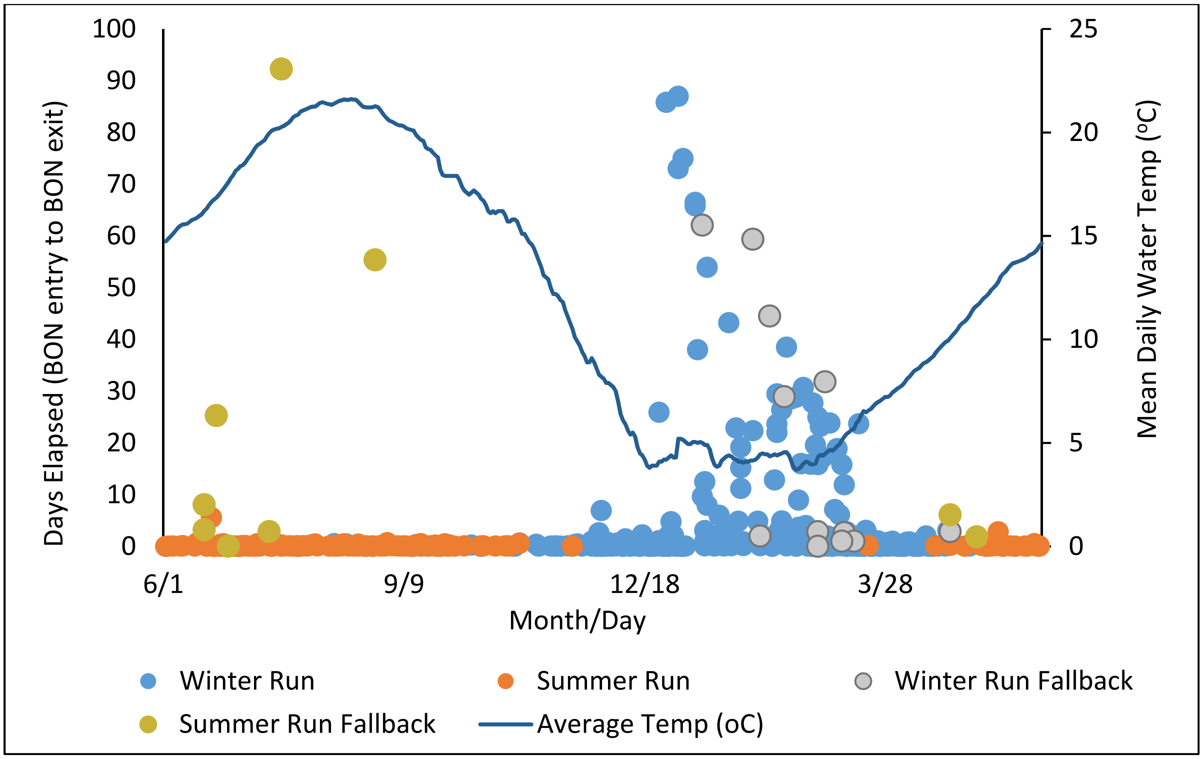

Figure 19. Number of days elapsed between Bonneville adult ladder entry and exit for wild steelhead, and average daily water temperature (spawn years 2007 – 2018).

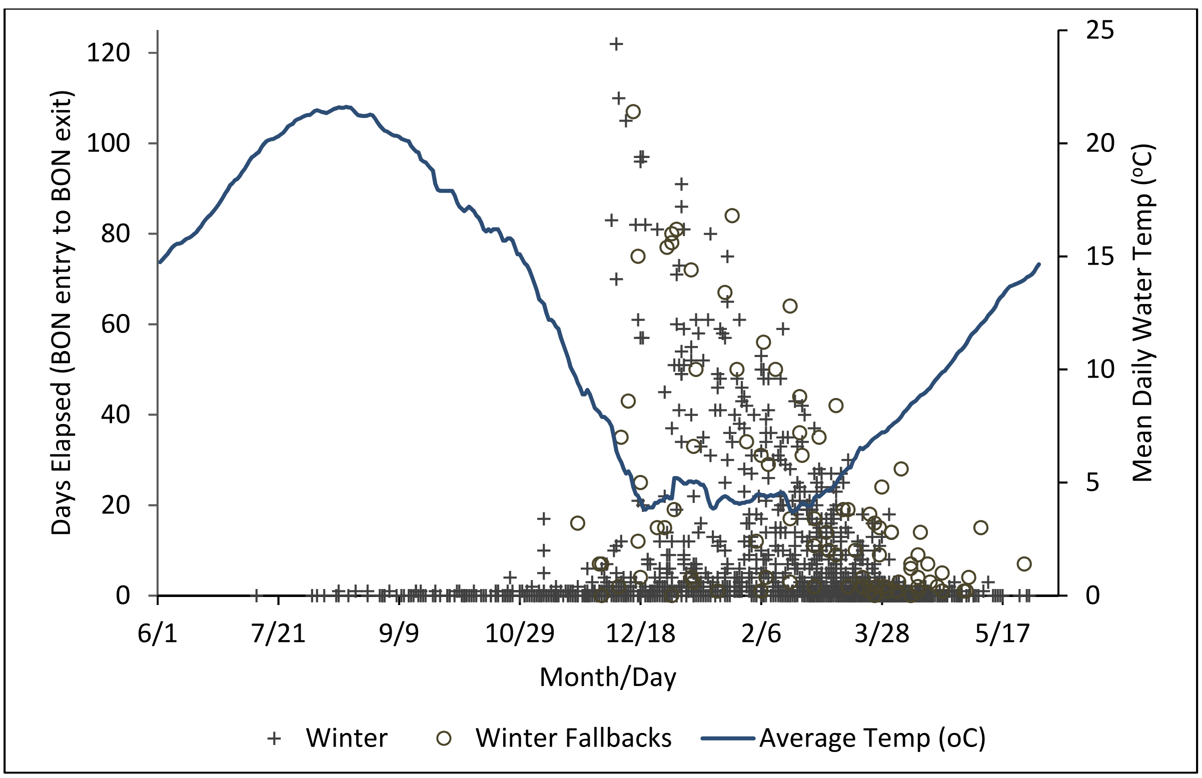

Figure 20. Number of days elapsed between Bonneville adult ladder entry and exit for hatchery steelhead, and average daily water temperature (spawn years 2007 – 2018).

Summer steelhead included in the 2018 – 2019 run year were collected during May 1, 2018 – May 31, 2019 (during periods where adjacent run years may overlap (i.e. May 1 – May 31) summer steelhead were identified with a given run year primarily based on state of sexual maturity). Summer steelhead that were captured during the 2019 calendar year that constitute the early part of the 2019 – 2020 run year will be presented in the 2020 CY Annual Progress Report. The first wild summer steelhead for run year 2018 – 2019 was sampled May 25, 2018 and the first hatchery summer steelhead was sampled on May 18, 2018 (Figure 21). Travel time from Bonneville Dam to the Hood River mouth averaged 30.1 days and ranged from 1.0 – 120.1 days (Table 16) which is similar to observations in the past, where the majority of wild summers migrated to Powerdale Dam within 16 days following detection at Bonneville (Simpson et al. 2015), and nearly 90% had migrated from Bonneville to Powerdale with 32 days.

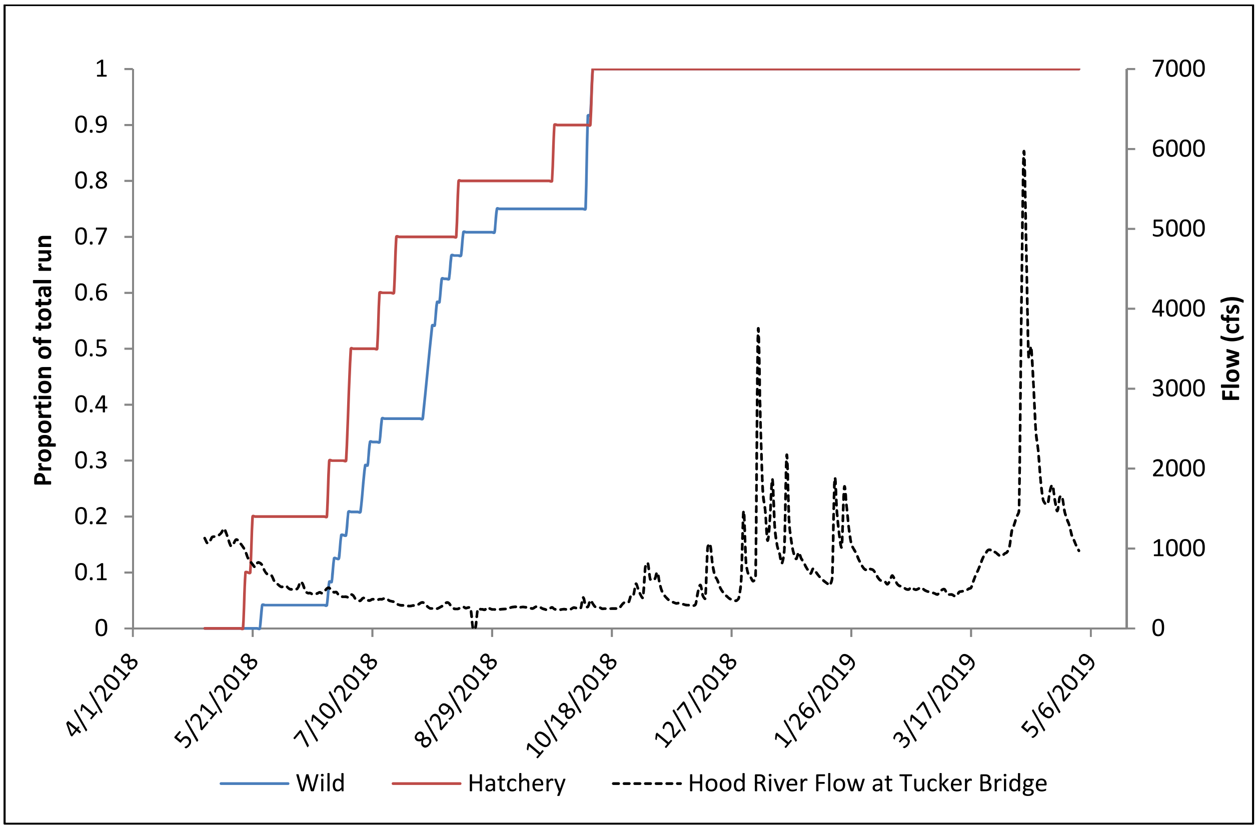

Figure 21. Run timing of returning adult summer steelhead to Hood River adult collection sites relative to discharge at Tucker Bridge (cfs), 2018 – 2019 run year.

Diversity of winter and summer steelhead as a function of age distribution is displayed below in Tables 17 and 18.

Run Year	Total Escapement	Freshwater/Ocean Age 1/1	2/1	3/1	1/2	2/2	3/2	4/2	1/3	2/3	3/3	1/4	2/4	3/4	1/5	Repeat Spawners
1991-1992	698	0.0%	1.4%	0.1%	0.4%	60.7%	15.9%	0.1%	0.6%	11.0%	2.4%	0.0%	0.0%	0.0%	0.0%	7.2%
1992-1993	415	0.0%	8.9%	0.2%	0.5%	41.7%	4.8%	0.0%	1.4%	29.6%	4.1%	0.0%	0.2%	0.0%	0.0%	8.4%
1993-1994	404	0.0%	2.2%	0.2%	0.5%	67.6%	4.2%	0.0%	1.5%	19.3%	0.5%	0.0%	0.0%	0.0%	0.0%	4.0%
1994-1995	206	0.0%	13.6%	1.5%	0.5%	51.9%	4.4%	0.0%	0.5%	16.5%	1.5%	0.0%	0.5%	0.5%	0.0%	8.7%
1995-1996	279	0.0%	6.5%	0.4%	3.9%	65.6%	7.5%	0.0%	0.4%	10.4%	2.2%	0.4%	0.0%	0.0%	0.0%	2.9%
1996-1997	290	0.0%	4.1%	1.0%	0.3%	67.9%	8.6%	0.3%	0.3%	12.1%	2.4%	0.0%	0.0%	0.0%	0.0%	2.8%
1997-1998	227	0.0%	5.7%	1.3%	0.4%	58.6%	8.8%	0.0%	0.0%	18.5%	1.8%	0.0%	0.0%	0.0%	0.0%	4.8%
1998-1999	298	0.0%	18.1%	0.7%	2.7%	51.3%	7.7%	0.0%	0.0%	12.8%	3.7%	0.0%	0.0%	0.0%	0.0%	3.0%
1999-2000	921	0.0%	0.5%	0.1%	0.4%	85.8%	4.3%	0.0%	0.1%	4.7%	0.2%	0.0%	0.1%	0.0%	0.0%	3.7%
2000-2001	1015	0.0%	2.1%	1.6%	0.3%	57.2%	11.1%	0.1%	0.1%	12.6%	1.3%	0.0%	0.1%	0.0%	0.0%	13.5%
2001-2002	1059	0.0%	2.1%	0.8%	1.1%	57.3%	19.2%	0.0%	0.5%	12.9%	2.3%	0.0%	0.0%	0.0%	0.0%	3.8%
2002-2003	745	0.0%	1.6%	0.4%	0.7%	55.2%	9.1%	0.0%	0.7%	23.0%	4.0%	0.0%	0.0%	0.0%	0.0%	5.4%
2003-2004	598	0.0%	1.2%	0.0%	3.0%	59.9%	12.0%	0.0%	0.7%	14.5%	3.5%	0.0%	0.2%	0.0%	0.0%	5.0%
2004-2005	345	0.0%	2.3%	0.6%	1.2%	57.1%	13.6%	0.0%	3.5%	17.1%	2.0%	0.0%	0.0%	0.0%	0.0%	2.6%
2005-2006	462	0.0%	6.5%	0.4%	1.3%	49.1%	18.6%	0.0%	0.4%	15.8%	5.0%	0.0%	0.4%	0.0%	0.0%	2.4%
2006-2007	480	0.0%	0.8%	0.2%	1.3%	61.5%	5.8%	0.0%	4.6%	19.0%	5.0%	0.0%	0.0%	0.0%	0.0%	1.9%
2007-2008	339	0.0%	1.5%	1.2%	2.1%	54.9%	9.4%	0.3%	1.2%	18.9%	3.2%	0.0%	0.3%	0.0%	0.0%	7.1%
2008-2009	215	0.0%	7.4%	0.0%	4.2%	53.5%	10.2%	0.0%	0.0%	8.4%	3.3%	0.0%	0.0%	0.0%	0.0%	13.0%
2009-2010	654	0.0%	1.7%	0.3%	14.7%	65.6%	7.5%	0.2%	2.0%	5.5%	1.5%	0.2%	0.0%	0.0%	0.0%	0.9%
2010-2011	314	0.0%	0.0%	0.0%	0.0%	59.8%	4.9%	0.0%	2.9%	20.6%	2.9%	0.0%	0.0%	0.0%	0.0%	6.9%
2011-2012	685	0.5%	1.1%	0.0%	3.3%	41.3%	19.0%	0.0%	2.2%	25.0%	1.1%	0.0%	0.5%	0.0%	0.0%	6.0%
2012-2013	330	1.3%	0.7%	0.0%	0.7%	47.0%	7.9%	0.7%	2.0%	21.2%	7.9%	0.0%	0.0%	0.0%	0.0%	10.9%
2013-2014	190	0.0%	1.3%	0.0%	0.0%	62.7%	32.0%	0.0%	1.3%	0.0%	1.3%	0.0%	0.0%	0.0%	0.0%	1.3%
2014-2015	1275	0.0%	2.0%	0.0%	1.6%	60.0%	16.1%	0.0%	0.4%	12.5%	3.9%	0.0%	0.0%	0.0%	0.0%	3.5%
2015-2016	670	0.0%	0.3%	0.0%	4.5%	54.9%	10.1%	0.3%	2.8%	23.8%	1.4%	0.3%	0.3%	0.0%	0.0%	1.0%
2016-2017	481	0.0%	3.1%	0.0%	0.0%	56.3%	6.3%	0.0%	0.0%	21.9%	6.3%	0.0%	0.0%	0.0%	0.0%	6.3%
2017-2018	519	0.0%	3.5%	0.5%	0.5%	80.6%	8.0%	0.0%	0.5%	4.0%	0.5%	0.0%	0.0%	0.0%	0.0%	2.0%

Table 17. Total adult wild winter steelhead escapement to the Hood River adult collection facilities by age class.

		Freshwater/Ocean Age														
Run Year	Total Escapement	1/1	2/1	3/1	1/2	2/2	3/2	4/2	1/3	2/3	3/3	1/4	2/4	4/1	1/5	Repeat Spawners
1992-1993	491	0.0%	5.3%	1.2%	0.0%	1.0%	62.9%	15.9%	0.2%	0.0%	0.0%	9.8%	0.0%	0.0%	0.0%	3.7%
1993-1994	245	0.0%	4.5%	2.0%	0.0%	0.4%	44.5%	18.0%	0.0%	0.0%	0.8%	21.6%	2.9%	0.0%	1.2%	4.1%
1994-1995	218	0.0%	2.8%	0.9%	0.0%	0.0%	36.7%	31.7%	0.0%	0.0%	0.0%	15.6%	5.5%	0.0%	0.0%	6.9%
1995-1996	132	0.0%	10.6%	2.3%	0.0%	0.0%	62.1%	8.3%	0.0%	0.0%	0.0%	13.6%	0.8%	0.0%	0.0%	2.3%
1996-1997	184	0.0%	3.8%	1.1%	0.0%	1.1%	70.1%	12.0%	0.0%	0.0%	0.0%	7.6%	1.1%	0.0%	0.0%	3.3%
1997-1998	82	0.0%	9.8%	1.2%	0.0%	1.2%	54.9%	15.9%	0.0%	0.0%	0.0%	8.5%	0.0%	0.0%	0.0%	8.5%
1998-1999	132	0.0%	9.8%	0.8%	0.0%	1.5%	56.8%	10.6%	0.0%	0.0%	0.0%	11.4%	0.0%	0.0%	0.0%	9.1%
1999-2000	188	1.1%	13.8%	3.2%	0.0%	0.5%	56.9%	8.5%	0.0%	0.0%	0.0%	10.1%	0.5%	0.0%	0.0%	5.3%
2000-2001	221	0.0%	10.4%	2.7%	0.0%	1.8%	45.7%	26.7%	0.5%	0.0%	0.9%	2.7%	0.9%	0.0%	0.0%	7.7%
2001-2002	494	0.8%	14.6%	7.3%	0.0%	0.2%	63.6%	6.7%	0.0%	0.0%	0.2%	2.4%	0.8%	0.0%	0.2%	3.2%
2002-2003	708	0.3%	7.3%	2.4%	0.0%	3.4%	45.2%	25.4%	0.6%	0.1%	0.4%	6.9%	2.0%	0.0%	0.0%	5.9%
2003-2004	267	0.0%	15.4%	4.1%	0.0%	1.1%	41.9%	22.1%	0.0%	0.0%	0.4%	4.9%	1.5%	0.0%	0.0%	8.6%
2004-2005	234	0.0%	5.6%	3.4%	0.0%	1.3%	51.7%	21.4%	0.0%	0.0%	0.0%	6.8%	0.9%	0.0%	0.0%	9.0%
2005-2006	207	1.4%	17.4%	7.2%	0.5%	1.4%	35.7%	27.1%	0.5%	0.0%	0.0%	5.3%	0.0%	0.0%	0.0%	3.4%
2006-2007	194	0.0%	11.3%	5.7%	0.0%	4.6%	43.3%	17.5%	0.0%	0.0%	2.1%	11.3%	0.0%	0.0%	0.0%	4.1%
2007-2008	235	0.0%	8.1%	5.1%	0.0%	3.0%	54.9%	8.1%	0.0%	0.0%	2.1%	11.5%	2.6%	0.0%	0.9%	3.8%
2008-2009	241	0.8%	9.1%	5.0%	0.4%	5.0%	46.9%	17.8%	0.0%	0.0%	0.4%	7.9%	2.1%	0.0%	0.0%	4.6%
2009-2010	286	3.1%	23.1%	4.5%	0.0%	3.8%	44.4%	11.2%	0.7%	0.0%	0.3%	4.5%	1.4%	0.0%	0.0%	2.8%
2010-2011	42	0.0%	0.0%	0.0%	0.0%	0.0%	78.6%	19.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%
2011-2012																
2012-2013																
2013-2014																
2014-2015	403	0.8%	3.3%	4.9%	1.6%	27.6%	52.8%	0.0%	0.0%	2.4%	4.1%	0.0%	0.0%	0.0%	0.0%	2.4%
2015-2016	170	0.0%	5.1%	3.4%	5.1%	47.5%	35.6%	0.0%	0.0%	1.7%	0.0%	0.0%	0.0%	1.7%	0.0%	0.0%
2016-2017	137	0.0%	6.8%	9.1%	4.5%	43.2%	29.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.8%
2017-2018	150	3.1%	20.3%	9.4%	3.1%	32.8%	23.4%	1.6%	0.0%	3.1%	3.1%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 18. Total adult wild summer steelhead escapement to the Hood River adult collection facilities by age class.

Productivity

Table 19 displays the annual composition of winter steelhead spawners and the subsequent recruit-per-spawner as a function of wild spawners only as well as total spawners (hatchery and wild). The number of available spawners may vary considerably on an annual basis, as can the composition of spawners by origin. Stock-recruit data for Hood River winter steelhead are somewhat noisy (Figure 22), which is not atypical of fisheries data in general (Hilborn and Walters 2001).

Run Year	Total Escapement	Wild Spawners	Hatchery Spawners	Total Spawners	% Hatchey Spawners	Wild Recruits	R/S (wild spawners only)	R/S (all spawners)	East Fork Weir (EFW) Efficiency	Variance EFW Efficiency
1991-1992	698	618	284	902	31.5%	278	0.45	0.31		
1992-1993	415	345	10	355	2.8%	303	0.88	0.85		
1993-1994	404	300	5	305	1.6%	213	0.71	0.70		
1994-1995	206	161	5	166	3.0%	267	1.66	1.61		
1995-1996	279	210	161	371	43.4%	1119	5.33	3.02		
1996-1997	290	238	252	490	51.4%	977	4.11	1.99		
1997-1998	227	182	162	344	47.1%	906	4.98	2.63		
1998-1999	298	255	187	442	42.3%	619	2.43	1.40		
1999-2000	921	865	224	1089	20.6%	510	0.59	0.47		
2000-2001	1015	877	656	1533	42.8%	419	0.48	0.27		
2001-2002	1059	950	683	1633	41.8%	375	0.39	0.23		
2002-2003	745	654	412	1066	38.6%	457	0.70	0.43		
2003-2004	598	507	570	1077	52.9%	255	0.50	0.24		
2004-2005	345	273	246	519	47.4%	228	0.84	0.44		
2005-2006	462	342	299	641	46.6%	560	1.64	0.87		
2006-2007	480	423	364	787	46.3%	634	1.50	0.81		
2007-2008	339	264	111	375	29.6%	397	1.50	1.06		
2008-2009	215	170	177	347	51.0%	302	1.78	0.87		
2009-2010	654	568	563	1131	49.8%	509	0.90	0.45		
2010-2011	314	271	393	664	59.2%	1037	3.82	1.56		
2011-2012	685	653	853	1506	56.6%	570	0.87	0.38		
2012-2013	330	298	377	675	55.9%	364	1.22	0.54		
2013-2014	190	177	797	974	81.8%	439	2.48	0.45		
2014-2015	1275	1233	6	1239	0.5%				0.682	0.039
2015-2016	670	618	628	1246	50.4%				0.505	0.031
2016-2017	481	513	534	1047	51.0%				0.077	0.004
2017-2018	519	456	242	698	34.7%				0.401	0.018
2018-2019	341	298	266	564	47.2%				0.174	0.067

Table 19. Total spawning escapement of wild and hatchery adult winter steelhead used to calculate pHOS (proportion hatchery origin spawners), and wild recruits-per-spawner (R/S). Efficiency and variance of East Fork Weir (EFW) used to determine number of available hatchery spawners (2015 – 2019).

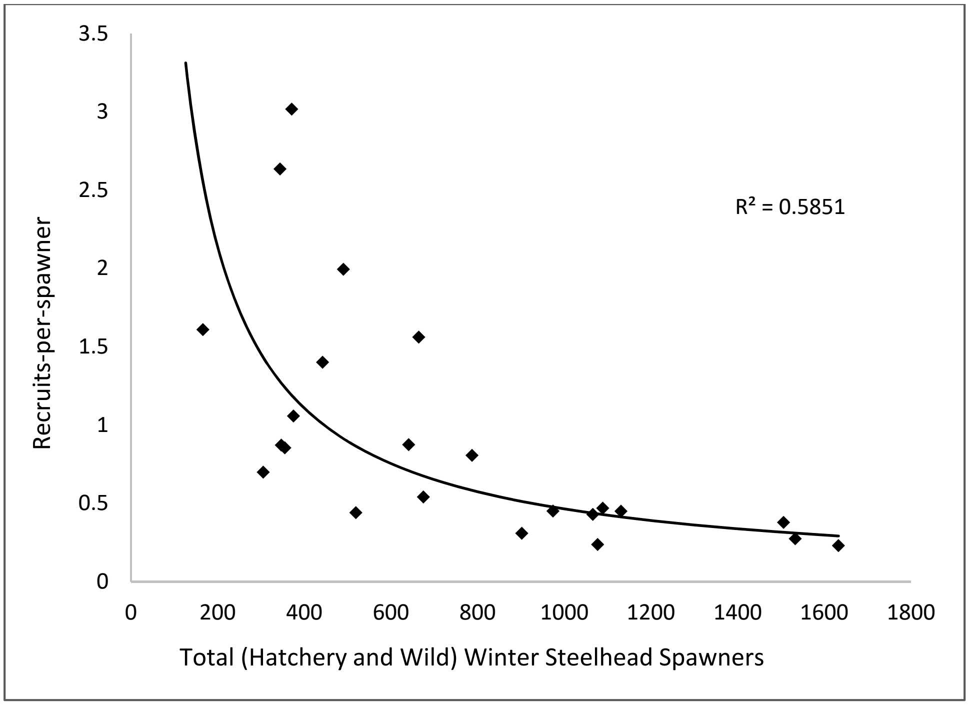

Figure 22. Recruit-per-spawner (R/S) curve, wild winter steelhead (spawner years 1992 – 2014).

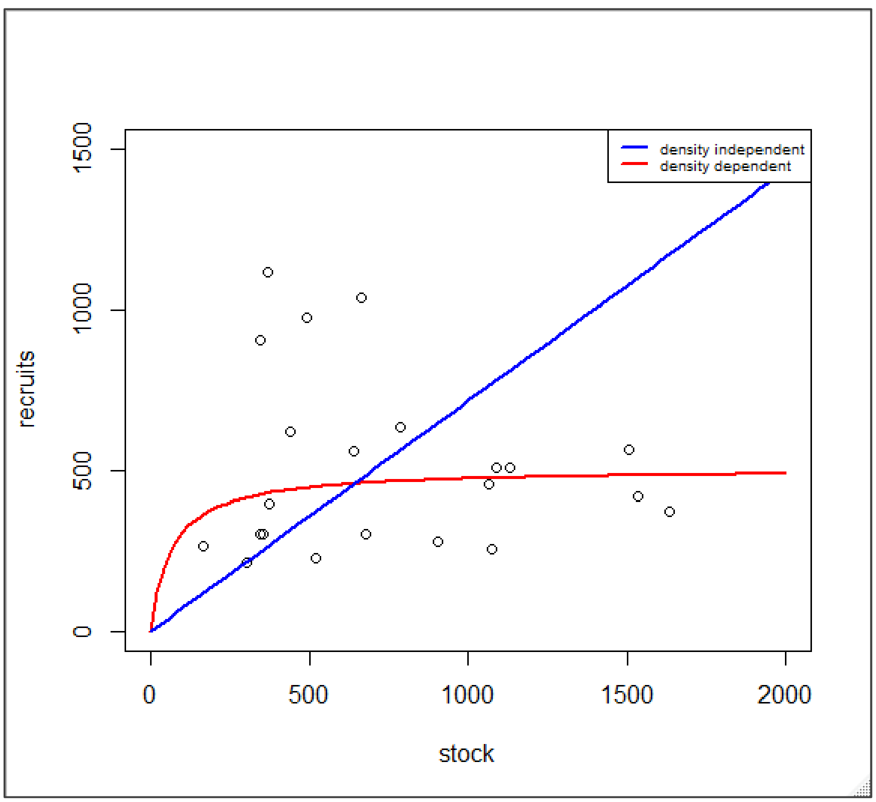

Figure 23. Beverton-Holt stock-recruit model for Hood River wild winter steelhead (1994 – 2014 spawn years).

The second parameterization of the Beverton-Holt model (spawn years 1992 – 2014; https://CRAN.R-project.org/package=FSA) confirms that winter steelhead exhibit density-dependence by virtue of a small p-value and a lower AIC score than density-independence (Figure 23). The model suggests that peak recruitment (Rp) is equal to roughly 505—or loosely interpreted as the number of winter steelhead spawners that the Hood River can currently support. Additionally, the number of spawners needed to reach peak recruitment (i.e. where the density-dependent and density-independent models converge) is closer to 700 adults (Myers 2002). The output from the R-software FSA package is presented below:

Analysis of Variance Table:

```
Model 1: logR ~ log(a * stock)
Model 2: logR ~ log(bh2(stock, a, Rp))
  Res.Df Res.Sum Sq Df Sum Sq F value    Pr(>F)
1     21    12.4870
2     20     5.2265  1 7.2606  27.784 3.698e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

       df      AIC
bh0fit  2 53.97351
bh2fit  3 36.81248
```

Parameters:

```
   Estimate Std. Error t value Pr(>|t|)
a     7.848     13.338   0.588  0.56285
Rp  504.749    114.877   4.394  0.00028 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Smolt-to-adult survival rates for wild winter and summer steelhead have not been reported by run type since the existence of Powerdale Dam (2010). Prior to that, run type of outmigrating smolts was retrospectively assigned based on winter and summer adult returns to Powerdale Dam of the same brood class. Following the removal of Powerdale dam, adult summer steelhead escapement estimates were unknown. The lack of adult summer steelhead being included in the total adult returns negatively affected SAR rates of wild steelhead beginning with the 2008 smolt outmigrant class. Because adult summer steelhead observations at adult collection facilities during the 2011 – 2014 sampling years were relatively null, we were unable to estimate adult abundance and the subsequent SAR rate. The SAR rate for wild steelhead (combined winter- and summer-run 1994 – 2010) varied from 2.55% to 21.00%, whereas the SAR rates for Hood River hatchery stock of winter steelhead where smolt FL ≥ 150mm varied from 0.68% to 4.43%. The post-release SAR rate of Hood River stock hatchery winter steelhead smolts released from 1994 – 2010 ranged from 49.9% to 89.7% lower than the SAR rate for wild steelhead migrating as smolts in the same years (Table 20).

A more applicable, contemporary SAR evaluation using wild and hatchery PIT tag returns to Bonneville Dam interrogation facilities indicated that the SAR rate of wild steelhead has typically exceeded that of hatchery winter steelhead, however the recent 5-year moving average (run year 2013 – 2017) SAR rates of hatchery and wild steelhead indicates that the return rate of hatchery fish may

exceed that of wild fish (Figure 24). Increased survival of hatchery steelhead in recent years may be related to size at release, as there is a positive correlation between apparent survival to Bonneville Dam and size at release (Figure 25).

Smolt Migration	Smolts (FL ≥ 150mm)	Adult Returns to HRM NO KELTS	Wild Steelhead SAR (Run Reconstruction)	Wild Steelhead SAR (PIT tag)	Hatchery Smolts (FL ≥ 150mm)	Hatchery Winter Steelhead SAR (Run Reconstruction)	Hatchery Winter Steelhead SAR (PIT tag)
1994	9,554	451	4.72%				
1995	5,955	518	8.69%				
1996	8,755	336	3.83%				
1997	15,972	408	2.55%		53,475	0.71%	
1998	31,035	1312	4.23%		56,752	1.06%	
1999	23,942	1207	5.04%		45,360	3.04%	
2000	19,266	1677	8.70%		59,898	2.81%	
2001	6,804	1429	21.00%		47,939	1.49%	
2002	12,290	896	7.29%		54,393	2.82%	
2003	14,460	656	4.53%		47,064	1.18%	
2004	15,042	722	4.80%		52,666	2.53%	
2005	21,484	733	3.41%	1.67%	67,452	0.68%	0.26%
2006	8,395	522	6.22%	1.14%	26,997	1.03%	0.55%
2007	4,316	486	11.25%	1.90%	35,591	1.99%	2.44%
2008	16,080	986	6.13%	5.06%	65,194	4.43%	5.05%
2009	9,317	598	6.42%	2.23%	51,943	2.07%	1.75%
2010	16,810	598	3.56%	3.47%	46,103	3.85%	3.42%
2011	18,298	224	1.23%	1.06%	47,289	2.17%	2.15%
2012	16,243	471	2.90%	2.13%	53,910	2.20%	2.40%
2013	42,220	1682	3.98%	2.48%	54,624	1.71%	2.02%
2014	18,305	907	4.95%	2.30%	49,709	3.38%	3.25%
2015	26,273	514	1.96%	0.62%	49,952	1.00%	0.72%
2016	22,705	661	2.91%	1.50%	51,505	2.39%	2.02%
2017	17,318	78	0.45%	0.60%	37,579	0.68%	0.65%

Table 20. Estimates by year of migration of wild steelhead smolt abundance, Hood River stock hatchery winter steelhead subbasin smolt production releases, subsequent adult escapements to the mouth of the Hood River, and smolt-to-adult survival rate. Return totals are based on first-time spawners. Release/Migration year is bold faced for those years in which estimates of adult escapements back to the mouth of the Hood River subbasin are more than 97% complete, and is italicized for years where adult returns of wild summer steelhead were not included in the total returns due to data limitations.

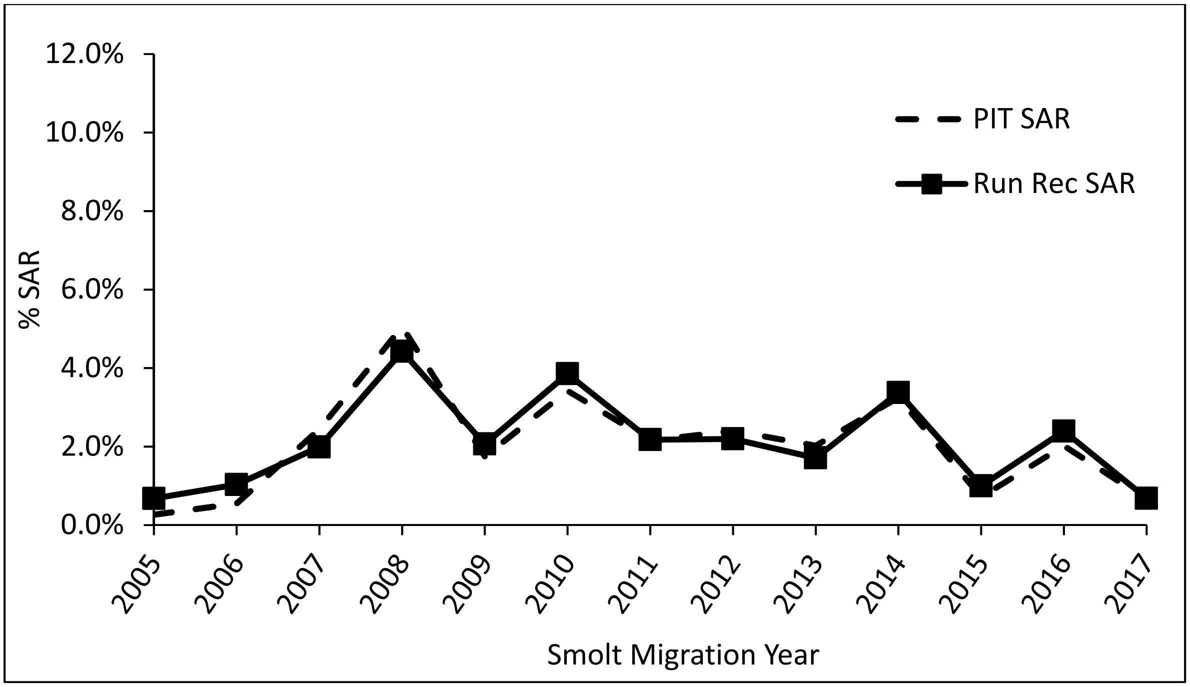

Figure 24. Smolt-to-adult return rate of hatchery winter steelhead based on PIT tag interrogations at Bonneville Dam adult ladder detection facilities (PIT SAR), and run reconstruction (Run Rec SAR). Return totals are based on first-time spawners.

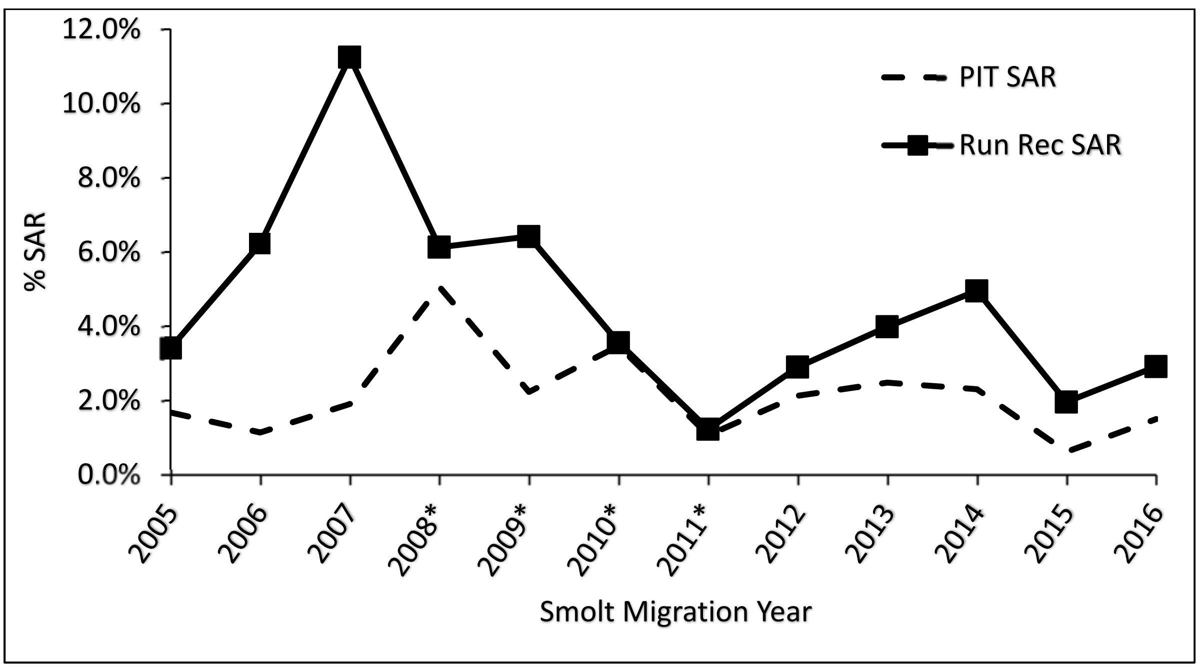

Figure 25. Smolt-to-adult return rate of wild steelhead (summer and winter run combined) based on PIT tag interrogations at Bonneville Dam adult ladder detection facilities (PIT SAR), and run reconstruction (Run Rec SAR). Return totals are based on first-time spawners. Smolt migration years denoted with an asterisk did not include summer-run adults in the run reconstruction SAR calculation.

Tributary Habitat Status and Trends—Stream Discharge Monitoring

Stream discharge estimates for April – October 2019 are summarized for all respective sites by figures 26 – 31. Generally flows recorded during 2019 were below average during the summer months following a high flow event that occurred in early April.

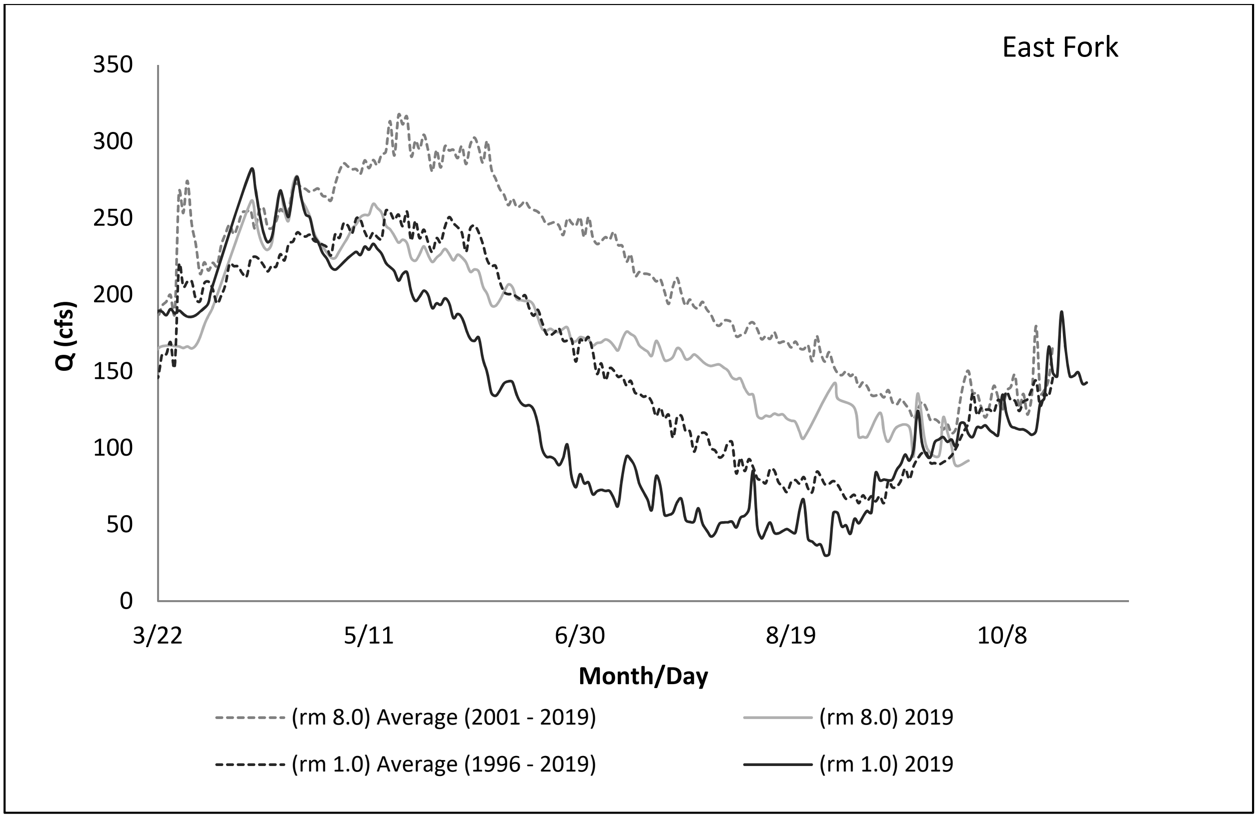

Figure 26. Estimated East Fork Hood River stream discharge (cfs) for 2019 and average discharge for years of associated data collection.

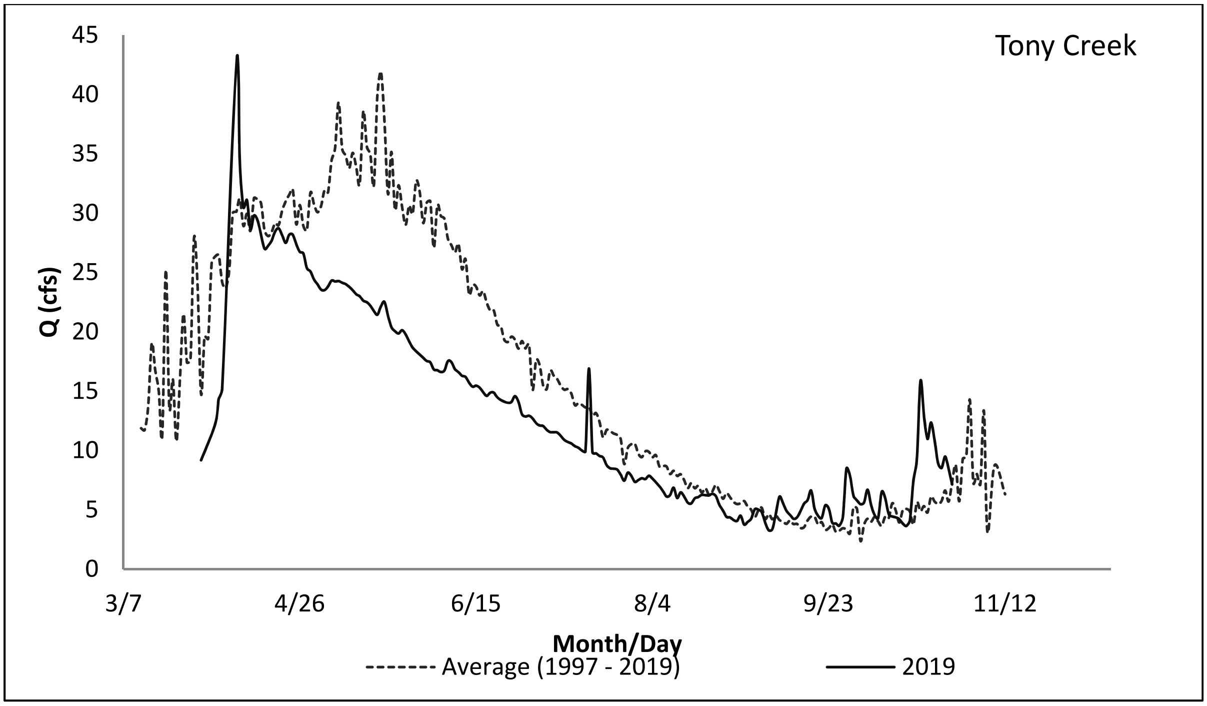

Figure 27. Estimated Tony Creek stream discharge (cfs) for 2019 and average discharge for years of associated data collection.

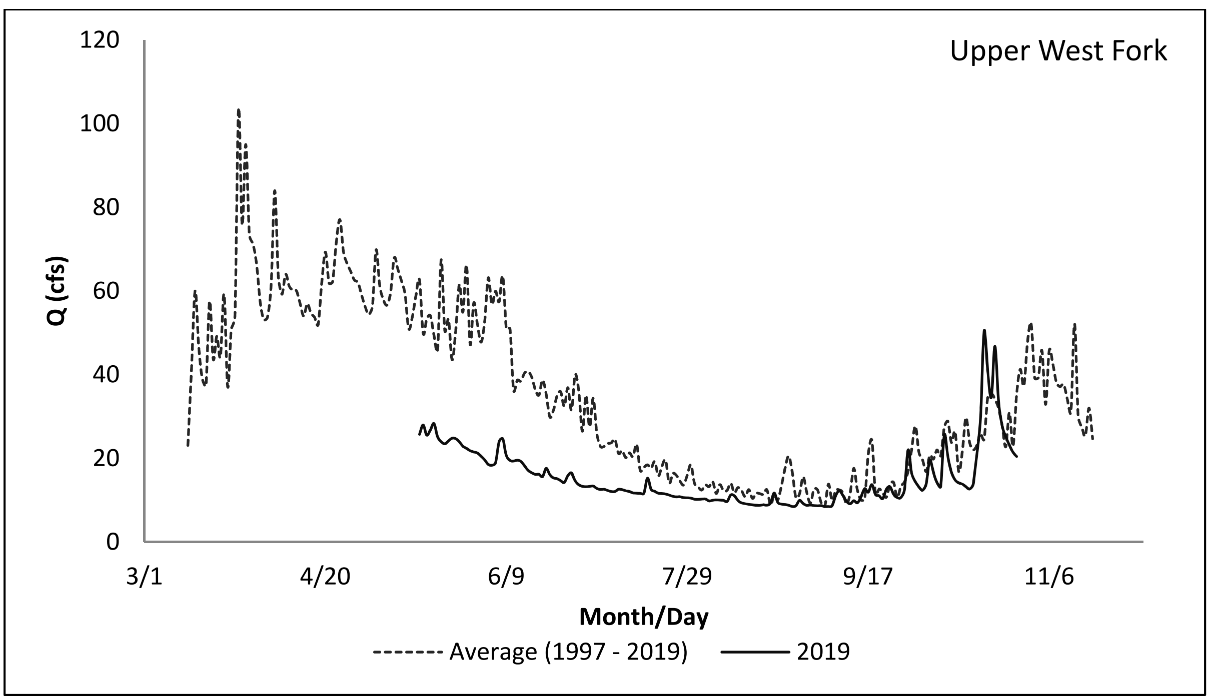

Figure 28. Estimated Upper West Fork Hood River stream discharge (cfs) for 2019 and average discharge for years of associated data collection.

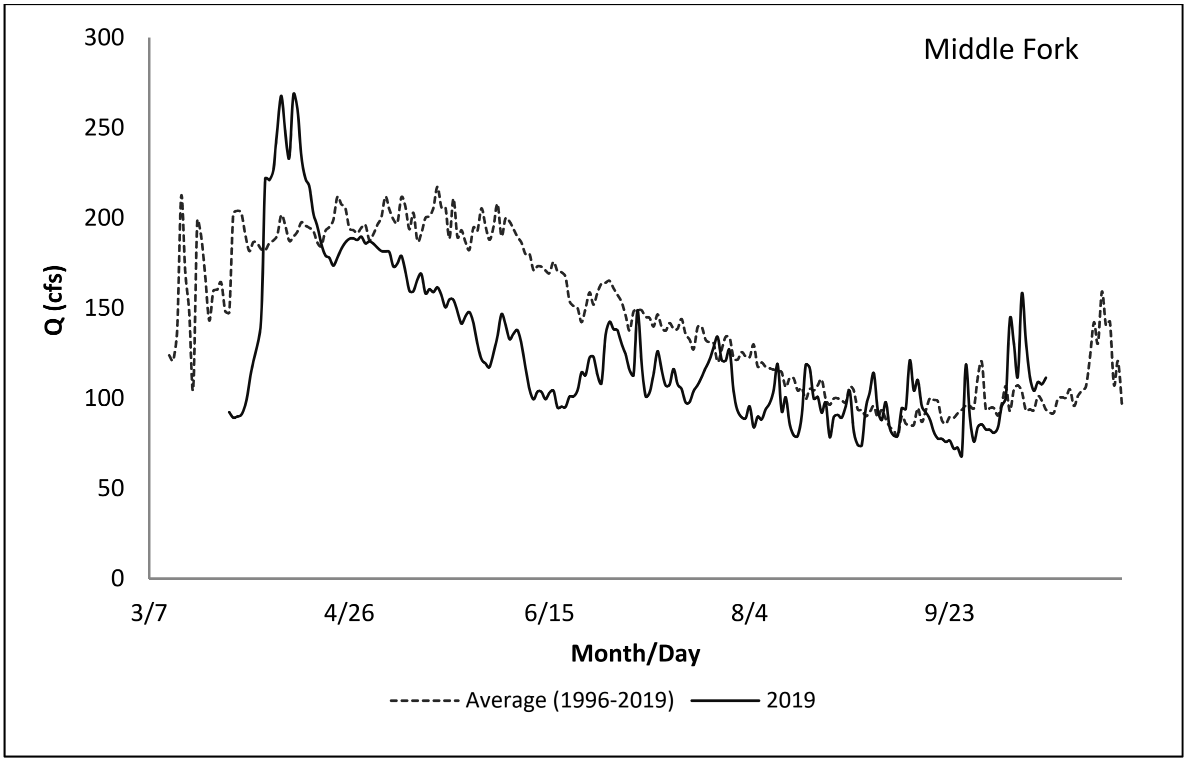

Figure 29. Estimated Middle Fork Hood River stream discharge (cfs) for 2019 and average discharge for years of associated data collection.

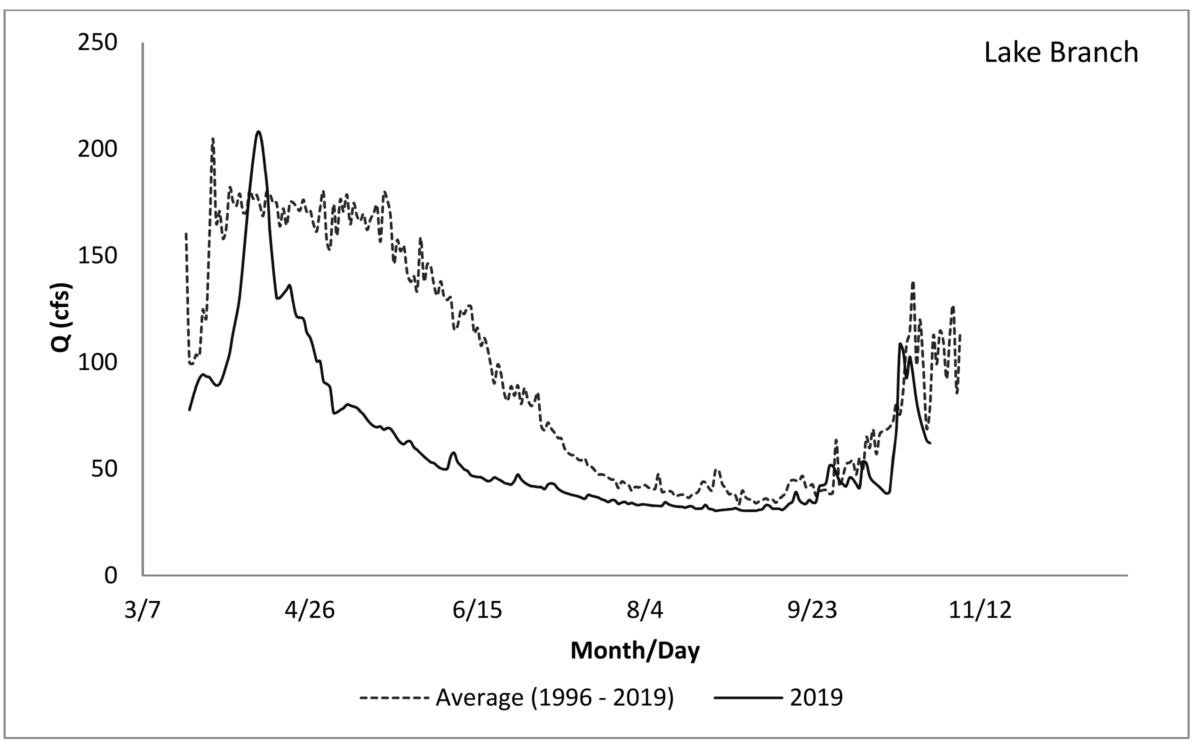

Figure 30. Estimated Lake Branch Creek stream discharge (cfs) for 2019 and average discharge for years of associated data collection.

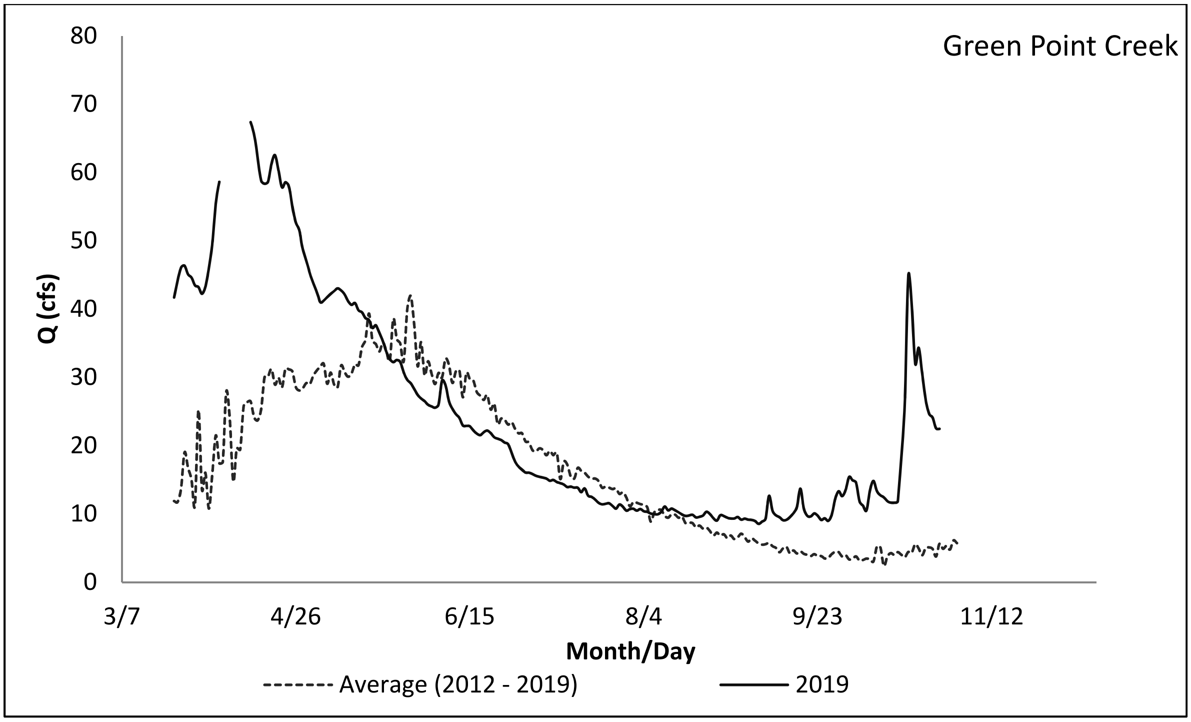

Figure 31. Estimated Green Point Creek stream discharge (cfs) for 2019 and average discharge for years of associated data collection.

DISCUSSION

Juvenile Abundance—Steelhead

Although 2019 wild steelhead smolt production exceeded the numerical fish objective (n = 16,870) established by the Revised Master Plan for the Hood River Production Program for wild winter and summer steelhead smolts combined (HDR|FishPro 2008), the estimate was below the recent 5-year average (n = 20,306). Production may have been limited by the presence of hatchery winter steelhead residuals from the 2017 release group. Steelhead smolt production may potentially be primed for an increase in 2020 however, as several variables appear to be lining up to benefit juvenile growth and survival. For example, efforts to cull undersized hatchery winter steelhead prior to release were enacted during 2018 and 2019 and resulted in release groups with very few undersized (and potentially residual) fish. Additionally, flow conditions during the past two brood years have been conducive for spawning and rearing. Smolt production modeling indicates a positive correlation exists between the number of wild age-2 smolts and spring flows (March – May) during the respective brood year (Simpson et al. 2018), as spawning potential increases due to more conducive migratory flows, additional availability of spawning habitat, and favorable incubation conditions (Quinn 2005). The number of wild steelhead smolts in 2019 was likely positively influenced by both above average spring flow during brood year 2017, and average flow during the summer 2018 period. During the fall 2019 trapping period high numbers of young-of-the-year and age 1+ rb-st were caught and, coupled with fairly mild winter conditions favorable for growth and survival, the 2020 outmigration season could represent a strong year class.

Mean wild steelhead smolt production in the Hood River subbasin has generally increased since the removal of Powerdale Dam in 2010. A potentially diverse suite of factors are responsible and may include, but are not limited to, dam removal, habitat restoration actions, increased spawning and rearing access, suspension of the summer steelhead hatchery program, and improved hatchery practices. A factor that directly influenced the recent increase in smolt abundance was the relocation of the mainstem RST in 2011 to downstream of Neal Creek, which provided the opportunity to catch additional steelhead smolts that were previously unaccounted for. Limited sampling with fyke nets and screw traps indicated that Neal Creek may produce around 400 - 800 downstream migrant rb-st (unpublished data on 2/3/2002 from ODFW, Fish Research, High Desert Region, Mid-Columbia District, The Dalles, Oregon). Given the number of adult wild winter steelhead that were passed upstream of the Neal Creek weir during run years 2011 – 2016 (annual mean = 26), we speculate that the production potential of the creek may exceed 800 smolts (assuming fecundity of 3500 eggs/female and egg-to-smolt survival of 1.5% - 4.0%) under favorable environmental conditions.

As previously noted, the presence of residual hatchery winter steelhead smolts released during 2017 likely negatively influenced 2019 smolt production. According to the ISRP Review of the Revised Hood River Production Master Plan (2008), impacts to wild fish related to residualism have been largely unaddressed given current data collection methods. Therefore we attempted to make best use of existing resources and address this issue using data collected by our program and the CTWSRO (1988-053-03). Beginning in CY2014 (Simpson et al. 2015), methods were implemented to estimate the number of hatchery winter steelhead smolts that failed to immediately migrate to the ocean and instead exhibited an age-2 freshwater life history variation (i.e. residing in the Hood River subbasin an additional year, then making an ocean migration). Although we determined the percentage of hatchery winter steelhead surviving overwinter to become age-2 downstream migrants was typically low (Table 6), what could not be assessed using those methods was the number of hatchery non-migrants that did not survive overwinter, or their effect on wild steelhead. In order to address those concerns, we examined pre-release length data taken from a subsample of hatchery smolts just prior to acclimation to

characterize the release group. The annual proportion of non-smolts (FL<150mm) was included as predictor variable in a multiple regression wild steelhead production model. A negative correlation between the proportion of hatchery non-smolts during year *y* and the number of estimated age-2 wild steelhead smolts during year *y+1* was evident, suggesting that a high proportion of undersized, non-migrant hatchery steelhead can impact wild steelhead production. The potentially negative impacts of these residual hatchery winter steelhead include displacement of wild parr for summer rearing habitat, competition for prey resources and direct consumption of wild steelhead fry (ISRP 2008).

Following the initial CY2014 analysis, we continued to report the estimated number of hatchery age-2 freshwater migrants as well as refine the non-migrant/wild steelhead production relationship. In a concurrent study, Larsen et al. (2017) identified potential hatchery residuals prior to release based on hormone levels and histology, and they concluded that 96 – 97% of the release group was destined for smoltification (brood years 2011 – 2013), however only 0.8% of the individuals they evaluated during the study were identified as immature parr.

During hatchery release years 2007 – 2016, size targets for hatchery winter steelhead were generally attained (Table 5). However, as reported two years ago (Simpson et al. 2018), the mean fork length of hatchery smolts in 2017 was below average due to unforeseen predation issues within the hatchery rearing ponds (J. Schmitz, personal communication). The proportion of hatchery non-migrants within the 2017 release group was well above average (2017=19.3%; mean=6.2%). The decline in wild production can likely at least be partially attributed to the high proportion of non-smolt hatchery steelhead within the 2017 release group. The estimated number of hatchery winter steelhead residuals exhibiting an age-2 freshwater life history variation was nearly three times the average (Table 6).

The assumption made by the ISRP that "yearling 'residuals' may compete with and displace wild underyearling parr, but die over summer (likely due to physiological reasons)" may be supported by length and weight data collected during rotary screw trapping. The average condition factor for hatchery steelhead at release is typically similar to that of wild fish, near or slightly above 1.0. However, as the months pass following release, the condition factor of hatchery fish slowly deteriorates. Our data supports the hypothesis that hatchery fish may behave aggressively and initially displace wild steelhead parr, but then die because they fail to adapt to the natural environment. Given carrying capacity limitations of the Hood River coupled with the hatchery releases occurring relatively high in the East Fork Hood River (RM 21.2)—where a large proportion of wild winter steelhead likely rear—effects of non-migratory hatchery steelhead warrant consideration. Non-migratory hatchery reared steelhead essentially represent oversized (FL ≈ 120mm – 150mm) age 1 fish that are predominantly competing for rearing space with wild age-2 steelhead of potentially similar size, or their smaller wild age-1 counterparts (FL ≈ 80mm – 110mm). Previous studies indicate that interactions between wild and hatchery juvenile steelhead are dominated by hatchery fish approximately 79% of the time (McMichael et al. 1999). As additional data are collected the model will be developed further but preliminary findings suggest that hatchery residuals may pose a prospective threat to wild steelhead.

Juvenile Abundance—Spring Chinook Salmon

Mark and recapture rates are perpetually low for naturally produced juvenile Chinook salmon in the Hood River subbasin, and expanded smolt population estimates are generally unattainable as a result. Based on available data, it appears that Chinook salmon captured at a RST during the spring period are true age 1+ smolts bound for the ocean, while those tagged during the fall period (age 0+) may immediately migrate to the Columbia River and/or estuary or hold over until the following spring. Generally, the rearing habitats associated with age 0+ Chinook remain unclear. Interrogation data generated from juvenile Chinook tagged during each fall season during 2012 – 2019 inferred that there is a mixture of migrants moving out to the Columbia and fish that remain in-basin. PIT tag interrogations at Bonneville Dam of individuals that migrated downstream to the Hood River mouth and/or to the Columbia River were limited. Whether this behavior is an inherited life history trait or possibly a circumstance of density dependence (given the limited rearing habitat available in the Hood River subbasin) is unclear. Additional data collection may ultimately reveal successful juvenile Chinook salmon life history variations in the Hood River and appropriately guide Production Plan management action (i.e. potential integration of LCR stock for hatchery production).

Preliminary data suggests that survival of juvenile Chinook salmon in the Hood River to the adult life stage, irrespective of life history strategy, is poor. Estimates generated from CJS modeling indicated that survival to Bonneville Dam of naturally produced juvenile Chinook downstream migrants tagged in the spring was greater than those tagged in the fall; however, there are limitations to the survival models used to estimate juvenile Chinook survival, particularly survival of the age 0+ group tagged during the fall months (Simpson et al. 2017). Because interrogation opportunities downstream of Bonneville Dam such as the NOAA Estuary Trawl and the East Sand Island tag recovery projects are not available during the fall months, interrogation records included in the model input are generated primarily from those individuals that survive overwinter somewhere upstream of Bonneville Dam and then are detected the following spring. Essentially, the model likely estimates overwinter and subsequent downstream survival of Chinook tagged in the fall, rather than survival through the migration corridor during the fall or winter months.

We can conclude with a high degree of certainty that although it is unclear exactly where and when mortality is occurring, juvenile Chinook salmon tagged in the Hood River are not surviving to recruitment age. Very few naturally produced PIT tagged juvenile Chinook salmon returned to Bonneville Dam as adults (<1.0%).

Juvenile Abundance—Cutthroat Trout

Production of downstream migrant cutthroat trout in the Hood River subbasin is limited but potentially increasing. The rising frequency of occurrence may represent an expansion in production and/or survival or it may possibly be an artifact of misidentification in previous years. Recapture and interrogation data imply that cutthroat trout captured at a RST site are indeed true downstream migrants, as PIT-tagged cutthroat trout are typically observed moving to the estuary in a matter of days. PIT tag interrogations also suggest that estuary-bound cutthroat trout exhibit a limited saltwater phase and generally migrate back to the Hood River within six months. A larger sample size may provide further insight into Hood River cutthroat trout life history. Preliminary survival modeling using the same parameters for wild rb-st indicated that apparent survival of downstream migrant cutthroat trout to Bonneville Dam is slightly greater than that of wild steelhead. This result was not unexpected given that the average FL of tagged cutthroat is slightly higher than the average FL of tagged rb-st.

The level of cutthroat trout and rainbow trout (wild or hatchery) hybridization is poorly understood within the Hood River subbasin. During the last Master Plan Review issued by the ISRP (2008), "hybrid swarms" of cutthroat with hatchery steelhead that residualized within the subbasin and reached sexual maturity without making an ocean migration were noted as an unexplored possible negative effect of hatchery residualism (ISRP 2008). From a morphological perspective Hood River cutthroat display a broad continuum of characteristics with regard to defining traits (i.e. spotting patterns, red coloration on the underside of the maxillary, etc.). Whether the variety of morphological appearance can be attributed to hybridization, natural variation or some other contributing factor remains unknown but could represent a topic of further evaluation. One ancillary result of genetic analyses conducted to determine the proportion of wild summer- and winter-run steelhead sampled at the mainstem Hood River RST (performed by the CRITFC Hagerman Laboratory; subcontract issued by BPA Project #1988-053-03, contract #66120) was that researchers may be able to define the number of cutthroat that were misidentified as steelhead during sampling as well as the rate of steelhead/cutthroat hybrids which may help address the importance of this issue in the future.

Juvenile Abundance—Bull Trout

Although 2019 represented another good year for the capture and tagging of bull trout (n=9, Table 10), few conclusions can be formulated for bull trout within the Hood River subbasin given the limited amount of available capture data. We assume several bull trout were likely forced over the Laurance Lake dam during the glacial storm surge that occurred in October 2017, and the residual effects of that storm were still being felt in 2019. Typically Hood River bull trout are not observed in downstream migrant traps. Downstream migration patterns evident for the 2018 tagging group were not observed with regard to the bull trout tagged during 2019. In 2018, 3 of the 15 tagged fish were detected at the Hood River mouth PIT tag antenna located near the confluence of the Columbia. In addition to those three individuals, another was recaptured in the Middle Fork screw trap that appeared to have made the downstream migration to the Columbia based on the observed growth (tagged June 12th, fork length = 168mm and weight = 49.9g, recaptured September 21st, 267mm and 199.5g). Past scale analysis and mark-recapture data indicate rapid growth is uncommon for bull trout residing within the Hood River subbasin. Generally growth rates are very protracted and bull trout are relatively slow to reach age of first reproduction. Length and weight data from PIT tagged bull trout that have been recaptured after interrogation at the HRM antenna suggest there may be a growth advantage to downstream migration.

Prior to 2018, PIT tag interrogation data suggesting that bull trout migrate downstream towards the Columbia River were limited. We assumed most bull trout captured in downstream RST's were not true downstream migrants, as typically HRM and Bonneville interrogations occurred several months or even years after the initial tagging event. Additional PIT tag interrogation records of Hood River bull trout may help reveal fluvial migration patterns and help managers better understand this threatened population as well as the relative importance of habitat connectivity at the Laurance Lake dam.

Adult Harvest, Abundance, Diversity and Productivity—Winter Steelhead

The 2019 sampling year for adults was characterized by a limited number of collections in the weeks after the installation of the EFW, followed by a high flow event that occurred in early April rendering the weir inoperable for the remainder of the season. Low trapping efficiency of the weir (17.4%) coupled with additional complications at the supplementary East Fork Irrigation Diversion ladder trap (i.e. diversion panels lowered, attraction flow limitations) created significant sampling difficulties. Despite those setbacks, wild broodstock goals were nearly met (desired pNOB = 1.0, actual 0.87).

This year marks the third time since the removal of Powerdale Dam in 2010 that the EFW has been compromised resulting in difficulties collecting wild broodstock. The other two problematic collection years (2014, 2017) resulted in pNOB values of 0.380 and 0.347 respectively and, along with pHOS values above 0.5, resulted in PNI values well below the HSRG guideline of 0.67 for integrated hatchery populations. For 2019, wild broodstock collections were sufficient to somewhat negate the estimated pHOS rate, ultimately producing a PNI value of 0.648. Diversity of the naturally spawning population continues to be driven by the number of hatchery steelhead removed through the sport fishery as well as adult collection facilities. Annual estimates of pHOS remain highly variable and are seemingly subject to environmental conditions and EFW efficiency.

Difficulties in keeping adult trapping facilities operational emphasizes the need for increased escapement model precision, which can only be generated with greater numbers of PIT-tagged juveniles and/or higher recapture rates of returning adults. Following the removal of Powerdale Dam, preliminary mark-recapture and survival modeling analyses indicated that the tagging rate of juvenile steelhead was not sufficient to employ statistical models used to estimate escapement. Subsequently, tagging effort was intensified and ultimately produced an adequate number of PIT tagged returning adults to estimate the total run. Despite those improvements, overall precision of the model estimates for wild adult winter steelhead remains relatively substandard (mean CV = 41.2%). The volume of hatchery winter steelhead tagged, while greater than wild steelhead, also does not typically produce escapement estimates with a CV value (mean = 25.3%) that meets the NOAA standard CV of 15% (Crawford and Rumsey 2011). The sizeable variance associated with both the mark-recapture and CJS models can be attributed to generally low detection probability (HRM antenna) and recapture rates at adult trapping facilities. While subtle improvements have been made to both the antenna and adult trapping facilities to augment efficiency, future escapement estimates will likely continue to have wide confidence intervals without a considerable investment in trapping capacity at both the juvenile and adult life stages. Model simulations were conducted that varied 1) the detection efficiency of the HRM antenna, 2) the number of adult recaptures in basin, and 3) a combination of the two variables, and indicated precision thresholds may be met under certain scenarios. Improving the detection efficiency of the HRM antenna only appeared to have a marginal effect on improving the precision of the model. Additional CJS models were run using 2013 wild winter steelhead data as the baseline since that return year represented the lowest CV out of all return years (26.6%). Simulations that included an increase in detection efficiency of the HRM antenna from 40% to about 80% lowered the CV to 24.5%. Simulations where the proportion of marked adult winter steelhead that were recaptured at adult trapping facilities increased from 35% to 66% lowered the CV to 20.1%. A combination of increasing the number of fish detected at the mouth antenna, along with increasing the recapture rate at the weir, produced a CV of 10.8%. Although that CV value meets the NOAA threshold it is hard to imagine a scenario ever being realistic where the mouth antenna functions at 80% efficiency and recapture efficiency is 66% of the total marked group.

Increasing the number of smolts tagged also has the potential to improve model precision, as demonstrated by the CV values associated with hatchery winter steelhead. The mean CV for hatchery fish is 25.3%, with a low of 16.0% observed in 2018, whereas the mean CV for wild winters is 41.2%, with a low of 26.6%. The number of previously PIT-tagged hatchery adults returning to Bonneville has been anywhere from 2 times to nearly 8 times the number of PIT-tagged wild returners. A small increase in the number of wild smolts tagged would not alter the CV substantially, as the number of smolts tagged would need to increase dramatically to significantly increase precision. Despite the relatively low model precision, our escapement estimates do appear to be fairly accurate as they are consistent with other data indicators such as the number of PIT tag contacts at Bonneville Dam during the return migration, the number of spawning adults based on adult-mark/kelt-recapture methods, and the relatively high number of estimated wild steelhead caught and released in the non-tribal fishery. Given the objectives

of the Production Program, NWPCC FWP, and the Lower Columbia River Conservation & Recovery Plan for Oregon Populations of Salmon & Steelhead (2010), having the ability to accurately estimate wild and hatchery adult winter steelhead escapement is essential.

Model estimate limitations associated with adult recapture rates can be partially attributed to the functionality and operational schedule of adult trapping facilities. Delayed weir deployment/trap operation is a recurring limiting factor with regard to data collection and analysis and causes model precision issues due to fewer recapture opportunities. Based on interrogations of previously PIT tagged individuals at the Bonneville Dam upstream migrant interrogation facilities as well as results from non-tribal angler harvest surveys, both wild and hatchery winter steelhead likely enter the Hood River subbasin and potentially migrate above the location of the adult collection sites prior to installation. However, due to the highly variable flow patterns associated with the Hood River, the risk of installing the EFW earlier in the year likely outweighs the benefits of sampling the few available early returning winter steelhead. Discussion among fishery managers has occurred to develop a more stable, permanent adult collection facility on the East and/or Middle Fork that would function similarly to the Moving Falls adult ladder. From a monitoring perspective the increased reliability of such a facility would be welcomed given the potential data analysis issues. Since the primary function of adult trapping facilities is broodstock collection with monitoring purposes as a secondary objective, operational changes may not occur so long as broodstock collection goals are met annually.

The aforementioned discussion of modeling limitations is also important within an applied context, as escapement estimates are used to guide certain management decisions such as broodstock selection. To ensure that the guidelines established by the HSRG are being met (i.e. 0.67 Proportion Natural Influence (PNI) for integrated populations), hatchery broodstock will be comprised of 100% wild fish, at least until a more reliable adult sampling option becomes available that is better able to remove hatchery fish from the natural spawning population, thus limiting pHOS. While utilization of 100% wild broodstock is the target for future winter steelhead hatchery production, regression models that include predictors such as cumulative PIT-tag returns to Bonneville Dam and/or environmental variables can be utilized to provide fishery managers a real-time prediction of wild escapement to help avoid "mining" the wild population. Potential regression models are only effective if annual escapement estimates are accurate.

Escapements of wild winter steelhead were certainly expected to trend downward due to unfavorable ocean conditions (https://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/g-forecast.cfm#Table1) during 2015 – 2017, where each year ranked in the lowest 20th percentile observed over the past 20 years. Sea surface temperatures and PDO rankings during 2015 – 2016 were among the poorest within the past 20 years and did not offer ideal survival conditions for salmon and steelhead. It was therefore not surprising that wild winter escapement did not meet Production Program objectives in 2019. Although ocean conditions observed during 2018 ranked better than the previous three years and will hopefully translate into higher SARs, escapement potential will likely be somewhat limited in the immediate future due to mediocre smolt production during 2017 – 2018. Productivity of wild winter steelhead, while appearing to be frequently below replacement value, is subject to seemingly volatile population dynamics likely influenced by unpredictable environmental conditions.

Adult hatchery returns in 2019 experienced a significant downturn as predicted in the CY2018 Annual Report (Simpson 2019). Below average returns likely stemmed from a combination of poor ocean conditions and limited apparent survival of hatchery outmigrants during release year 2017. Typically, the 2-salt returning adults comprise the majority (mean = 71.3%) of the run class. The average fork length of hatchery winter steelhead released during 2017 (181.7mm) was significantly less than the recent 5-year moving average (206.3mm), and the 2017 release group also consisted of a relatively large proportion (14.3%) of potentially non-migratory (FL<150mm) individuals. Additionally, apparent survival

from release at the East Fork Sandtrap acclimation site (RM 21) to the mainstem RST—a metric potentially indicative of non-migratory behavior—was only 0.60 compared to the 5-year moving average of 0.88. As a result, the SAR rate of hatchery steelhead released in 2017 appears to mirror that of the 2015 outmigration class, where SARs were among the lowest on record (<1.0%, PIT-tag based SAR) due to drought conditions and the warm ocean offshore "blob."

Apparent survival of returning adult winter steelhead from Bonneville Dam to the mouth of the Hood River was slightly above average for hatchery fish (77.4%, mean = 76.6%) and above average for wild fish during 2019 (88.9%, mean = 72.8%). A multitude of factors likely influence the survival rate through the Bonneville pool, however we suspect the number of fallbacks may play a significant role in the apparent survival estimate. During run years 2012 – 2018, 4.0% of wild adult winter steelhead and 5.1% of hatchery winter steelhead exhibited a PIT tag detection history characteristic of fallback behavior (i.e. successfully ascended the ladder but suddenly reappeared at the bottom of the ladder, inferring downstream passage through the spillway or turbines; were immediately detected at downstream migrant PIT-tag interrogation sites; were detected moving downstream through the ladder and exiting). During 2019, no wild winter steelhead appeared to exhibit a fallback detection history, however 4.7% of hatchery winter steelhead were identified as fallbacks. Migration timing for wild and hatchery winter steelhead were nearly identical, with the majority of detections occurring from mid-March to early April. A negative correlation existed between the date a hatchery adult left the Bonneville ladder and survival to the Hood River. While extremely difficult to determine the exact mechanism for decreased survival, the issue may represent a major limiting factor for Hood River steelhead.

Harvest and exploitation of hatchery winter steelhead both fell below Production Program objectives in 2019 generally due to low adult returns. There remains great uncertainty, however, that using the CJS model parameters to estimate sport harvest will sufficiently replace angler harvest surveys. It will not be possible to discern harvest from emigration or prespawn mortality using the CJS model. Additionally, the ability to estimate this parameter relies on a functional PIT tag detection system present at the Hood River Mouth site as well as an operational East Fork Weir, both of which have been routinely damaged during past high flow events.

Despite low adult returns observed in 2019, the winter steelhead hatchery program has demonstrated adaptability and overall improved performance over the past decade. Evidence to support that notion can be derived from a comparison of wild and hatchery SAR rates (Table 20). Generally, as reported during the Powerdale Dam era (Reagan 2011), the prevailing conclusion was that the SAR rate for wild Hood River steelhead greatly exceeded that of hatchery reared steelhead. However, since the respective SARs were calculated differently, there was inherent inequality in that comparison (Reagan 2011). The SAR rate of hatchery fish was based on the percentage of adults that returned to the subbasin out of the total hatchery release group, whereas the wild SAR was generated by the number of adult returners out of smolt outmigrant groups where the minimum smolt size was 165mm FL. Reclassifying the minimum smolt size for wild steelhead to 150mm caused the SAR rate to decrease, however when hatchery release groups were restricted to the same smolt size classification, the SAR rate for hatchery fish slightly increased. Using this more equitable calculation method, coupled with evaluating both groups for first time spawners only and excluding kelts (since hatchery adults are removed from the population within-basin), hatchery winter steelhead have experienced an overall upward trend in SAR rate and are currently much closer to, and possibly in exceedance of, the SAR reported for their wild counterparts.

Increasing average smolt size and refining the feeding schedule of hatchery winter steelhead has certainly played a role in improving the SAR rate. The positive correlation observed between average smolt size at release and apparent survival to Bonneville Dam is reflective of recent hatchery practices (Figure 7). One possibility for the increased size at release is that the date fish are transferred out of the

hatchery and to the acclimation ponds has shifted from early-mid April to early May (Gerstenberger et al. 2012). The result of delaying the transfer out of the hatchery is that the fish stay on feed for an additional two weeks during a period of rapid growth. Another possibility for the increased size at release is that Oak Spring Hatchery management has made improvements to the rearing environment to provide greater security and cover for the fish. The Hood River stock winter steelhead has traditionally been a difficult fish to grow due to its tendency to not take food when stressed. Predation netting has been installed and shade cloth draped in strategic locations to provide cover. Hatchery staff also utilized automatic feeders to supplement hand feeding. This provides constant, regular feed throughout all daylight hours (personal communication, 1/13/2014, Lyle Curtis, ODFW, Oak Springs Hatchery, Maupin, OR). As a result of these and other improvements to the hatchery program, the SAR rates of hatchery winter steelhead have remained relatively steady over the past decade.

Adult Harvest, Abundance, Diversity and Productivity—Summer Steelhead

The spawner escapement estimate for the 2018 – 2019 run year of Hood River wild summer steelhead (n=167, ±150) did not meet the Revised Master Plan for the Hood River (HDR|FishPro 2008) objective (n=510) and generally reflected the trend for many Columbia River tributaries, as summer runs throughout the basin have been declining with many populations reporting 25-year lows. Many of the model limitations described for winter steelhead (i.e. limited detection probabilities and recapture rates, field classification of run type, etc.) apply to summer steelhead, in addition to other assumptions specific to summer steelhead. For example, since summer steelhead run timing is greatly protracted with different brood years potentially overlapping (Reagan 2011). We utilized temporal assumptions to identify run year for returning adults interrogated at Bonneville Dam. Unless noted during field sampling that run type or run year was identified with a high degree of certainty, we categorized run type and run year of wild adult steelhead based on a suite of assumptions developed primarily through the genotyping results reported by the CRITFC Hagerman Lab (Simpson et al. 2017).

Given the threatened status of the population and associated Production Plan objectives, accurately assessing future run years of wild summer steelhead population is imperative for recovery and/or reinstatement of hatchery programs. Data collected during FY19 indicated that the wild summer steelhead population is likely well below Master Plan objectives. Hopefully the increased tagging rate of juveniles coupled with additional data collected from MFFF (i.e. MVF PIT-tag antenna installed by BPA Project #1988-053-03) will perpetuate the evaluation of the status of wild summer steelhead well into the future. The number of hatchery stray summer steelhead captured and removed at adult trapping facilities was minimal during 2019 (n=4), another indicator of poor summer returns throughout many of the Columbia River tributaries. Productivity of the summer steelhead population exhibits patterns similar to that of the winter steelhead population, where the number of recruits appears to plateau with an increasing number of spawners, potentially indicative of habitat and/or environmental limitations.

Because of the limited number of previously PIT tagged adults detected at Bonneville Dam and the subsequent low number of recaptures at Hood River adult trapping facilities, refining run estimates of both wild and hatchery summer steelhead in a post-Powerdale Dam environment remains one of the biggest M&E challenges moving forward. Additionally, understanding the impact that stray hatchery summer steelhead have on natural production is also vital towards achieving population recovery.

Adult Harvest, Abundance, Diversity and Productivity—Spring Chinook Salmon

Escapement, harvest, broodstock and spawning escapement goals as stated by the Revised Master Plan for the Hood River (HDR|FishPro 2008) for adult hatchery spring Chinook salmon were exceeded during 2019. Despite meeting program objectives during 2019 managers should adopt a management plan for returning hatchery jacks, as the number of available spawning jacks exceeded adults during 2019. Upstream releases have typically been dominated by hatchery origin fish (Simpson et al. 2017), where hatchery jacks comprise a disproportionate percentage of spawners relative to what is generally observed in wild populations throughout the Columbia River basin (Quinn 2005). Out of the 139 spring Chinook handled and released upstream, 90 of them were hatchery jacks. Further clarification of hatchery:wild and male:female ratios that are preferred on the spawning grounds is needed as well.

Escapement of hatchery spring Chinook, although down from the previous year, was sufficient to provide sport and tribal fisheries while also meeting broodstock needs. The number of spring Chinook adults escaping to natural production was somewhat limited (n=105). A total of 243 spring Chinook were collected for broodstock, the majority of which were hatchery origin (97.1%). The number of spring Chinook escaping to natural production was also notable (n=564). A total of 243 spring Chinook were collected for broodstock, the majority of which were hatchery origin (97.1%).

Model estimates of naturally produced spring Chinook escapement were not available for the 2019 run year due to data limitations. A total of 28 adults and 3 jacks were captured at adult collection facilities. Natural production levels of spring Chinook remain unclear, however the sparse rate of incidence at adult trapping facilities may be indicative of a relatively low return. Continued monitoring of smolt production and subsequent smolt-to-adult survival of naturally produced spring Chinook is currently the most effective assessment tool in guiding future spring Chinook reintroduction management decisions, thus further emphasis will be placed on these monitoring objectives.

From the perspective of meeting harvest objecitves established by the Revised Master Plan (HDR|FishPro 2008), 2019 sport harvest exceeded stated goals for hatchery spring Chinook salmon. Revision of program objectives outlined in the plan may be needed if escapement and broodstock goals of hatchery fish are being met in addition to harvest objectives. Conversely, and more importantly, if harvest goals are exceeded and escapement and broodstock objectives are not met, fishery managers should also consider policy revision. Managers may wish to adhere to a sliding scale sport harvest model during 2019 to ensure adequate numbers of hatchery spring Chinook are available for tribal harvest and broodstock collection.

Stream Discharge Monitoring

Hood River flow rates began the spring at roughly average levels during 2019 and then experienced a rain-on-snow event in early April that pushed discharge to over 8,000cfs. Following that storm surge, there was a notable lack of precipitation throughout the remainder of the spring, resulting in below average flow rates for the remainder of the spring and summer. Considering the number of surface water rights spread throughout the Hood River subbasin and the potential for reduction in glacial input, instream water rights and their respective effects on fish populations will likely become an increasingly contested subject (Lillquist and Walker 2006). Monitoring both salmonid production and instream flow as well as developing models that explore relationships between production, survival, and streamflow will continue to be a focus of the HRRP in future data collection years. Given the stated goals of the Production Program and the associated monetary investment made by BPA to achieve those goals, understanding the effects of water withdrawals on salmonid populations is vital towards restoring fish populations in the Hood River subbasin.

Oregon Water Resources Department (OWRD) holds an in-stream water (IWR) right on the East Fork Hood River in trust for the people of Oregon. The IWR was granted for the purpose of supporting

aquatic life and minimizing pollution. The IWR measurement point is slightly upstream of the confluence of the East and Middle forks of the Hood River and establishes a minimum flow for specific time periods of the year. No permanent gauging station exists at the site of the IWR that can be used to monitor whether or not the IWR is being met. Observations made prior to 1994 indicated that the IWR was probably not being met during certain times of the year. A gauging station was installed in the East Fork of the Hood River in 1992, by the OWRD, and jointly monitored by both the OWRD and the ODFW from 1992 – 1994 (Olsen et al. 1995) and by ODFW from 1996 – 2019. Data collected to date indicates that the IWR is not always being met, at least during periods when the gauging station was monitored (Olsen et al. 1995). Full benefits associated with the HRPP may not be completely realized unless the IWR is met on an annual basis.

ADAPTIVE MANGEMENT AND LESSONS LEARNED

Monitoring adult winter steelhead became more difficult with the discontinuation of harvest surveys. Given the dynamic nature of the Hood River, particularly with regard to stream discharge fluctuations occurring during the spring months, current monitoring protocols are routinely challenged just to maintain status quo. Realistically, additional resources need to be devoted to Hood River Production Program monitoring in order to effectively assess program objectives. Given the monetary investment by BPA in PIT-tag infrastructure and tagging efforts within the Hood River subbasin and the Columbia River hydrosystem in general all reasonable opportunities to interrogate or recover tags—especially at the adult life stage—should be implemented. Additionally, while the CJS apparent survival model may provide an adequate method to estimate in-basin pre-spawn mortality/harvest, without angler harvest surveys no mechanism exists to support or refute the findings. Comparisons made during past sampling years proved somewhat inconsistent. With a monitoring framework that is already subject to high CV values associated with adult abundance estimation, relying on the CJS model to ultimately determine pHOS may introduce an additional layer of uncertainty.

The culling of undersized hatchery fish has seemed to alleviate some of the risk that those fish won't make an immediate migration downstream. The capture rate of hatchery residuals during the fall trapping period and the subsequent spring trapping period has been reduced. Based on the negative correlation between the number of undersized hatchery winter steelhead released and the subsequent year's wild smolt production, we may expect to see an increase in 2020.

Given the downward trend of ocean conditions during 2015 – 2017, real-time monitoring of wild winter steelhead and hatchery spring Chinook will likely be needed to ensure broodstock collection targets are met. Development of models capable of providing fishery managers the information essential to make decisions relies heavily on past escapement model output accuracy and precision. Additional emphasis should be placed on juvenile tagging rates of wild steelhead, interrogation efficiency at PIT tag interrogation sites (i.e. HRM), and recapture frequency of returning PIT-tagged adult salmonids in order to create useful real-time run models.

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APPENDIX A.1: DETAILED METHODS

Juveniles

Smolt Trapping

Juvenile and downstream migrant salmonids were caught using a rotary screw trap (RST) at the following locations (Figure 1):

- Hood River mainstem, 2 traps (1.5m diameter cones)
- West Fork Hood River 2 traps (1.5m diameter cones)
- Middle Fork Hood River (1.5m diameter cone)
- East Fork Hood River (1.5m diameter cone)

During the 2019 trapping season, all RST sites were checked daily from April 1 – June 30, and on weekdays (traps not fished on the weekend) during September 4 – October 19. Periods where the traps were not fished due to high flows, hatchery releases, or trap maintenance are noted in Figure A-1. RST's were fished at sites as low in the system as possible where flows were optimal for capture (i.e. swift current near the head of the pool fished) and where cross-sectional area fished was maximized. As streamflow varied, RST's were occasionally repositioned in the stream channel to increase trapping potential. Estimates of the number of downstream migrant rainbow-steelhead (rb-st) were not adjusted for production below the migrant trap. Prior to 2011 estimates did not include numbers of downstream migrant rb-st originating from Neal Creek, a major tributary that drains into a side channel of the mainstem river at RM 4.6 and eventually reconnects to the mainstem below the RST site. Beginning in 2011, the mainstem RST was relocated downstream of Neal Creek.

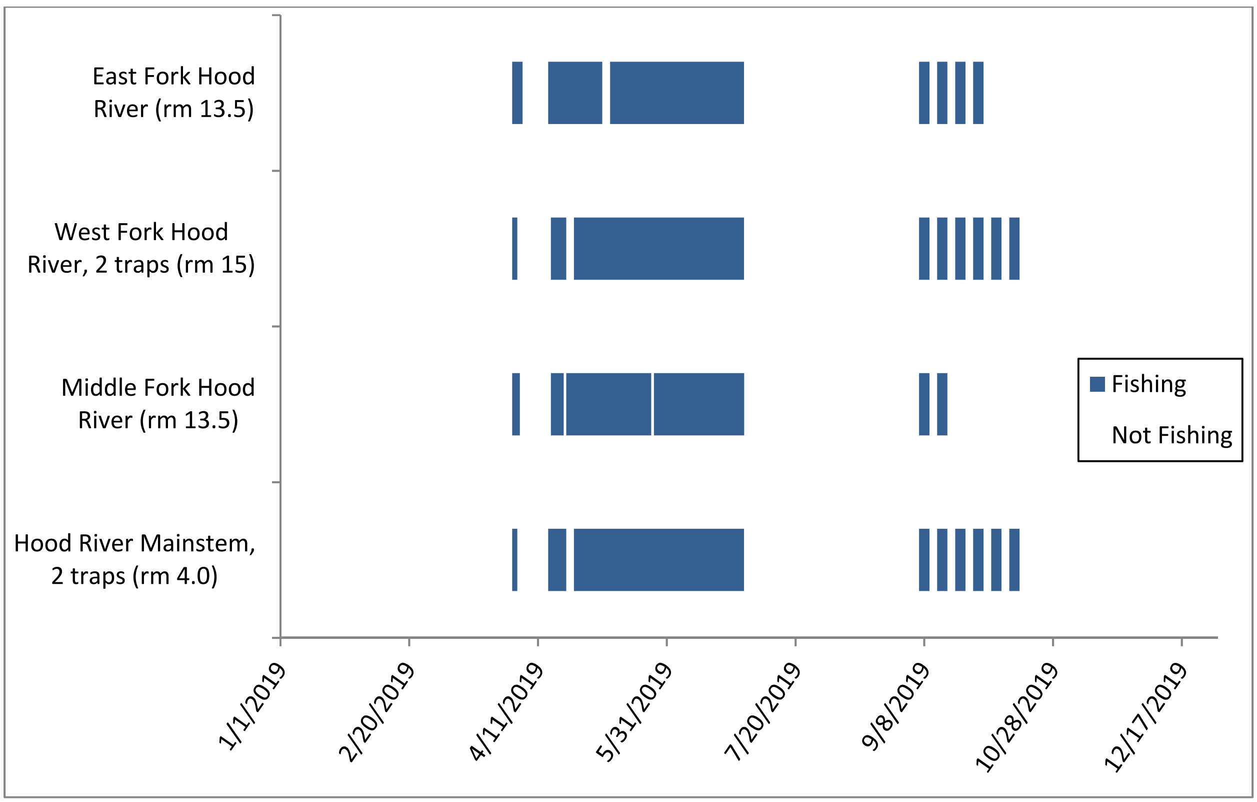


Figure A-1. Days sampled (BPA Project #1988-053-08) at rotary screw traps within the Hood River subbasin, January 1, 2019 – December 31, 2019.

Each RST was sampled on a daily basis and was generally conducted in the morning to minimize temperature related stress. All wild salmonids were transferred from the RST live box to aerated holding buckets or net pens where they were held at ambient water temperatures. A portion of the total catch (generally <10 individuals) was transferred to an anesthetic bath (MS-222, or Tricaine Methanesulfonate) and examined for fin and maxillary mark combinations. All fish were scanned for a Passive Integrated Transponder (PIT) tag, weighed to the nearest 0.1g, and measured (fork length (FL)) to the nearest millimeter. Any previously tagged recaptures were released downstream of the RST site. For rb-st and cutthroat trout, if no PIT tag was present and FL ≥ 100mm, a 12.5mm pre-loaded PIT tag (Biomark HPT12 (134.2 kHz ISO FDXB)) was inserted into the abdominal cavity of the fish. Individuals where FL < 100mm generally did not receive a PIT tag but were weighed, measured, identified to species when feasible, then released downstream of the RST site. All juvenile Chinook and coho where FL ≥ 80mm were PIT tagged. Scale and tissue (1mm x 1mm) samples were collected from all first-time captures of wild salmonids ≥ 80mm. Scale samples collected from juvenile steelhead were placed directly on gum cards in the field, and fin clips were placed on Whatman paper and stored for future analysis. All other scale samples collected from juvenile salmonids were placed in scale envelopes and later mounted on glass slides, or dry-stored along with tissue samples in scale envelopes. The procedure was repeated until all fish in holding buckets and/or net pens had been processed. All newly PIT tagged fish were released upstream of the RST site. PIT tagged salmonids were recorded electronically in the field using P4 software (https://www.ptagis.org/software/p4) and the information subsequently uploaded to the PIT Tag Information Systems (PTAGIS) database (maintained by the Pacific States Marine Fisheries Commission). Data collected from non-PIT tagged fish was recorded electronically into the HRRP program database. A subsample of downstream migrant hatchery winter steelhead that were not previously PIT tagged prior to release from the acclimation area were PIT tagged (up to 30 per day; any additional hatchery captures were released below the trap site).

The PIT tagging protocol was implemented by the HRRP during fall of 2004. For marking techniques used prior to fall 2004 please refer to the FY 2010 Hood River Research Program Annual Report (Reagan 2011).

Scale Processing and Analysis

All scales mounted on gum cards were pressed and sent to the ODFW Corvallis Research Laboratory where ODFW staff analyzed the scale samples and determined freshwater age and origin using methods described by Borgerson (1992). Data associated with scale reads were stored in the HRPP Program database, however generally gum cards and scale presses are stored at the ODFW Corvallis Research Lab.

Data Analysis

The mean length, weight and condition factor were reported for all wild downstream migrant rb-st sampled prior to July 1 for each RST site. Condition factor (CF) was estimated by (Piper et al. 1975):

$$CF = 100*weight(g)/length(cm)^3$$

The temporal distribution of wild rb-st captures at the mainstem Hood River trap during 2019 was summarized based on semimonthly periods from April 1 – June 30. The end date of the sampling period was defined based on the assumption that the steelhead smolt migration is virtually complete by June 30 (Reagan 2011).

Mark-Recapture Analysis

A pooled Petersen estimate with Chapman's modification (Ricker 1975) was utilized to estimate numbers of downstream migrants, by species and size category, of wild, natural, and hatchery produced anadromous salmonid smolts migrating past each RST site:

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)}$$

where:

$\hat{N}$	=	estimated number of downstream migrants passing the rotary-screw trap
M	=	number of migrants marked and released at the East Fork, Middle Fork, and West Fork rotary screw traps
C	=	total number of unmarked and marked migrants captured at the mainstem rotary screw trap
R	=	number of marked migrants recaptured at the mainstem rotary screw trap

Approximate 95% confidence intervals (C.I.) were calculated as follows (Seber 1973, cited by Lindsay et al. 1986; Ott 1977):

$$95\%\ C.I. = \hat{N} \pm 1.96\sqrt{\operatorname{var}(\hat{N})}$$

and

$$\operatorname{var}(\hat{N}) = [(M+1)(C+1)(M-R)(C-R)] / [(R+1)^2 (R+2)]$$

where:

$\operatorname{var}(\hat{N})$ = variance of estimated migrant abundance

Following initial capture and sampling, tagged fish were released upstream of the migrant trap as part of the mark release group (*M*), where subsequent PIT tag interrogations were used to classify them as recaptures (*R*) when collected with sampling group (*C*).

An estimate of total downstream migrant rb-st at the mainstem RST site was generated using the pooled Petersen methodology. Rb-st were used to indirectly estimate steelhead smolt migration timing because no accurate methodology exists to visually identify rainbow trout from downstream migrant steelhead smolts (Zimmerman and Reeves 2002). Semimonthly counts were not adjusted for seasonal

variation in trap efficiency because recapture rates were typically too low to accurately estimate trap efficiency for all unique time periods where smolts were migrating through the Hood River subbasin.

Traditionally, subbasin smolt production estimates used to calculate SAR rates for wild steelhead were generated by applying a pre-defined size break to the statistical estimate of out-migrant rb-st where FL < 165mm were assumed to be rainbow trout or pre-smolt steelhead, and migrants ≥ 165mm FL were assumed to be out-migrant steelhead smolts. Based on recent analyses it was determined that the minimum smolt size be lowered to 141mm FL (https://www.monitoringmethods.org/Method/Details/5367). However because of past data recording limitations, smolt abundance estimates reported for all data years are based on size criteria of FL ≥ 150mm. Past data records indicate a relatively limited presence of individuals where FL is greater than 141mm but less than 150mm.

A Cormack Jolly-Seber (CJS) open population model was constructed using Program MARK (White and Burnham 1999) based on PIT tag mark-recapture histories where a minimum size criteria of FL ≥ 150mm was used to estimate apparent survival of downstream migrant rb-st (Figure A-2). Data was retrieved from the PTAGIS database from the following sites:

Recaptures

- Within basin RST locations

Interrogations

- HRM—Hood River Mouth PIT Tag Antenna
- B2J/BCC—Downstream migrant interrogation facilities at Bonneville Dam
- TWX—Estuary trawl survey
- BON—Upstream migrant interrogation facilities at Bonneville Dam

Recoveries

- ESANIS—East Sand Island avian colony (or similar)

Individual covariates used in the model evaluation process included FL (mm) at tagging and mainstem Hood River flow (cfs) on the day of tagging and release. Capture histories for each individual were comprised of five sampling occasions, where p_i = sampling occasion *i*, and ϕ_j = survival from interval $p_i \longrightarrow p_{i+1}$:

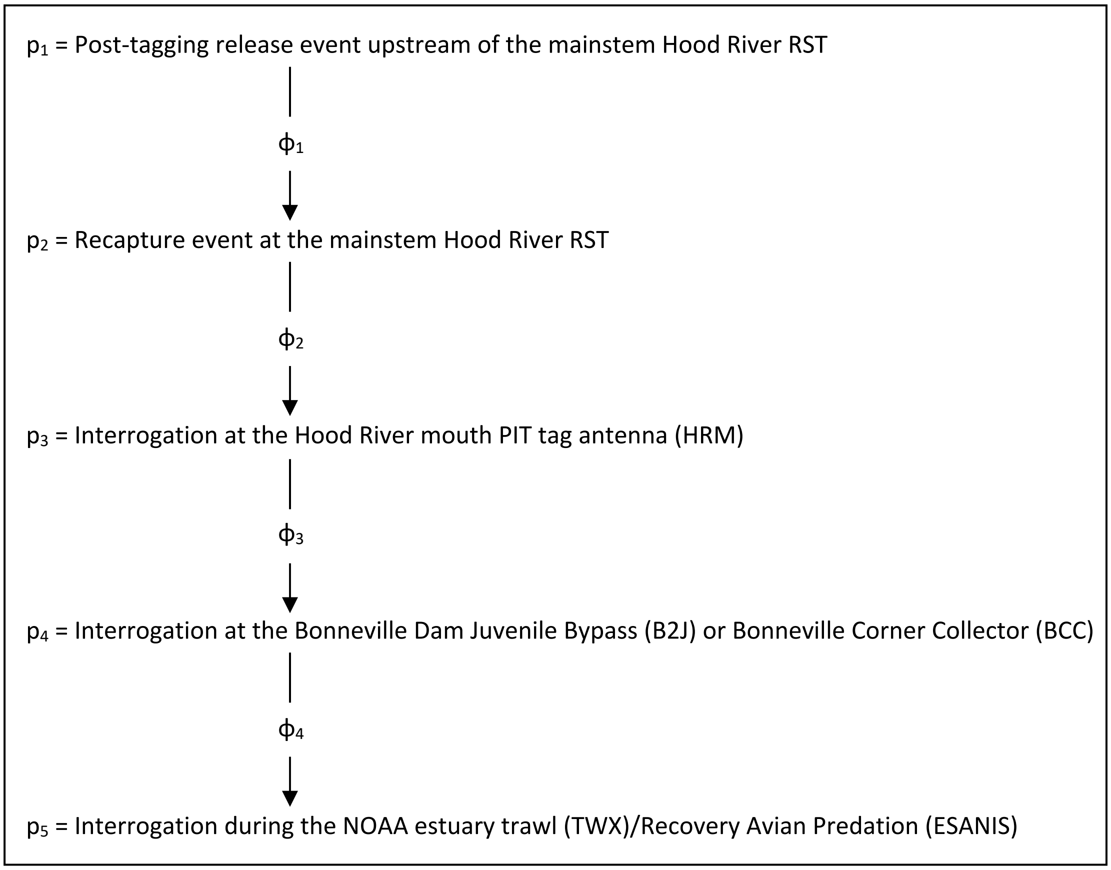


Figure A-2. Cormack-Jolly Seber open population model parameters apparent survival (ϕ) and recapture probability (p) for wild rb-st (≥ 150mm FL).

Although CJS open models are based on live capture-recapture histories and do not utilize tag recovery (mortality) data, survival for the final interval (ϕ_4) is not estimated by the CJS model. Therefore, since any marked fish detected on the East Sand Island colonies were assumed to be alive upon reaching Bonneville Dam, tag recovery data was incorporated to estimate survival parameter ϕ_3 (Evans et al. 2012, Lebreton et al. 1992). Only time-varying models were selected for evaluation since capture histories were founded on occasions that vary spatially as well as temporally. Subsets of the time varying model using both individual covariates were evaluated for model selection purposes, although models with a likelihood of <0.01 and models with confounded parameters were discarded. Based on corrected Akaike's Information Criterion (AICc) the simplest, best-fitting model was selected. The GIBBSIT sample size calculation was then applied (chains = 3) to determine the minimum number of samples required using the Markov Chain Monte Carlo (MCMC) estimation method, and then the MCMC estimation was repeated using the minimum number of required samples indicated by the GIBBSIT procedure.

Migration Timing

Migration timing was evaluated for PIT tagged rb-st, cutthroat trout (*Oncorhynchus clarkii*), and Chinook salmon using recaptures, interrogations, and tag recoveries as reported by the regional PTAGIS

database. The average, minimum and maximum migration time (days) between the tagging event and the subsequent recapture or interrogation was calculated. The average values for each respective species are presented for all years where PIT tag data is available along with data specific to salmonids tagged during the current year. Juvenile Chinook salmon from a respective brood year class were divided into three temporal strata based on tagging period. “Summer” fish were considered those tagged between June 30 and August 31, “Fall” were considered those tagged between September 1 and the end of the trapping season (typically mid-October), and “Spring” were considered those tagged (age 1+) between the start of the sampling season (i.e. April) and June 30.

Residualism of Hatchery Winter Steelhead Smolts

To identify potential residuals that exhibit a freshwater age-2 life history, (individuals failing to immediately migrate to the ocean following release), the co-managers examined recapture and interrogation records of hatchery winter steelhead that were previously PIT tagged within the parameters of current data collection protocols, and then calculated the number of days that elapsed between the initial release date and one or more of the following:

1. Subsequent PIT tag interrogations at rotary screw trap sites within the Hood River subbasin.
2. PIT tag detections recorded at the Bonneville Dam juvenile bypass or the Bonneville Dam Corner Collector.
3. PIT tag detections recorded by the NOAA estuary trawl survey.

Based on the number of days elapsed between release and subsequent interrogation, temporal differences between true outmigrants and potential residuals were discerned, where the majority of residuals (94%) were detected in the spring of the year following (*y+1*) the year of release (*y*). Any individual that was interrogated at a location other than a rotary screw trap was queried to ensure that a detection for the Bonneville Dam adult ladder had not been recorded previously, which might indicate that particular fish was a repeat spawner as opposed to a true residual. For outmigration years 2005 – 2015, the number of hatchery winter steelhead residuals exhibiting a freshwater age-2 life history was estimated as:

$$N_y = \frac{\sum_{y_i}^{n}(d_{ky+1}) * \left[\frac{1}{(p_{ky+1})}\right]}{M_y}$$

where:

N_y = Total number of residuals originating from release year y

D_{ky} = Recaptures/interrogations of hatchery winter steelhead during release year y

P_{ky} = Probability of detection at site k during release year y

M_y = Proportion of hatchery release group year y that was PIT tagged

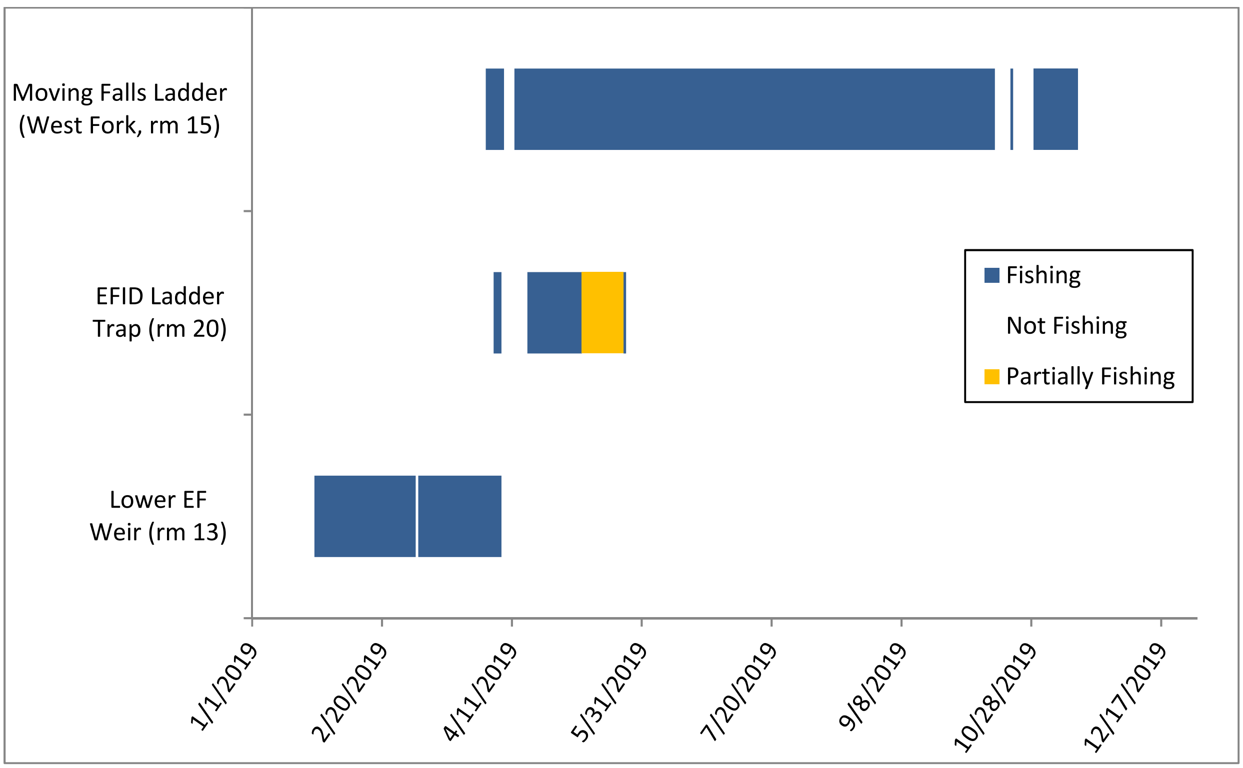
ADULTS

Weir Trapping

Adult sampling facilities managed by ODFW mid-Columbia District staff (BPA Project #1988-053-08) included (Figure 1):

- East Fork Hood River resistance board weir (EFW, RM 13)—channel-spanning resistance board weir with a large passive swim-in trap box (10’x6’x8’). The entrance is an adjustable finger weir where the height can be altered to coincide with the concurrent flow rate. The resistance panels collectively span 40’ of the channel along with 50’ of fixed panels.
- Moving Falls Fish Facility (MFFF, RM 15)—adult fish ladder with a swim-through fyke trap on the upstream end that empties into a large holding cell (20’x18’x16’). When not trapping the trap is closed and fish are allowed to pass through the ladder unimpeded.
- East Fork Irrigation ladder trap (EFID, RM 20)—adult fish ladder with a trap installed within one of the mid-ladder cells. The upstream end of the cell is blocked with a fixed aluminum pipe gate while the downstream end is blocked with plywood. A finger weir attached to the cell dam boards forces upstream migratory fish to jump into the cell and enter the trap box equipped with a fyke/crab-trap-style entrance.

Weirs were operated intermittently throughout the sampling period depending on site and environmental conditions (Figure A-3).



(Figure A-3). Days sampled (BPA Project #1988-053-08) at adult collection sites within the Hood River subbasin, January 1, 2019 – December 31, 2019.

Trap boxes were checked daily in the morning hours to minimize the potential handling stress associated with increasing daily water temperatures. Once removed from the trap box, each fish was temporarily immobilized using CO_2 or electroanesthesia. Jack and adult salmonids were scanned for a PIT tag, identified to species and run type, classified by sex, measured and examined for fin marks and injuries. Injury categories included predator scars (i.e. sea lions), net marks, hook scars, scrapes, fungus, and open wounds.

Summer and winter races of adult steelhead were classified as wild, subbasin hatchery, or stray hatchery adult. Classification was based on 1) fin and maxillary clip combination (mark combination) and 2) scale analysis. Scale analysis was used to determine if an unmarked adult was either a wild or hatchery produced fish. Unmarked wild adult summer and winter steelhead were assumed to be the progeny of wild production in the Hood River subbasin. Unmarked hatchery adult summer and winter steelhead were assumed to be the mismarked progeny of hatchery production releases in the Hood River subbasin. The number of unmarked hatchery adult summer and winter steelhead sampled in the Hood River is typically low (based on 100% marking rate of hatchery steelhead and minimal observations of marking error during pre-release sampling). Initial assignment of run timing was applied based on morphological and conditional characteristics. Summer and winter races of steelhead were primarily distinguished based on capture location, external hatchery marks and phenotypic characteristics. Examples include fin and maxillary mark combinations, external coloration, degree of scale tightness and scale erosion (i.e. summers have tighter more deteriorated scales), state of sexual maturity relative to the time of year (i.e. the abdominal area of winter females should appear to be full with mature eggs), external parasite load (more salt water parasites on winter steelhead, potentially more freshwater copepods on summers), color of gill filaments (lighter gill color associated with summers), and general appearance (summers tend to be more long and slender). Both runs may coexist within the subbasin and although generalizations of run type are made based on geography, temporal and spatial overlap does occur. Given the timing of weir/trap deployment, nearly all Chinook captured by the weirs were considered spring run, however some summer/fall Chinook were also captured.

All jack and adult salmonids were measured to the nearest 0.5 cm FL, and scale and genetic samples (anal fin clip) were collected. Each individual was scanned for a PIT tag and if no tag was present, a PIT tag was inserted in dorsal sinus region for all fish that were passed upstream of the collection site. A proportion of captured wild and hatchery winter steelhead and natural production and hatchery spring Chinook salmon were collected for broodstock purposes, and all fish collected received a PIT tag prior to being transferred to Parkdale Hatchery. All hatchery steelhead not collected for broodstock, regardless of stock (i.e. Hood River or out-of-basin stray based on fin and maxillary mark combinations), were removed and either euthanized or transferred to an alternative site (i.e. reservoir or lake). Any unmarked steelhead collected for hatchery broodstock that were not spawned were released upstream of the original collection site. Adult coho salmon were also sampled following the aforementioned protocol. All PIT tagged salmonids were recorded in the field using P4 (PTAGIS) and the information subsequently uploaded to the PIT Tag Information Systems (PTAGIS) database. Data collected from non-PIT tagged fish was recorded into the HRRP program database.

Disposition of jack and adult salmonids was recorded for each species and race based on both the stock of origin and fin and maxillary mark combination. Unmarked adult steelhead were assumed to be of wild origin and were passed above the weirs except when they were 1) collected for hatchery

broodstock or 2) have a highly deformed dorsal fin. Any adult steelhead with a highly deformed dorsal fin was treated as a hatchery origin fish and was removed. From 1992 – 2010, wild steelhead collected for hatchery broodstock were released back into the mainstem of the Hood River after they were spawned, or when they are no longer needed for hatchery broodstock. Traditionally, males collected for hatchery broodstock were released in the Powerdale Dam forebay, and females collected for hatchery broodstock were transferred to the Powerdale Dam trap where they were passed above Powerdale Dam if 1) they were not used for hatchery broodstock, 2) retained more than 10-20% of their eggs subsequent to spawning, or 3) were only partially spawned. Adults collected for broodstock post-2010 were spawned and released near the mouth of the Hood River or retained for a kelt reconditioning study being conducted by CTWSRO (Hatch et al. 2011).

Refinement of Stock, Run Type, Origin and Brood Year Selection—Steelhead

Marked adult summer and winter steelhead were classified as progeny of Hood River stock production releases if the identifying mark combination was valid for the corresponding brood year of release. Marked adult summer and winter steelhead were typically classified as subbasin hatchery production if the mark combination was valid for a Hood River stock production release, but invalid for the corresponding brood year of release. This was based on the assumption that the mark combination was probably recorded incorrectly, or the mark combination was incorrect for the respective release year. However, on rare occasions, these adults may have been classified as strays. In all cases, the brood year of release was determined based on both scale analysis and the adult race designation. Marked adult summer and winter steelhead were assumed to be progeny of a Hood River stock production release if the age of the adult could not be determined, but the identifying mark combination was valid for a Hood River production release. This occurred in the very rare circumstance when either no scales were collected from an adult or all the scales collected from an adult were regenerated.

During adult sampling at Powerdale Dam (1992 – 2010), marked adult summer and winter steelhead were classified as stray adults if they bore a mark combination that did not correspond to a combination released in the Hood River subbasin, with two exceptions:

1. Hatchery adult summer steelhead with a single maxillary clip, or a single maxillary clip in combination with an adipose clip, were typically (but not always) assumed to be a Hood River stock hatchery summer steelhead adult, even if the mark combination was invalid for the brood release as determined from the scale read (this exception was applied to hatchery adults that aged back to the 1998 – 2006 broods because of the high mismark rate observed on juveniles sampled at OSH, the potential for miscoding of marked adults at the Powerdale Dam collection facility, and the fact that very few identifiable hatchery summer steelhead strays (i.e., based on coded wire tagged adults or known invalid marks) are observed at the Powerdale Dam collection facility).
2. Hatchery winter steelhead with an adipose or single ventral fin clip combination were typically (but not always) assumed to be a Hood River stock hatchery winter steelhead adult, even if the mark combination was invalid for the brood release as determined from the scale read. Again, this exception was applied to hatchery adults that aged back to the

1992 – 2006 broods because of the high mismark rate observed on juveniles sampled at OSH, the potential for miscoding of marked adults at the Powerdale Dam collection facility, and the fact that very few identifiable hatchery winter steelhead strays (i.e., based on coded wire tagged adults or known invalid marks) are observed at the Powerdale Dam collection facility. The same protocol was applied to individuals collected during the post-Powerdale Dam removal run years (2011 – present), however since recent winter steelhead hatchery release groups were marked with maxillary clips, those respective clip combinations were evaluated for hatchery winter steelhead.

During all years of adult collection, scale analysis identified a number of unmarked steelhead as hatchery fish and marked steelhead as wild fish (i.e., origin unknown). The latter group includes marked wild and natural strays and Hood River stock wild steelhead which either had deformed fins or had the fins removed by sport anglers. Fin removal, by anglers, has been observed in the Hood River subbasin (unpublished data on 04/07/2008 from ODFW Mid-Columbia District, The Dalles, Oregon). The former group includes steelhead that were either misclassified as hatchery fish or were unmarked hatchery fish. Unmarked hatchery steelhead are believed to primarily be progeny of subbasin hatchery production releases because of problems associated with poor marking of both hatchery summer and winter steelhead smolts. Numbers of adult steelhead in either of the two above groups was typically low.

Unmarked "hatchery" adults and marked "wild" adults were summarized as subbasin hatchery or wild adults, respectively, for purposes of estimating preliminary escapement. Unmarked and marked (i.e., with a subbasin mark combination) steelhead of unknown origin were allocated to wild and subbasin hatchery components of the run based on the marked wild:unmarked hatchery ratios in the corresponding scale verified population. Un-aged steelhead were allocated into specific age categories using the age structure estimated for the corresponding component of the run to which they were assigned with one exception—marked steelhead with a regenerated scale pattern were assumed to be a subbasin hatchery produced adult with a freshwater age-1 life history pattern if 1) the mark combination was valid for a hatchery production release in the Hood River subbasin, 2) the salt water life history pattern could be determined from the scale sample, and 3) the mark combination was valid for the estimated brood year of release (http://www.fpc.org).

Migration timing, sex ratio, and age structure was estimated from only those adult steelhead in which scale analysis classified the origin of an unmarked adult as wild and a marked adult as hatchery. Freshwater/ocean age category and mark combination was then used to classify a marked adult steelhead as either a subbasin or stray hatchery produced steelhead. The above protocol was designed to minimize the potential for biasing stock and race specific estimates for populations of wild and hatchery adult steelhead in the Hood River subbasin.

Refinement of Stock, Run Type, Origin and Brood Year Selection—Chinook

Jack and adult spring Chinook salmon were classified as either a natural, subbasin hatchery, or stray hatchery produced fish based on 1) the mark combination and 2) scale analysis. Scale analysis was used to determine if an unmarked spring Chinook salmon was either a natural or hatchery produced

fish. Unmarked naturally produced spring Chinook salmon were assumed to be the progeny of natural production in the Hood River subbasin. Unmarked hatchery spring Chinook salmon were assumed to be the mismarked progeny of subbasin hatchery production releases in the Hood River subbasin. The number of unmarked hatchery spring Chinook salmon sampled in the Hood River subbasin is typically low because 100% of the hatchery production group is marked prior to release (the exception being that subbasin production groups were released either entirely, or partially, unmarked prior to the 1994 brood release (http://www.fpc.org), the progeny of which returned in the 1992 – 1998 run years).

Marked jack and adult spring Chinook salmon were classified as progeny of a Carson or Deschutes stock production release if the identifying mark combination was valid for the corresponding brood year of release. Marked jack and adult spring Chinook salmon were classified as stray fish if the mark combination was valid for a Carson or Deschutes stock production release, but invalid for the corresponding brood year of release. In both cases, the brood year of release was determined from scale analysis. Marked jack and adult spring Chinook salmon were assumed to be the progeny of a Carson or Deschutes stock production release if the age of the adult could not be determined, but the identifying mark combination was valid for one of these two stocks of release. This occurred in the very rare circumstance when 1) no scales were collected from an adult or 2) all the scales in the scale sample were regenerated. Marked jack and adult spring Chinook salmon were classified as a stray fish if they bore a mark combination that did not correspond to a combination released in the Hood River subbasin. Migration timing, sex ratio, age structure, and escapements were estimated using the same methods described for summer and winter steelhead.

Scale Processing and Analysis

Scales were collected from the key scale area, which is located above the lateral line behind the posterior end of the dorsal fin, from virtually all jack and adult salmonids sampled. Scales were collected from at least one side of the fish and placed into uniquely numbered scale envelopes. Scale samples were later mounted on gummed cards and subsequent acetate impressions were taken and sent to ODFW's research laboratory in Corvallis, Oregon. ODFW staff viewed the scale impressions under a microfiche to determine both the origin (wild or hatchery) and freshwater/ocean age category of each jack and adult salmonid in the scale sample.

Adult Abundance Estimation

Abundance was estimated using a combination of mark-recapture and open survival models. All mark-recapture models refer to "adult weir facilities" as the second capture event. The described methodology may be used to assess returns of wild and hatchery winter steelhead, wild summer steelhead, natural production spring Chinook, and hatchery spring Chinook salmon given a sufficient number of PIT-tag interrogations at Bonneville Dam and adult weir facilities.

Adult Escapement to Bonneville Dam

The primary model type used to establish adult returns to Bonneville Dam was the Lincoln-Petersen (with Chapman's modification) mark-recapture model:

$$\hat{N} = \frac{(M+1)(C+1)}{(R+1)}$$

where

$\hat{N}$	=	estimated number of adults of species *x*, run type *y*, and origin *z* returning to Bonneville Dam
M	=	previously PIT tagged species *x*, run type *y*, and origin *z* detected at the adult Bonneville Dam interrogation facilities as upstream migrants
C	=	the total marked and unmarked species *x*, run type *y*, and origin *z* captured at the adult weir facilities within the Hood River basin
R	=	the total number of recaptures within the second capture group (*C*)

Variance of the estimate was calculated by:

$$var(\hat{N}) = [(M+1)(C+1)(M-R)(C-R)] / [(R+1)^2 (R+2)]$$

To accurately determine model parameter *M* for wild steelhead it was necessary to determine which steelhead with an unknown run type were likely to be winter-run or summer-run. Wild steelhead with an existing PIT tag that were detected at Bonneville Dam were classified as either winter, summer, or unknown run type during their initial mark/release event during the juvenile/smolt life stage. Native populations of both summer- and winter-run types occur with some degree of presumed spatial separation (i.e. winter steelhead occupy the East and Middle Fork Hood River whereas summer steelhead reside in the West Fork). Although geographic location of collection is used to assign run type during juvenile trapping events, the vast majority of steelhead smolts sampled each year are collected from the lower mainstem Hood River where geographic considerations are nullified and thus all steelhead are assigned an unknown run type. Adult steelhead with an unknown run type that are detected at Bonneville Dam are retrospectively classified as summer or winter-run if they are contacted at a Hood River adult collection weir, where run type is determined at the adult life stage. Steelhead of unknown run type that are detected at Bonneville Dam but are not recaptured at an adult collection weir are assigned to winter or summer-run based on a mixture probability model that was developed using a combination of BON interrogations and data records of adult steelhead captured at Powerdale Dam. Using PIT tag detections of adults at Bonneville Dam upstream migrant interrogation facilities, proportions of the total run for each run type were determined for semimonthly periods. To supplement available PIT tag interrogation data, adult data from Powerdale Dam was also incorporated into the model at time *t-1*, and the two relative run proportions for each temporal period were averaged (Figure A-4). The period *t-1* was selected for averaging purposes to account for the migration days required to move from Bonneville Dam to Powerdale Dam, ultimately providing a more accurate depiction of an actual return to Bonneville Dam. Using the resulting proportionate values, a run type likelihood value was assigned for each semimonthly period and assigned to any adult steelhead detected at Bonneville Dam but not detected at an adult collection weir.

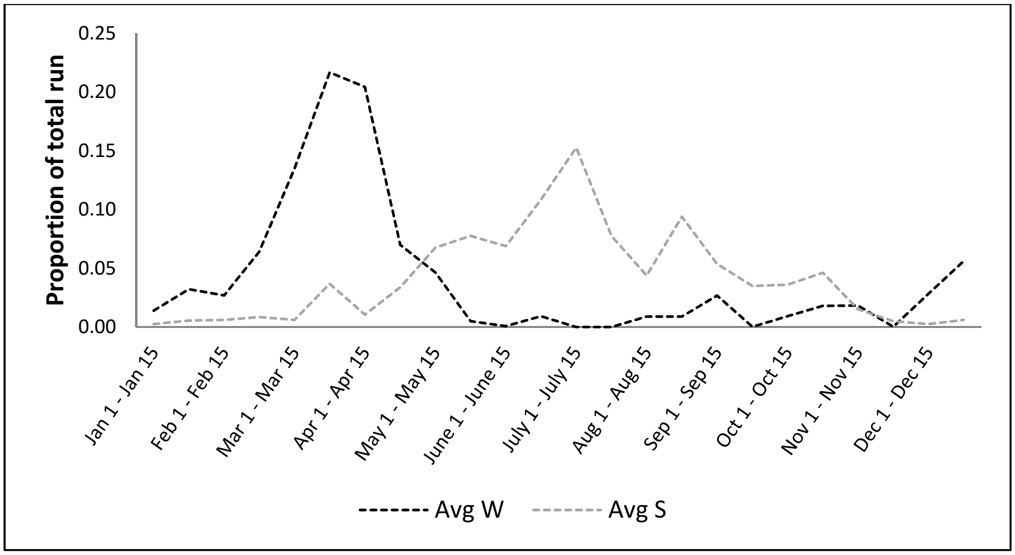


Figure A-4. Hood River wild adult summer (S) and winter (W) steelhead average run timing to Bonneville Dam.

PIT tag interrogation data is also evaluated to determine the number of attempts an upstream migrant makes to ascend the dam, as well as the time elapsed between entering and exiting the fish ladder system. Steelhead exhibiting a PIT tag detection history where multiple attempts were made to ascend the Bonneville Dam fish ladders, or a ladder entry and downstream exit pattern was evident, are classified as "fallbacks." PIT tag interrogation data may also be used to determine the number of "overshoots," or in the case of Hood River adults, any upstream migrant that migrates past The Dalles Dam.

Adult Escapement to the Mouth of the Hood River

Estimations of adult escapement to the mouth of the Hood River were calculated using the aforementioned mark-recapture model to calculate total adult returns to Bonneville Dam, and then reducing that estimate by apparent survival parameter (ϕ_1), which was modeled with a CJS open population model (Figure A-5) using Program MARK (White and Burnham 1999).

The fundamental mark-recapture model that provides a closed population estimate to Bonneville Dam clearly violates the assumptions of closure, as deaths and straying are known to occur between Bonneville Dam and the Hood River adult collection weirs. To account for loss within the mainstem Columbia River (i.e. due to Zone 6 fisheries, potential strays that did not enter the Hood River, potential fallbacks, etc.), the apparent survival value ϕ_1 was applied to the model estimate. The result was reported as the actual number of adults escaping to Hood River weir collection facilities. Variance was calculated using the approximation method to calculate the variance of two products (Goodman 1960):

$$Var(xy) = (x^2 * Var(y)) + (y^2 * Var(x)) - (Var(x) * Var(y))$$

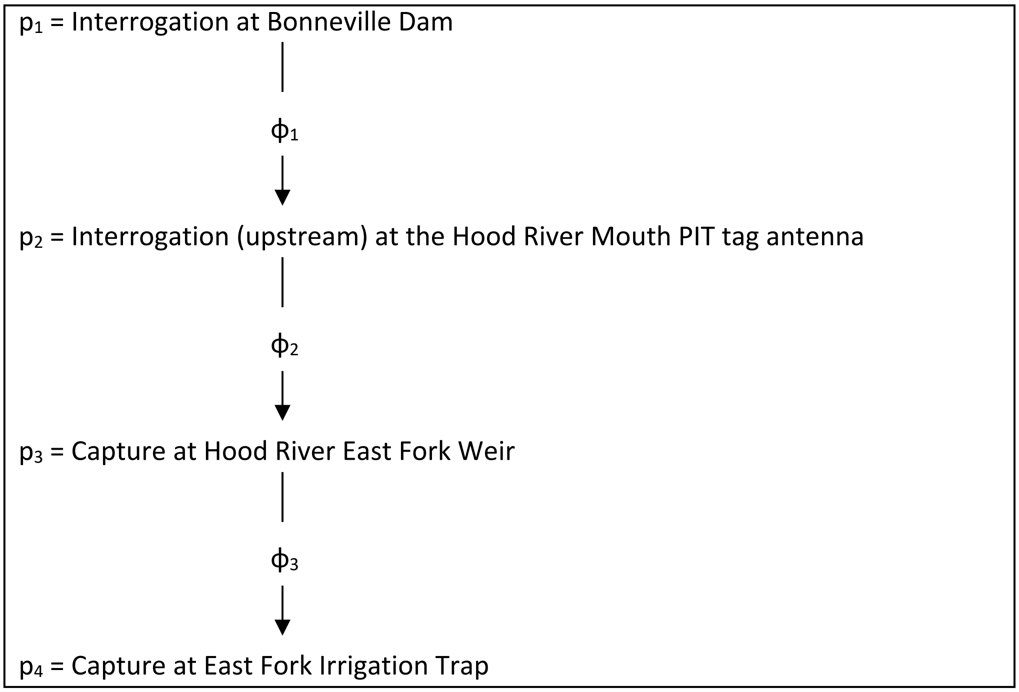


Figure A-5. Cormack-Jolly Seber open population model parameters apparent survival (ϕ) and recapture probability (p) for adult wild and hatchery winter steelhead and hatchery spring Chinook.

Upstream movements were defined by directionality associated with detections at multiple individual antennas at the HRM, or time elapsed between the first HRM detection and the next interrogation at HRM or the Bonneville Dam Corner Collector. If elapsed time between the two detections was greater than 21 days, then it was assumed that the fish migrated into the basin and spawned without being intercepted at the Hood River adult collection weirs unless other PIT tag interrogations or recaptures indicated otherwise. Apparent survival of wild winter and summer steelhead and hatchery spring Chinook were calculated using the same model described in Figure 6 minus the capture-recapture occasion at the East Fork Irrigation trap (p4).

Adult Escapement to Adult Collection Weirs and Weir Efficiency

Escapement to the adult collection weirs was estimated by applying the survival estimate calculated by the CJS model to estimate escapement to the mouth of the Hood River, and then subtracting non-tribal harvest estimates (hatchery origin) or an assumed pre-spawn mortality of 10% (wild origin steelhead) (HDR|FishPro 2008). The remaining number of adults constituted the number of available spawners and was used to calculate pHOS (proportion of hatchery origin spawners) for winter steelhead after subtracting any fish collected for hatchery broodstock. Weir efficiency was estimated by CJS model detection probability parameter p3.

<u>Non-tribal Harvest Estimates</u>

Data Collection Methods

Creel surveys were conducted from April 15, 2019 – June 30, 2019 on the Hood River to estimate the non-tribal harvest of spring Chinook salmon. Harvest estimates have traditionally been reported for the calendar year, however since the suspension of the summer steelhead hatchery program, surveys typically conducted during the summer months (July – November) were eliminated from the creel survey design.

Additional sections of the Hood River were made available to public anglers following the removal of Powerdale Dam. Angler creel surveys were consequently redesigned from previous years—where non-tribal angling was restricted from the mouth to river mile 4.5—to reflect the change in available angling area. The survey area extended from the mouth of the Hood River to the upstream angling boundary as described in the ODFW Oregon Sport Fishing Regulations. Non-tribal angling was allowed in the mainstem Hood River from the mouth to the confluence of the West Fork, and in the West Fork upstream to 200 feet below Punchbowl Falls. The survey area was divided into four geographic sections (Figure A-6).

Within authorized angling areas, year-round angling in the 2019 calendar year was allowed for the harvest of adipose fin clipped coho salmon and steelhead. Adipose fin clipped Chinook salmon could be harvested from April 15 – June 30 under adopted emergency rule. The daily bag limit in the Hood River subbasin was restricted to a combined catch of two adult coho salmon or steelhead, with the exception that one additional adipose fin clipped adult steelhead could be retained per day for a total aggregate of three adult fish. The daily bag limit for Chinook salmon was one adipose fin clipped adult. There was no annual bag limit on adipose fin clipped steelhead or salmon as long as anglers had the appropriate number of state issued harvest cards. The daily bag limit for jack salmon was five Chinook salmon and five coho salmon and there was no annual bag limit. Trout season was open in the mainstem of the Hood River and in the East and Middle forks of the Hood River from May 22 – October 31 for catch and release only. Trout angling was restricted to artificial flies and lures in all tributaries upstream of the mainstem confluence with the West Fork. The West Fork of the Hood River and its tributaries were closed to all trout angling.

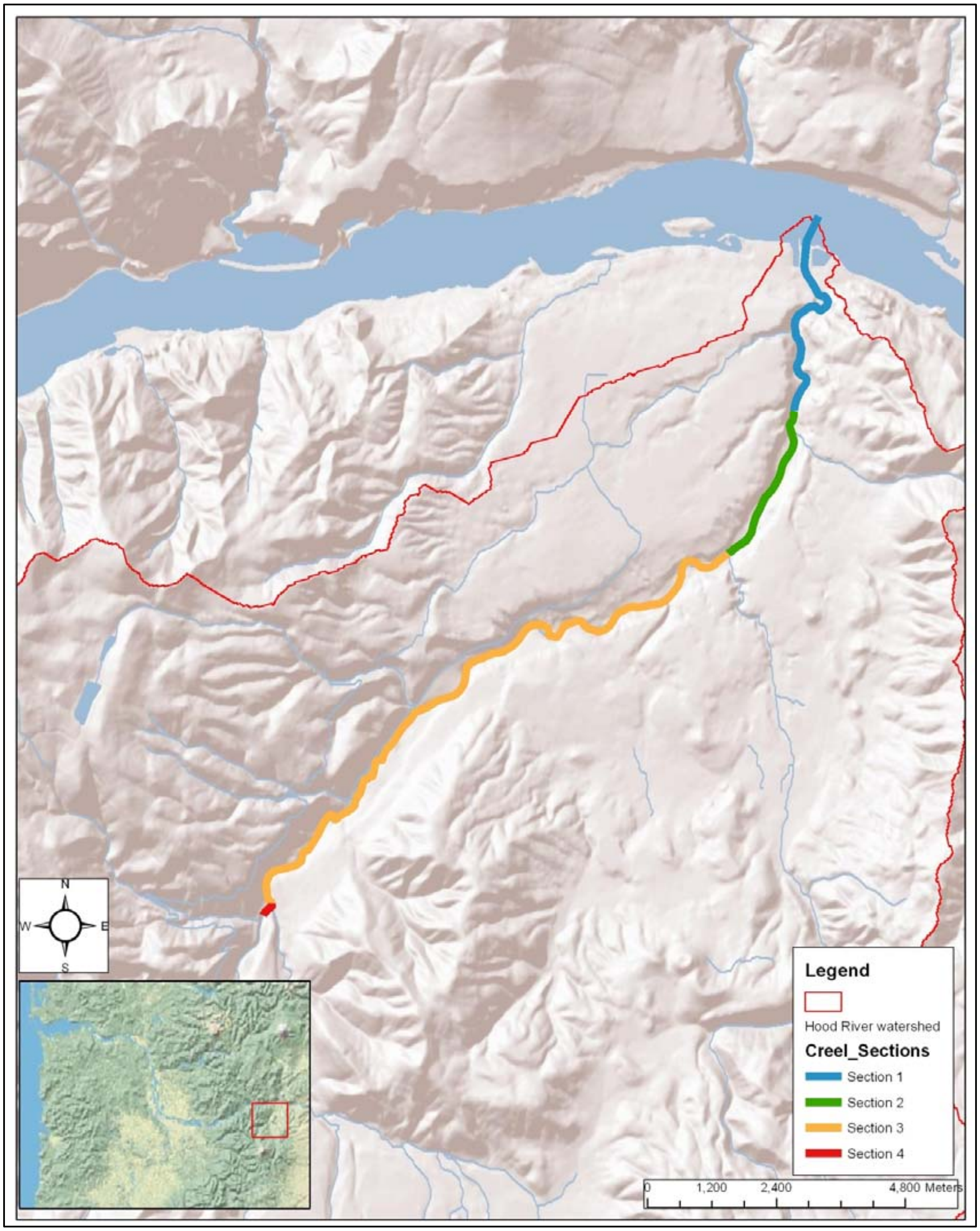


Figure A-6. Creel survey sections used to estimate non-tribal harvest of salmon and steelhead in the Hood River (2011 – present).

Two levels of stratification (day type and weekly period) were used in evaluating these data. Estimates of catch, catch rate, and effort were determined for both strata. Sampling days were categorized as either a weekend-holiday or weekday and total catch was summarized by week. The total number of days sampled in any given sampling period ranged from 40-67% of the weekdays and 33-100% of the weekend-holiday days.

Effort (i.e., total hours fished) for each sample day (H_i) was estimated by calculating the mean pressure based on random samples of periodic pressure counts:

$$H_i = \frac{\sum_{k=1}^{r} [\, (C_k)]}{r}$$

where:

r = number of pressure counts per day

C_k = angler count at the kth pressure count, where:

angler count = total cars counted * the average number of anglers per party

Pressure counts were conducted three times during the day. Times were determined randomly by dividing the sampling day into three equal length periods and conducting a pressure count at a random point within the first period. The remaining pressure counts were conducted 2.5 and 3.5 hours following the first count. The direction the surveyor traveled for the first pressure count was randomly selected. Subsequent pressure counts were generally made in the opposite direction of the previous count. Anglers were interviewed throughout the day to obtain catch rate information (fish caught/hour), where the catch rate on day *i* (R_i) was estimated by:

$$R_i = \sum_{j=1}^{m_i} f_{ij} \,/\, \sum_{j=1}^{m_i} h_{ij}$$

where:

m_i = number of anglers interviewed on the ith day
f_{ij} = number of fish caught by the jth angler on the ith day
h_{ij} = number of hours fished by the jth angler on the ith day

Total daily catch in numbers of fish on day *i* (TC_i) was estimated by:

$$TC_i = (R_i)(H_i)$$

Total catch for a given stratum (TC_s) was estimated by:

$$TC_s = (N/n)\sum_{i=1}^{n} TC_i$$

where:

N = number of days within a stratum

n = number of days sampled within a stratum

Variance for the estimate of total catch in a given stratum [$V(C_s)$] was estimated by (Su and Clapp 2013):

$$\hat{V}(\hat{C}_s) = \frac{(N^2)}{n} * \frac{\sum_{i=1}^{n} (TC_i - \overline{TC})^2}{n-1}$$

Semimonthly and annual estimates of total catch, and the variance associated with each estimate were determined for a given category of fish by summing the corresponding stratum estimates. Approximate 95% confidence intervals (C.I.), for a given category of fish, were calculated as follows:

$$95\% C.I. = TC \pm 1.96\sqrt{\hat{V}(\hat{C}_s)}$$

Stream Discharge Estimates

Seasonal (≈April – October) discharge (ft^3/sec) estimates were made using the direct discharge method at the following sites throughout the Hood River subbasin (conditions permitting):

- West Fork Hood River (RM 14.3)
- Middle Fork Hood River (RM 1.3)
- East Fork Hood River (RM's 1.0 and 8.0)
- Tony Creek (RM 0.1)
- Lake Branch Creek (RM 0.1)
- Green Point Creek (RM 0.1)

To estimate discharge, a tape measure was stretched across the sampling site cross-section to define one foot wide cells across the entire wetted area of the stream. Two foot cells were defined across the wetted area of the stream if the one foot intervals divided the stream into more than approximately 40 cells. If the wetted area of the stream was less than 12’, half-foot cells were used. This scenario occurred only at very low flows in Tony Creek. The tape was oriented perpendicular to the stream at the point of measurement. Depth and water velocity measurements were recorded at the length midpoint of each cell. Depth was measured to the nearest tenth of an inch using a top setting stadia rod. Velocity was measured using a Hach FH950 portable flow meter. Velocity was measured at 60% of the water depth when the depth of the individual cell was less than or equal to 2.0 feet. When water depth in a cell measured more than 2.0 feet, two velocity measurements were taken per cell; one at 20% of water depth and one at 80% of water depth. To calculate velocity for cells where water depth was greater than 2.0 feet, the velocity taken at 20% of cell depth and the velocity taken at 80% of cell depth were averaged together. Flow for each cell was calculated as cell area ^{x} velocity ^{x} depth. Flow in each cell was calculated and summed to estimate total discharge at the sampling site. Estimates of discharge were recorded, along with the water height reading at the corresponding staff gauge maintained at the sampling site. Discharge was calculated on multiple days over a wide range of flow conditions. The relationship between total discharge and staff gauge reading for each day sampled was used as a point

on an x-y scatterplot. A regression line was fitted to the data and the subsequent equation was used to estimate discharge on days when only a staff gauge reading was available. Staff gauges were typically read every 1-3 days. Selected data sites were also supplemented with HOBO® U20 Water Level Data Loggers to compare automated pressure readings with the staff gauge readings traditionally recorded by the HRRP.

The average daily stream discharge for each calendar day was also calculated using all years' worth of available data for a given site. Average discharge was plotted with the site's respective current year discharge estimate.