U.S. Fish and Wildlife Service

WINTHROP NATIONAL FISH HATCHERY SUMMER STEELHEAD ANNUAL REPORT - 2018 -

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***On the cover**: Steelhead spawning in a Winthrop NFH research spawning channel as part of a relative reproductive success study comparing adults of different juvenile rearing-strategies at Winthrop NFH, Michael Humling, Mid-Columbia FWCO.*

The correct citation for this report is:

Humling, M., S. Reese, T. Becker, C. Pasley, and M. Cooper. 2019. Winthrop National Fish Hatchery summer steelhead annual report – 2018. U.S. Fish & Wildlife Service, Mid-Columbia Fish & Wildlife Conservation Office, Winthrop, WA.

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Executive Summary – This report summarizes the Winthrop National Fish Hatchery (WNFH) summer steelhead program through 2018 activities, including a summary of broodyear 2016 (hereafter "BY16") performance from broodstock collection through smolt migration. Where appropriate and available, production metrics are reported in the context of longer-term datasets. This report provides comprehensive evaluation of program performance as well as to consolidate ESA reporting requirements identified under NOAA's Biological Opinion (NOAA 2017) and ESA Section 4(d) Limit 5 authorization (NOAA 2019).

Following evaluation of BY16 artificial production metrics are analyses of adult escapement-related metrics (e.g., fishery contribution, straying, gene flow dynamics on the spawning grounds, etc.), with reference to program goals, objectives, and permit terms and conditions.

The BY16 rearing cycle had fully completed prior to issuance of a revised Biological Scientific Research/Enhancement Permit; however, managers worked with NOAA Fisheries to anticipate developing permit terms and conditions and tier management towards these expectations. All general ESA-species special handling, notification, and reporting requirements were followed.

Production of BY16 steelhead at WNFH generally met all fish culture-related goals. Full broodstock collection with stepping stone implementation was achieved. Goals for eggtake were nearly met but imperfect egg enumeration results and/or undocumented mortality prior to tagging precluded accurate evaluation of this metric for the group. Other in-hatchery rearing and juvenile release-related goals were attained and consistent with interim guidance, with the possible exception of residualism targets, which continue to be a focal topic for which the program is actively conducting collaborative research.

Achieving the subbasin's collective steelhead program adult escapement and gene flow management objectives remained challenging in the Methow Subbasin through return year 2018. Interim gene flow goals (hatchery to spawning ground metrics of pNOB, pHOS and PNI) were partially met but results suggest that selective pressures in the Methow Subbasin still likely favor the hatchery environment, not the natural environment. Still, these values have remained stable with slight improvement over the last 5 years due to increasingly coordinated adult management, spawning, and juvenile release strategies. Continued coordinated efforts between the subbasin's steelhead programs may be sufficient to achieve gene flow objectives in the natural environment by 2022 as identified in the Biological Opinion.

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Leavenworth Fisheries Complex

The US Fish & Wildlife Service (USFWS) operates the Entiat, Leavenworth, and Winthrop National Fish Hatcheries as mitigation hatcheries authorized by the Grand Coulee Fish Maintenance Project April 3, 1937, and reauthorized by the Mitchell Act (52 Stat. 345) May 11, 1938. The three hatcheries, along with the Mid-Columbia Fish & Wildlife Conservation Office (MCFWCO), comprise the Leavenworth Fisheries Complex (Complex). Funding for the Complex is provided by the U.S. Bureau of Reclamation. Production, marking, and tagging goals for the facilities are determined through the management framework established as an outcome of the U.S. v Oregon decision and are described in the 2008-2017 U.S. v Oregon Management Agreement.

Winthrop National Fish Hatchery

Winthrop National Fish Hatchery (WNFH) is located adjacent to the Methow River at approximately river-mile (RM) 50 (rkm 80), near the town of Winthrop, Washington (Figure 1). The Methow River is a tributary to the Columbia River, entering at RM 524 (rkm 843), near the town of Pateros, Washington. Fish migrating from the hatchery to the ocean (or vice versa) must traverse nine mainstem Columbia River dams over approximately 923 rkm.

WNFH has a rich and diverse history of fish culture and currently produces ESA-listed spring Chinook (*Oncorhynchus tshawytscha*) and summer steelhead (*O. mykiss*) and assists the Yakama Nation with reintroducing Coho Salmon (*O. kisutch*) to the Methow Subbasin.

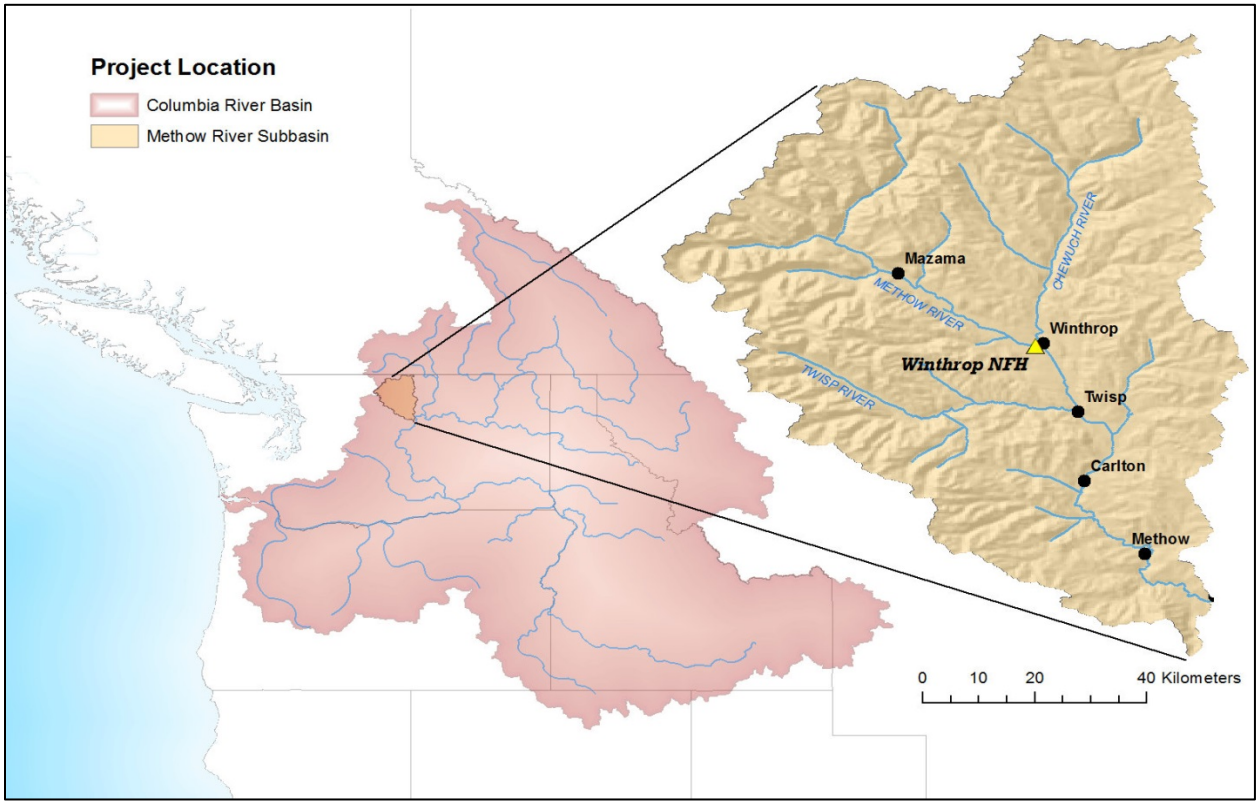

Figure 1. Winthrop National Fish Hatchery location.

All federal programs and activities are subject to compliance with the Endangered Species Act (ESA) of 1973. As such, all WNFH programs (spring Chinook Salmon, summer steelhead, and Coho Salmon), as well as general facility operation and maintenance have undergone ESA consultation with NOAA Fisheries and USFWS. This process includes submitting Hatchery and Genetics Management Plans (HGMP) to NOAA, and Biological Assessments (to USFWS), then operating under terms and conditions of resulting Biological Opinions (BiOps) and associated permits/authorizations.

Specifically for the summer steelhead program, ESA consultation with NOAA Fisheries was initiated through the submission of an HGMP (USFWS 2009), which was updated multiple times (USFWS 2012, USFWS 2017, USFWS 2019), and issuance of a Biological Opinion (NOAA 2017). In 2019, NOAA released a decision memo (NOAA 2019) authorizing the Winthrop NFH program under Section 4(d), Limit 5, of the ESA. ESA effects specific to Bull Trout were analyzed through submission of a Biological Assessment (USFWS 2014) and issuance of a separate Biological Opinion (USFWS 2016). Reporting requirements associated with the Bull Trout BiOp are mostly non-specific to the steelhead program and provided in specific annual reports to USFWS Ecological Services elsewhere. The only direct discussion pertinent to Bull Trout occurs in the Non-target Taxa Monitoring section.

Hatchery Evaluation Program

The MCFWCO's Hatchery Evaluation program assists Complex programs through implementation of targeted research, monitoring, and evaluation (RM&E) activities focused on helping programs meet mitigation goals while balancing responsibilities under the Endangered Species Act (ESA) and other permit conditions.

The goals of the Hatchery Evaluation program can be categorized into three main areas of focus:

1. *Performance Optimization* - Evaluate hatchery operation and practices to maximize program performance.
2. *Risk Management* - Research, assess, and recommend methods to minimize impacts of hatchery production and operations on natural fish populations and their environment.
3. *Facilitation and Coordination* – Actively facilitate coordination between partners and managers involved in artificial production, RM&E, and management of fisheries and habitat within and beyond the Columbia River basin.

Fish Health Program

The Pacific Region Fish Health Program staff support the summer steelhead program's fish health goals at the WNFH. The focus of the fish health program is to support the release of healthy smolts through a preventative medicine ethos. Regular monthly examination of fish at the hatchery aims at the identification and treatment of disease issues early in their course to both mitigate potential future disease losses and to optimize in hatchery rearing conditions. In addition to following USFWS National Fish Health Policy, disease surveillance and party notification of regulated pathogens is conducted in concordance with "*The Salmonid Disease Control Policy of the Fisheries Co-managers' of Washington State*" (2006). Sample collection and laboratory testing follows nationally recognized standards outlined in the American Fisheries Society "Blue Book" (AFS, 2014). Any disease treatments are performed under veterinary guidance.

Hatchery Evaluation Team Approach

The Complex uses a consensus-based advisory body, the Hatchery Evaluation Team (HET) composed of NFH staff, Fish Health specialists, and representatives from the Hatchery Evaluation program. The HET works together to shape management of NFH programs according to the USFWS Pacific Region's HET guidance document (Peery, 2016), address technical challenges, and shape the scope of RM&E efforts and reporting. Annual reports are ideally co-authored by representatives of each of these entities.

WNFH Summer Steelhead Trout Program

The WNFH summer steelhead trout (hereafter 'steelhead') program has dual roles as mitigation and recovery in the Upper Columbia Region. Its functions are integrated with the Douglas County Public Utility District's (DPUD) Wells Hatchery program within the *Stepping Stone* context (HSRG 2014). Specifically, the WNFH and DPUD Twisp conservation programs function as integrated/conservation programs with goals of increasing natural spawner abundance and distribution. These programs can then provide excess integrated broodstock to support DPUD's Wells Safety-net program thereby maintaining genetically related fish within the subbasin. Through this process, safety-net adults can provide a genetic reserve to the naturally spawning population when needed (Figure 2). The WNFH and DPUD programs share cooperative and related gene flow targets (pHOS [percent hatchery-origin spawners] and PNI [proportionate natural influence]) on the spawning grounds, which are targeted cooperatively via juvenile release, broodstock management, and adult escapement management strategies.

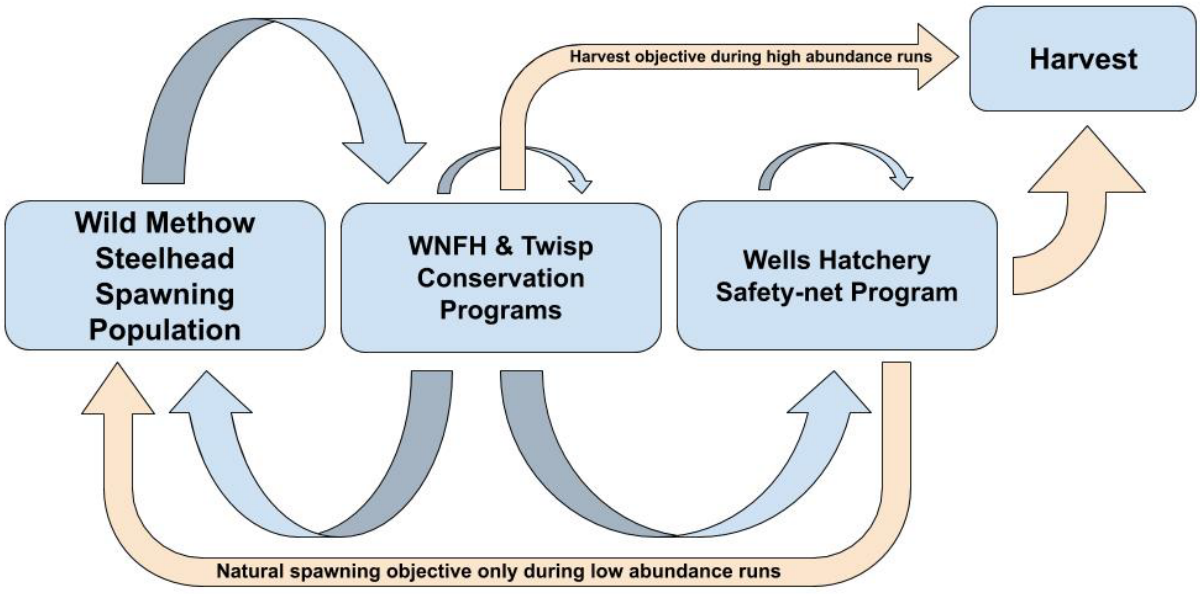

Figure 2. Methow Subbasin steelhead hatchery supplementation conceptual.

Prior to 2008, all steelhead released from WNFH were obtained from Wells Hatchery as eyed eggs and reared to yearling (hereafter 'S1') smolt size at WNFH. Broodstock supporting this strategy were a composition of mixed-stock and origin fish collected at Wells Dam on the mainstem Columbia River (Rkm 830; about 13km downstream of the mouth of the Methow River). Mainstem collection occurred during the upstream migration in the fall prior to the adults apportioning to their respective tributaries of origin. This practice created a commingled brood with inclusion of fish from the Methow and Okanogan subbasins, as well as hatchery- and natural-origin fish from a range of tributaries, including populations outside the Upper Columbia distinct population segment (e.g., mid-Columbia and Snake basins). To

better integrate the natural-origin and hatchery populations and maintain local stock structure within the Methow Subbasin, WNFH transitioned to 100% locally-collected (Methow Subbasin only) broodstock over the 2008-2014 broodyears. Currently, the WNFH conservation program's eggtake goal supports a smolt release target of up to 200,000 age-2 smolts (hereafter 'S2') in the Methow Subbasin.

Steelhead Program Performance Goals and Objectives

The WNFH steelhead program is managed and operated with an over-arching goal of compensating for lost fish production associated with the construction and operation of Grand Coulee Dam. Specifically, the WNFH steelhead program partially meets this mitigation goal through two broad sub-goals – 1) providing a harvestable surplus of adult steelhead, and 2) supporting ESA Recovery efforts for steelhead in the Methow Subbasin. Each of these has an associated suite of objectives and operational guidelines deriving from a myriad of guidance documents. These include a combination of legally-binding terms and conditions (e.g., maximum stray rates in BiOp; NOAA 2017), USFWS and/or co-manager policy (e.g., fish health monitoring and prophylaxis), operational details described in the program's HGMP (USFWS 2009), case law and associated agreements (e.g., external marking requirements within the US v OR Management Agreement), and procedural best management practices that developed over time based on good fish culture and/or HET agreement (e.g., target pre-spawn survival rates). Below are broad program goals and associated objectives. Appendix A collates specific monitoring attributes and targets.

Goal – Mitigate for lost fish production and fishery opportunities

Objective – Provide a harvestable surplus of summer steelhead

Associated Sub-objectives:

- Annually rear and release up to 200,000 steelhead smolts to produce returning adults, some of which are intended to increase natural spawner abundance.
- Healthy, migration-ready smolts are released in a manner optimizing post-release performance.
- Smolt release numbers and external marking strategies employed are consistent with US v OR management agreement.
- Returning adults support selective harvest fisheries as deemed appropriate by co-managers.
- Excess program returning adults are provided to inland Northwest Indian tribal subsistence food programs when available.

Goal – Support the recovery of ESA-listed Upper Columbia Summer Steelhead DPS in the Methow River Sub-basin

Objective – Support efforts to increase natural spawner abundance

Associated Sub-objectives:

- Operate under the Hatchery Scientific Review Group's (HRSG) "stepping stone" broodstock management model as an integrated conservation program. This component entails many related sub-objectives listed below.

Objective – Minimize genetic and ecological risks and impacts to natural-origin steelhead, non-target taxa, and their associated habitats.

Associated Sub-objectives:

- Target locally-collected (Methow Subbasin), high pNOB (percent natural-origin broodstock) broodstock such that local Methow Subbasin stock structure is supported.
- Prioritize wild-origin adults for broodstock, followed by conservation program hatchery-origin adult according to a production sliding scale aimed at meeting production obligations while balancing risk of domestication.
- Provide facility/resources and work with co-applicants/co-managers in Methow Subbasin to optimize return gene flow dynamics by managing wild, conservation program, safety-net program, and stray hatchery-origin adults in the run and on the spawning grounds.
- Optimize juvenile rearing/release strategies to maximize the number of migration-ready smolts, while minimizing and/or managing non-migrant life history juveniles within acceptable levels.
- Prevent or minimize ecological considerations associated with operation/maintenance of the hatchery facility

Objective – Support USFWS and partners' Recovery efforts in the Upper Columbia through operation of an integrated recovery steelhead supplementation program within the HSRG Stepping Stone model

Associated Sub-objectives:

- Annually transfer incidentally encountered hatchery-origin adults to appropriate partner programs to support safety-net programs.
- Provide facility and expertise to support cooperative, inter-agency adult management efforts to help optimize gene flow dynamics on the spawning grounds.
- Support Joint Fisheries Party and Wells/Rocky Reach HCP Hatchery Committee efforts to implement best management practices for subbasin-wide DPS stock management through cooperative juvenile release strategies.

To effectively monitor and evaluate the steelhead program at WNFH, specific performance metrics/targets are tracked through hatchery rearing, juvenile release, and adult return (Appendix A). These metrics/targets are intended to give a point of comparison between cohorts and amongst similar hatchery programs, specifically answer terms and conditions required by various entities (e.g., BiOp reporting), and ultimately determine if program goals/objectives are being met.

The Complex's Hatchery Evaluation Plan (HEP; Cooper et al. 2017) synthesizes each program's range of goals and objectives and the Complex's permits and guidance documents (BiOp/take permits, NEPA documents, USFWS National and Regional guidance/policy, Washington Department of Fish & Wildlife's (WDFW) Scientific Collectors permit, etc.) to assess whether the program met mitigation objectives and maintain compliance with existing permits, rules, and regulations. These efforts simultaneously inform broader regional data collection efforts (e.g., inter-agency escapement analyses, coded-wire tag (CWT) recoveries in regional tagging databases, PTAGIS, etc.).

Generally, monitoring and evaluation categories can be grouped into broad categories associated with risk and performance of fish in, or released from, the hatchery. Though organized and presented differently, metrics are highly consistent with and complimentary to those presented in Habitat Conservation Plan-governed mitigation hatchery programs and their associated plans (e.g., Hillman et al. 2013 and 2017, Willard 2017, Murdoch and Peven 2005, etc.).

Data Sources

Data used for evaluation comes from direct collection by Complex staff, collection by other management agencies, and/or industry-specific databases. Other commonly used data sources include:

RMIS – The Regional Mark Information System (RMIS) is an online database operated by the Pacific States Marine Fisheries Commission (PSMFC) and designed to house coded-wire tag (CWT) and juvenile release data for the west coast of North America and the northern Pacific Ocean. When a group of fish is tagged with a CWT, tagging metadata are submitted to RMIS by the tagging entity. Subsequently, if/when a fish is lethally sampled, either for scientific or commercial purposes, the tag code information is submitted. RMIS allows managers to calculate survival, stray rates, and other metrics for target groups. Coded-wire tag data are less critical to steelhead evaluation since carcass recovery in the wild is rare; however, hatchery and fishery recovery data are often used.

PTAGIS – The PIT Tag Information System (*PTAGIS*) is an online database operated by the PSMFC, and designed to house Passive Integrated Transponder (PIT) tag data. When a group of fish is PIT tagged, tag codes and tagging event metadata are submitted to PTAGIS by the tagging entity. Subsequently, if/when the PIT tag is read remotely by a transceiver antenna ("interrogated") or recovered directly, the tag code information is submitted to the database. PTAGIS allows tagged fish to tracked, calculation of survival rates and travel times through the hydro system, etc.

DART – The Columbia River Data Access in Real Time (DART) is an online database operated by the Columbia Basin Research Department of the School of Aquatic and Fishery Sciences at the University of Washington. DART uses data from RMIS and PTAGIS to provide summaries of juvenile fish survival and counts fish passing hydroelectric facilities on the Columbia River and its tributaries.

At WNFH, all mass marking (CWT and PIT tags) is administered by the Columbia River Fish and Wildlife Conservation Office's hatchery marking team. This team marks and tags for a majority of the National Fish Hatcheries in the Columbia River Basin, as well as other hatchery facilities in the region.

Reporting Organization

There are inherent organizational challenges in balancing a desire for timely reporting against the ability to comprehensively consolidate broodyear performance from eggtake to escapement. By the time stream-type salmonids with lifespans up to 5-years have completed their lifecycles and data reporting streams have adequately matured (e.g., scale reading, CWT recoveries), a period of up to 7 years can have elapsed. As such, we report the most recent release cohort through juvenile migration (i.e. BY16, released in 2018) along with adult escapement-focused metrics through the most recent year for which a sufficient data upload processes have matured. This is consistent with reporting timelines established in the BiOp and Section 4(D) authorization (NOAA 2019), which require report submission by December of the year following release (i.e., BY16, release year (RY) 2018, report due December 2019).

Natural Environment Monitoring, including adult return, escapement, and gene flow metrics on the spawning grounds are highly dependent on monitoring results reported by WDFW as part of Wells Hatchery M&E obligations funded by DPUD. We report elements of their findings (e.g. Snow et al. 2019) as they pertain to WNFH programs but are subject to their publication timeframes. Effort to report results in the 2018 spawn escapement was made for this report, as available.

Broodyear 2016 Juvenile Rearing Monitoring includes summaries of:

- Parental broodstock composition (pNOB and related)
- Eggtake

- Rearing performance
- Disease occurrence and mortality events
- Rearing parameters (e.g. density index, flow index, feed conversion, etc.)
- Marking/tagging
- Survival rates for life stages between green egg and smolt

Broodyear 2016 Juvenile Release Monitoring includes summaries of:

- Number, dates, size at release, and tag/mark dispositions
- Migration survival through the Columbia River corridor
- Travel times to key points
- Estimates of residualism, precocial maturation, and over-winter survival/out-year migration

2018 Adult Return Monitoring includes summaries of:

- Smolt-to-adult ratios (pre- and post-harvest) and Hatchery Replacement Rate estimates
- Fishery contribution
- Returns and timing to key Columbia River locations (Bonneville and Wells dams)
- Returns and timing to key Methow Subbasin locations (Lower Methow River and WNFH)
- Age structure of run
- Out-of-basin straying

2018 Broodstock Collection and Adult Management Monitoring includes summaries of:

- Summary of broodstock collection and adult management efforts via all sources
- Surplusing to PNW Indian Tribes
- Collaborative steelhead Stepping Stone implementation and gamete management
- Number and composition/demographics of adults collected and spawned
- Effective parental pNOB of BY19 eggtake

2018 Natural Environment Monitoring includes summaries of:

- Escapement estimates/summary
- Effectiveness of pHOS management efforts – program partial pHOS
- Spawning ground gene flow dynamics

Non-Target Taxa Monitoring includes summary of:

- Summary of non-target taxa of concern (NTTOC) encounters by activity

RESULTS

Broodyear 2016 Juvenile Rearing Monitoring

Eggtake and Incubation

BY16 steelhead at WNFH were produced using locally-collected adults, 93% of which were collected via angling (Humling & Scheibel 2017). This was the second WNFH production cycle for which no eyed eggs were received from Wells Hatchery. The BY16 hatchery production phase began with an estimated eggtake of 243,340 green eggs from 53 families (Table 1; vs goal of 233K). Retained spawn crosses comprised 19 hatchery by wild and 31 wild by wild families with a fecundity-weighted program pNOB of 0.782 (Humling & Scheibel 2017). No green eggs were transferred from WNFH in 2016.

Following a 94.5% eye-up rate, completion of transfers (N=4,765 to NOAA Manchester Research Station and Methow SFH), and eyed egg culling (N=9,444 of Wells Safety-net parentage), excess to program needs), an estimated 220,456 eyed eggs were retained on-station, slightly above the eyed egg HGMP target of 216,000 (target prior to incorporation of DPUD Twisp component; Appendix A). Eyed eggs developed further, hatching at a rate of 97.4%, resulting in 207,910 ponded fry, about 101% of the target for ponding (Appendix A). Table 1 displays eggtake and egg-phase survival rates since the beginning of the WNFH steelhead program in 2006.

Table 1. Winthrop NFH steelhead eggtake and incubation summary, Broodyears 2006-2016.

Brood year	Females Spawned	Green Eggs		Eyed Eggs					Fry			
		Total Eggtake	Avg./ female	Eye-up %	Transfer (in)	Transfer (out)	Culled	Total	Total hatched	% Hatched	Transfer (out)	Total Ponded
2006	N/A[1]	0	0	N/A	129,347	0	0	129,347	128,692	99.5	0	128,411
2007	N/A[1]	0	0	N/A	124,293	0	0	124,293	120,936	97.3	0	119,497
2008	7[1]	30,713	4,388	98.3	111,904	0	0	142,109	139,697	98.3	0	138,664
2009	8[1]	57,047	7,131	96.4	81,200	0	0	136,194	133,943	98.3	0	132,978
2010	12[1]	66,697	5,558	98.6	67,381	0	0	133,160	129,779	97.5	0	128,331
2011	20[1]	120,015	6,001	94.7	70,975	6,008	49,100	135,551	126,805	93.5	0	124,066
2012	23[1]	120,290	5,230	96.0	55,473	6,160	0	170,935	163,070	95.4	0	161,335
2013	16[1]	90,620	5,664	98.2	54,217	4,160	0	143,225	137,890	96.3	0	136,715
2014	33[1]	153,627	4,655	98.0	26,238	3,570	0	176,808	172,386	97.5	840	170,712
2015	53	268,364	5,063	92.2	0	2,400	0	247,443	242,130	97.9	0	218,459
2016	53	243,340	4,591	94.5	0	4,765	9,444	220,456	214,817	97.4	0	207,910

[1]Past years' WNFH steelhead programs relied on eyed egg transfers from Wells Hatchery. This practice was phased out over broodyears 2008-2014.

Juvenile Rearing

BY16 steelhead performed fairly well during rearing. On-station survival (initial ponding until release) was calculated at 93.5%, slightly below the 95% goal (Appendix A). Evaluation from ponding to marking was difficult because approximately 30,000 fewer parr were accounted for at CWT tagging compared to the expected population estimated by traditional egg enumeration methods. It is not known whether this discrepancy was due to inaccurate egg enumeration (previous years' comparisons do not support this), undocumented mortality in the 6-7 month period when juveniles are in outside ponds subject to wintertime predation (suspected by hatchery staff), a combination, or other unknown sources of error/loss.

WNFH has purchased an improved egg counter, which may help address this concern. Note that all juvenile rearing performance metrics displayed in Table 2 were back-calculated using "corrected" population values obtained at the time of tagging. As such, estimated ponded totals in Table 1 differ by approximately 30,000, as discussed above. Eggtake data were not adjusted because we are not certain what the source of discrepancy was.

Steelhead alevins were initially ponded into 10 early rearing tanks inside the hatchery building on August 30, 2016, and first fed on September 4. Mortality levels were elevated during the first month of rearing; this is common and likely due to a combination of factors such as congenital defects and coagulated yolk or foma from early rearing. These fish were reared inside the hatchery building until November 22, 2016, at which time the entire population was moved outside into 2 A-bank Foster Lucas (FLs) ponds. Fish were reared in the FLs until May 2017, when they were tagged and moved to 15 D-bank raceways.

The steelhead population was affected by the ectoparasite, *Ichthyopthirius multifillis* ("Ich") during summer 2017. This is a common occurrence at WNFH during summer months. Standard treatment for Ich in Chinook Salmon is flow-through formalin; however, steelhead are sensitive to formalin. To flush the parasites from the population, staff increased flows and turnover rates in the raceways and fed an enhanced feed (Bio Pro©). Ich-associated mortality accounted for 7.8% of all mortality during the rearing period, but monthly survival only fell to 99.6% during August 2017 and the treatment successfully addressed the Ich by September 2017.

Throughout the rearing cycle, fish density and flow through the rearing vessel were monitored. Reduced densities and increased flow are desired to mitigate disease risk, and are manipulated when possible to optimize the rearing environment, as described previously for the Ich event. For the RY18 rearing cycle, the mean monthly Density Index (DI) and Flow Index (FI) were 0.09 and 0.55, respectively which met the performance goals (DI <0.20 &FI<1.0) for these categories (Table 14; Appendix A). The population was fed a total of 28,632 lbs. of feed and expressed a conversion rate of 0.96.

Table 2. WNFH steelhead juvenile rearing performance for release year 2018.

M/Y	Life Stage	Key actions	Inventory	Fish/ lb.	Mortality (%)	Survival (%)	Avg. temp (°C)	Water source (%)		Flow (GPM)	Flow Index[1]	Density Index[2]
								Well	River			
4/16	Egg	Spawning	178,096	NA	NA	NA	7.9	100	0	12	NA	NA
5/16	Egg	Spawning	209,758	NA	NA	NA	8.3	100	0	21	NA	NA
6/16	Egg	Transfers	191,553	NA	NA	NA	9.3	100	0	21	NA	NA
7/16	Sac fry	Cull	182,109	NA	NA	NA	10.2	100	0	12	NA	NA
8/16	Sac Fry		175,202	2,400	NA	96.2	11.0	100	0	2,000	0.39	0.08
9/16	Fry		170,779	1,446	2.5	97.5	10.4	100	0	2,000	0.53	0.11
10/16	Fry		169,887	654	0.5	99.5	9.9	100	0	4,000	0.45	0.10
11/16	Fry		169,271	288	0.4	99.6	8.9	30	70	600	0.52	0.06
12/16	Fry		168,958	262	0.2	99.8	5.0	30	70	600	0.55	0.06
1/17	Fry		168,548	293	0.2	99.8	4.5	30	70	600	0.51	0.06
2/17	Fry		168,339	267	0.1	99.9	4.6	30	70	600	0.54	0.06
3/17	Fingerling		168,219	146	0.1	99.9	7.1	30	70	600	0.81	0.09
4/17	Fingerling		168,150	105	0.1	99.9	7.7	30	70	600	1.01	0.11
5/17	Fingerling	Mark/tag	167,240[3]	56	0.5	99.5	7.2	100	0	3,600	0.21	0.04
6/17	Fingerling		167,082	34	0.1	99.9	7.9	100	0	3,600	0.23	0.05
7/17	Yearling		166,994	24	0.1	99.9	10.8	70	30	3,600	0.30	0.06
8/17	Yearling		166,326	17	0.4	99.6	9.7	70	30	3,600	0.37	0.07
9/17	Yearling		166,185	12	0.1	99.9	11.2	70	30	3,600	0.47	0.09
10/17	Yearling		166,095	10	0.1	99.9	8.8	40	60	3,600	0.54	0.11
11/17	Yearling		166,018	9	0.1	99.9	6.9	30	70	3,600	0.58	0.12
12/17	Yearling		165,939	8	0.1	99.9	6.1	30	70	3,600	0.60	0.12
1/18	Yearling		165,826	8	0.1	99.9	6.9	30	70	3,600	0.62	0.12
2/18	Yearling		165,695	8	0.1	99.9	5.9	30	70	3,600	0.63	0.13
3/18	Transitional		165,617	6	0.1	99.9	7.6	30	70	3,600	0.70	0.13
4/18	Smolt	Out-plant[4]	140,813	5	0.4	99.6	8.4	30	70	3,600	0.80	0.15
5/18	Smolt	Vol. rel.[5]	139,528	5	0.9	99.1	8.4	30	70	3,600	0.80	0.15

[1]Flow index calculated by fish weight (lbs.) divided by flow in GPM.
[2]Density Index calculated by fish weight (lbs.) divided by average fish length (in.) multiplied by volume of water (ft^3).
[3]Total inventory adjusted (upwards) by automated counting done during mark/tagging event.
[4]Direct plant to Twisp River (N=24,093).
[5]Volitional release concluded. See Table 4 for disposition of migrants vs. non-migrants.

Juvenile Marking Summary

The US v OR mark prescription for RY18 steelhead was 100% CWT and adipose-clip. WNFH S2 steelhead parr were marked May 8-13, 2017. Follow-up tag retention quality control assessments occurred in July 2017 (about 2 months post-tagging) and estimated tag retention 99.2% (population weighted average). To allow smolt migration timing/survival evaluation, residualism estimates, straying, and aid adult return projection, approximately 20,000 steelhead were PIT-tagged on October 2-6, 2017. Mass marking is summarized in Table 15, with release summaries in the following section.

Table 3. Summary of Broodyear 2016 WNFH steelhead mass marking.

Brood year	Tagcode	Inventory @ tagging	Est'd CWT retention	Ad-clipped (actual)	Ad-clip rate	# PIT tagged
2016	054968	117,416	100.0%	116,629	99.3%	14,949
	055645	25,247	96.7%	24,573	97.3%	0
	055646	25,310	97.7%	24,720	97.7%	4,986
	TOTAL	**167,973**	**99.2%**	**165,922**	**98.8%**	**19,935**

Broodyear 2016 Juvenile Release

The majority of BY16 steelhead smolts were volitionally released from WNFH from April 23 to May 15 (22 days), allowing managers to retain non-migrant fish to mitigate negative ecological effects to non-target taxa and natural-origin steelhead. The release period was similar in timing to 2017, in an effort to capitalize on increased natural hydrograph conditions expected in May. A separate group of 24,093 smolts was direct-planted into the Twisp River on April 24 and 26, 2018. This was part of a continued HCP Hatchery Committee and fishery party effort to mitigate spawner relatedness and small effective population size on the spawning grounds in the Twisp River Watershed (Snow and Humling 2017). Prior to transfer, the raceways from which Twisp-release fish came from were manually sorted to remove non-migrant parr to mitigate for potential ESA concerns in the Twisp River.

An estimated 13,229 non-migrants, comprising 8.1% of the pre-release population, remained in hatchery raceways at the conclusion of the volitional release. As in previous years, WNFH transferred non-migrants to hydrologically-closed inland lakes following Fish Health screening. Non-migrant steelhead contributed to recreational fisheries in Leader Lake (N=11,129) and WNFH trout pond (N=2,100). A summary of release groups is presented in Table 4, with additional detail on effectiveness of retaining non-migrant fish in the Early Maturation, Residualism, and Management section.

Table 4. WNFH steelhead release strategy implementation summary, 2018.

Species/program	Release Start	Release End	Number of days	Total in release group	Release Strategy
Production on-station S2	4/23/2018	5/15/2018	22	126,299	Volitional
Twisp River	4/24 & 4/26/2018		2	24,093	Trucked/direct
Anadromous Water Total				**150,392**	
Leader Lake	5/18, 5/21, & 5/22/2018		3	11,129	Trucked/direct
WNFH Trout Pond	5/22/2018		1	2,100	Direct
Land-locked Fishery Water Total (non-migrants)				**13,229**	

A total of 150,392 steelhead were released into anadromous waters in 2018 (Table 16), consistent with the 100-200K range identified in the HGMP (Appendix A). Guidance formalized through a BiOp and signed permit was yet incomplete during the time of broodstock collection/eggtake (spring 2016). Since parental pNOB exceeded 0.75 (0.782), the now-current production-pNOB sliding scale would have permitted full 200K smolt program size in 2016. A final detailed mark/tag release summary is displayed in Table 5, with summarized mark/tag data since the beginning of the WNFH program displayed in Table 6.

Table 5. WNFH steelhead code-wire tag release groups and PIT distribution summary, 2018.

	CWT code	Release Site	CWT+ release	CWT- release	Total Release	PITs Released
Steelhead	054968	Methow River	103,837	2	103,839	13,392
	055645		21,712	748	22,460	0
	055646	Twisp River	23,531	562	24,093	4,729
	Migrant Total		**149,078**	**1,314**	**150,392**	**18,121**
		Leader Lake	N/A[1]		11,129	N/A[2]
		WNFH Trout Pond	N/A[1]		2,100	N/A[2]
	Non-migrant Total		**N/A**	**N/A**	**13,229**	**N/A[2]**

[1]CWT breakdown unnecessary for fish released into non-anadromous waters.
[2]All retained fish with PITs were scanned and codes removed from release files.

Table 6. WNFH steelhead historic marking and tagging summary, broodyears 2007-2016.

Brood year	Release year	Rearing strategy	CWT tag rate[1]	Adipose clip rate	# PIT tagged	# Released by strategy	Total by RY	5-year moving avg.[2]
2007	2008	S1	99.1%	98.0%	4,915	116,897	116,897	106,564
2008	2009	S1	87.2%	98.0%	4,997	102,418	102,418	106,709
	2010	S2	89.9%	98.2%	14,756	29,170	100,378	108,809
2009		S1	97.9%	97.7%	14,841	71,208		
	2011	S2	96.7%	98.8%	14,881	43,205	107,141	107,774
2010		S1	97.9%	97.6%	14,698	63,936		
	2012	S2	49.7%	98.3%	14,892	59,352	117,210	115,370
2011		S1	97.5%	99.1%	14,917	57,858		
	2013	S2	96.4%	98.3%	14,475	57,894	111,721	114,391
2012		S1	87.8%	99.1%	14,543	53,827		
	2014	S2	95.0%	99.4%	14,630	90,599	140,398	118,679
2013		S1	95.1%	99.0%	14,689	49,799		
	2015	S2	99.6%	99.3%	13,887	76,078	95,483	139,081
2014		S1	81.2%	96.9%	13,920	19,405		
	2016	S2	99.6%	99.2%	19,562	128,585	128,585	146,816
2015	2017	S2	98.1%	99.5%	19,831	219,220	219,220	148,420
2016	2018	S2	99.1%	99.4%	18,121	150,392	150,392	166,066

[1]Tag rates not consistent with RMIS reported values since many release groups are aggregate rate of multiple tag groups.
[2]5-year moving averages for beginning/ending years calculated using nearest available years.

Collective pre-release sampling was historically focused on optimizing performance (e.g. identifying size range to maximize survival) but has evolved in recent years at WNFH. Standard sampling, including fish length, weight, and smoltification state (using smolt index, SI, similar to Gorbman et al., 1982) has occurred most years to describe the release population but has expanded to include metrics (gonadosomatic index) focused on sexual maturation, discussed in further detail later. Release sampling includes three components:

1. Pre-release sampling – demographic sample collected from entire population prior to release.
2. Post-release sampling – demographic sample collected from the non-migrant population remaining after conclusion of volitional release period.
3. Migrant group demographics as determined subtractively using pre- and post-release sample demographics.

A "held" group was introduced experimentally in 2018 to test if SI values collected at pre-release remained static over the volitional release timeframe. Both standard pre-release and "held" prerelease samples showed that the steelhead release to be composed of primarily (92.3-93.1%) smolts or transitional smolts and a small proportion of fish showing outward signs suggesting a non-migratory life history form (3.6-3.7% immature parr and 3.3-4.0% precocious males; Table 6). We are cognizant that outward appearance (SI) may not fully describe post-release behavior. More discussion follows in the Early Maturation, Residualism, and Management section.

Table 7. WNFH steelhead size and condition at pre-release, 2018.

Smolt Index (SI) Groups	FL (mm)		Weight (g)		N; %	K
	Avg.	CV	Avg.	Fish/lb.		
SST Pre-Release (collection – April 23; sampling – April 24)						
1 (parr)	143.3	8.3	33.3	13.6	11; 3.6%	1.10
2 (transitionals)	195.3	13.9	83.3	5.4	92; 30.4%	1.10
3 (smolts)	208.4	7.6	95.8	4.7	190, 62.7%	1.05
4 (prec. males)	186.6	8.0	84.2	5.4	10; 3.3%	1.28
Combined average	201.3	11.8	89.3	5.1	N=303	1.07
SST Held Pre-Release[1] (collection – April 23; sampling – May 30)						
1 (parr)	140.1	11.3	31.1	14.5	11; 3.7%	1.09
2 (transitionals)	198.0	10.6	87.7	5.2	100; 33.4%	1.10
3 (smolts)	210.2	7.2	102.2	4.4	176; 58.9%	1.08
4 (prec. males)	188.6	6.6	87.2	5.2	12; 4.0%	1.29
Combined average	206.4	11.6	91.6	5.0	N=299	1.10

[1]Held Pre-Release length and weight measured when fish were collected.

Early Maturation, Residualism, and Management

Steelhead are one component of sympatric, often interbreeding populations of *Oncorhynchus mykiss*, within which, individuals of differing life-history strategies (e.g., resident Rainbow Trout, "half-pounders", and anadromous steelhead) interbreed, creating offspring that may adopt either form (Olsen et al. 2006; Kendall et al. 2015). Burgner et al. (1992) identified up to 32 possible age combinations and life history trajectories for *O. mykiss* range-wide. Summer steelhead in the Methow Subbasin are no exception to life-history diversity. Peven et al. (1994) documented mid-Columbia River tributary migrants of between 1 and 7 years (freshwater age), and ongoing hatchery evaluation work in the these watersheds (Yakima, Wenatchee, Entiat, Methow, and Okanogan subbasins) continue to document diverse age structures including resident Rainbow Trout, variable migrant ages of anadromous steelhead, and iteroparous kelts, all contributing to population-level gene flow. Ongoing pedigree studies in the Twisp River has shown that unidentified male parents were likely resident form Rainbow Trout (Goodman, pers. comm.), and we have documented significant parentage contribution by residualized precocious males in semi-natural spawning trials (approximately 25%; Berejikian et al., *in press*). These findings are not surprising considering work in the Hood (Christie et al. 2011) and Yakima (Courter et al. 2013) rivers, where anadromous adults have been parentally assigned back to at least one resident parent through pedigree or otolith micro chemistry analyses.

Despite the well-documented importance of life-history diversity, including contribution by resident-form Rainbow Trout in the spawner aggregate, the Methow Subbasin lacks a baseline, 'normal' level of resident trout contribution to the metapopulation. We are not aware of any current or historic resident trout population estimate. Ultimately, the program's mitigation component and management direction focuses on anadromous steelhead mitigation and the current the HGMP and associated BiOp specifically identify anadromous parentage for program broodstocking.

Further, while we agree some input of non-anadromous *O. mykiss* is acceptable, the magnitude of production-scale non-migrant juvenile releases could vastly out-pace natural levels and impart unacceptable ecological and genetic risks, even at relatively low rates. With this in mind, juvenile releases from WNFH are intended to include <10% non-migrant composition, on average, to mitigate ecological and gene flow concerns (NOAA 2017).

Juvenile release monitoring for all Complex programs consists of a combination of physiological assessment at time of release along with secondary, retrospective analysis of post-release behavioral patterns using PIT detections in the natural environment. The physiological component includes standard size and smoltification stage assessment (smolt index; SI), cross-referenced with sexual maturation status determination using the gonadosomatic index (GSI; de Vlaming et al. 1982). The external assessment (SI) is effective at identifying two types of non-migrant: 1) immature parr that have failed to reach a size-threshold required for smoltification and 2) sexually mature precocious males. GSI analysis allows us to estimate the proportion the population of smolts and transitional smolts that are maturing males, preparing to spawn the following year, and thus likely to residualize. Interpretation of GSI-based data specific to steelhead is not yet supported in the peer reviewed literature and this remains a focal area of our current work and may result in retrospective analysis of existing data. These data are not reported in this report, though our SI-based findings are discussed, consistent with requirements of the Biological Opinion.

Table 8. WNFH steelhead release sampling and volitional release strategy effectiveness, 2018.
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This simple visual method suggests residualism in recent release groups has remained below the 10% BiOp target (Figure 3).

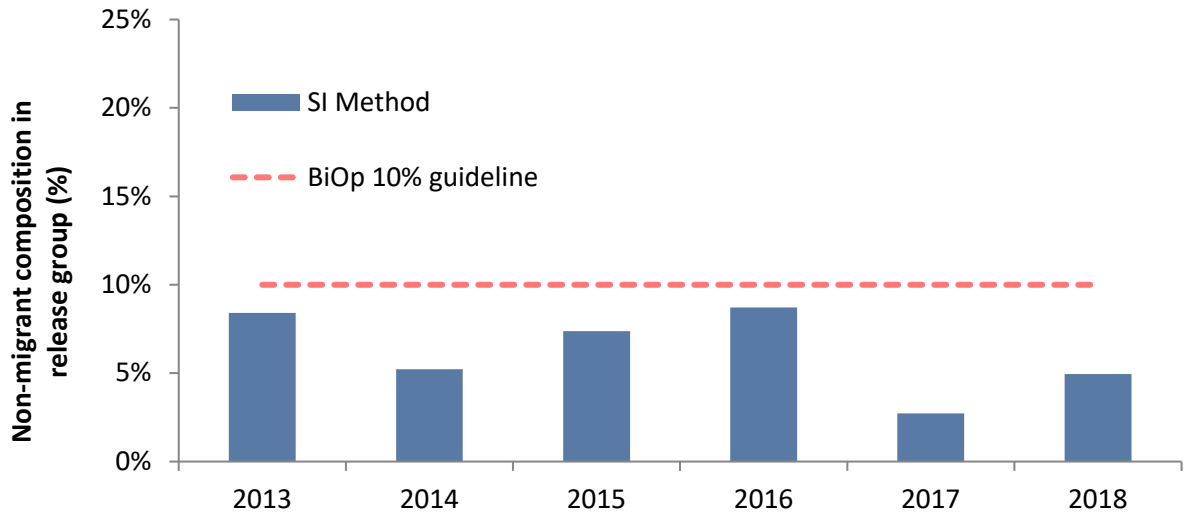

Figure 3. Estimated non-migrant composition in WNFH steelhead release groups, via smolt index assessment method.

Release data were supported by RY18 PIT tag detection data (PTAGIS.org) from release through May 2019. RY18 steelhead from WNFH were only detected at arrays within the Methow Subbasin and at expected Columbia River mainstem detection sites (i.e. no out-of-basin juvenile straying occurred in 2018 or early 2019). Sixty-five RY18 PIT tags (about 0.3% of releases) were detected remaining in the subbasin beyond the expected migration period but within the release season (July 1 – Dec 31, 2018). Only six unique PITs were re-detected during spring/summer 2019 (i.e. 1 year post-release). These results were similar to our findings from 2017 when we estimated that 0.1% of out-migrating PITs were released in a prior year (Humling et al. 2018). Detections across the subbasin's PIT interrogation network (Table 9) should not be used to extrapolate population estimates (variable detection probabilities and operational periods across sites). However, the rapidly diminishing re-detections over time suggest distribution patterns of non-migrants (most stay near the hatchery zone), rapid mortality of fish that do remain in the

subbasin, and discountable contribution to RY+1 seaward migration. These findings are further discussed in Tatara et al. 2019.

Nineteen unique PITs were detected entering the Natural Production Emphasis Zone (NPEZ) as identified in the BiOp (Appendix C), most of these in summer of 2018. These detections suggest that a small number of non-migrants pass into tributary areas including the Chewuch River, upper Methow River, Wolf Creek, and Twisp River where management prioritizes natural production and low pHOS. These fish may be exhibiting a summer feeding migration into tributaries but it's unknown if they attempt to over-winter or how far they travel into upstream areas – upstream PIT interrogation in the Chewuch and Twisp rivers is multiple miles upstream (no detections) or absent (upper Methow River and Wolf Creek). Based on lack of re-detections, we believe that these fish comprise well <1% of release groups and those that do enter the NPEZ have poor survival as they are seldom seen again.

Table 9. WNFH RY18 steelhead PITs remaining in subbasin post-release period.

Date[1]	Migratory Pathway Zone detection locations[2]								Off Migratory Pathways Zone detection locations[2]					
	SCP	MWF	M3R	18N	SSC	MRC	LMR	Uniq. N[3]	CRW	MSH	MRW	WFC	TWR	Uniq. N[3]
4-18	9443	143	29	1	1	57	8	9470		1				1
5-18	2854	21	18		6	3	1	2876	1	2				3
6-18	34	15	7			2		55		1				1
7-18	19	8		1		1		29	3					3
8-18	17	4				4		24	5		2	1		7
9-18	13					3		16	3	1	1			5
10-18						1	1	2	1	1	1			2
11-18								0		1				1
12-18								0						0
1-19								0						0
2-19								0						0
3-19								0	2				1	3
4-19	2					1		3						0
5-19	1							1						0

[1]Colorization indicates projected behavior of fish in temporal-spatial context: green = expected seaward migration; yellow = higher risk of residualism; orange = clear indication of residualism; purple = likely out-year migration.
[2]PTAGIS PIT array locations showed in Appendix C.
[3]Unique PITs within a month period overlap across months; i.e., total unique N for post-July 1 period exceed the 65 noted remaining in the subbasin.

Abundance of early-returning steelhead that descend the Columbia River, then re-ascend later in the year of release (similar to sexually mature Chinook "mini-jacks" or immature "half-pounders"; Snyder, 1925) was estimated using PIT detections at mainstem dams. Only four RY18 WNFH steelhead were detected in mainstem adult ladders (as of June 20, 2019). One of these was detected at McNary Dam but several days later at Bonneville, suggesting it was actually migrating downstream through the adult ladder. Mainstem dam PIT interrogation data were analyzed retrospectively through RY07 for re-ascending juveniles during year of release. Nearly all adult ladder detections of juveniles released in the same year occurred during April and May, suggesting they were simply juveniles migrating down adult ladders. There have been only three individual PITs detected in mainstem ladders after July 1 since 2007 (one at Bonneville Dam in 2009, one at Wells Dam in 2012, and one at Rock Island Dam in 2017), a time period during which >250,000 PITs were released from WNFH. These findings suggest these life history strategies are exceedingly rare (<0.1%), even absent, in WNFH steelhead.

Residualism in WNFH steelhead appears restricted to headwater/tributary forms. The magnitude appeared not to exceed the BiOp target of 10% for BY16 (based on smolt-index only). Most were likely males

undergoing maturation for the following spring; however PIT-derived data in the river suggests these fish have very poor survival and contribute minimally to natural spawning. We hope to further analyze this using DNA collected from naturally-produced adult steelhead (WNFH broodstock) in the future.

Smolt Outmigration

Steelhead volitionally emigrated over a protracted timeframe associated with the volitional release operation, reaching about 60% emigration by day 5 of the release. This was much more rapid than in 2017. Pond emigration did not directly correspond with flow increases as in previous years, but preceded major runoff slightly (Figure 4). Steelhead juveniles were generally prepared to leave the pond and approximately 95% of PIT-tagged fish (those that eventually left the pond) had done so within 14 days of the release beginning.

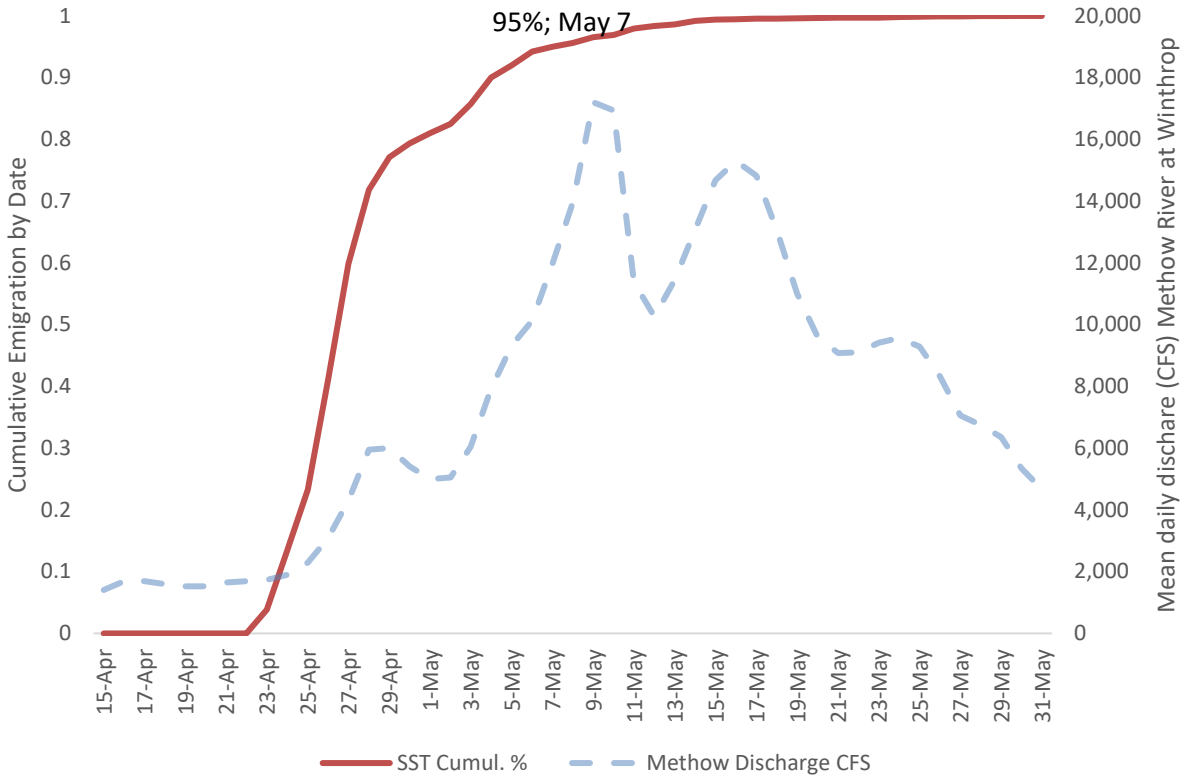

Figure 4. Steelhead volitional release emigration timing (at SCP) from WNFH.

Migration timing for steelhead from SCP to the Lower Methow River (LMR) has been reported in previous years. In 2018, high flows and corresponding damage to Methow River PIT monitoring sites precluded our ability to conduct similar run timing analyses within the Methow River. Detections at MRC and LMR were biased towards the early portion of the release due to antenna destruction during the latter half of the release. As such, only timing through key Columbia River projects is discussed. Both WNFH- and Twisp-release steelhead migrated to Rocky Reach Dam (RRJ) and Bonneville Dam faster than average, with on-station releases migrating faster than fish direct-planted into the Twisp River (Table 10).

Juvenile apparent survival rates through the Columbia River hydro system were calculated using Cormack-Jolly-Seber (CJS) models (Cormack, 1964; Jolly, 1965; Seber, 1965) available on Columbia River DART (Univ. of Washington, 2018). Both steelhead release groups exhibited higher apparent

survival than average in 2018, with Twisp River releases performing very well (76.5% survival to Rocky Reach; Table 10), likely due in part to obvious non-migrant fish being sorted out. Overall, combined WNFH steelhead release groups performed favorably when compared with other Upper Columbia releases (Figure 5).

Table 10. WNFH PIT-based juvenile steelhead survival rates and travel times to Rocky Reach (RRJ) and Bonneville dams (BON).

Brood year	Rel. year	Group	Travel Time > RRJ (median)			Survival to Rocky Reach		Travel Time > BONN (median)			Survival to Bonneville	
			Days	SE	N	%	SE	Days	SE	N	%	SE
2007	2008	WNFH S1	*no data*			*inf.*[2]		18.6	1.11	16	*inf.*[2]	
2008	2009	WNFH S1	*no data*			*inf.*[2]		26.3	2.24	9	*inf.*[2]	
	2010	WNFH S2	6.5	0.12	2,382	0.777	0.013	23.2	0.43	175	0.452	0.039
2009		WNFH S1	8.8	0.15	3,364	0.717	0.012	24.5	0.62	125	0.310	0.027
	2011	WNFH S2	13.8	0.11	1,810	0.641	0.013	23.9	1.35	18	0.335	0.091
2010		WNFH S1	16.7	0.25	804	0.472	0.014	27.2	1.65	13	0.247	0.096
	2012	WNFH S2	3.5	0.11	1,060	0.621	0.023	16.8	0.87	31	0.290	0.082
2011		WNFH S1	3.8	0.14	1,132	0.647	0.021	22.3	1.60	20	0.387	0.111
	2013	WNFH S2	4.6	0.06	3,174	0.591	0.017	14.8	0.44	74	0.341	0.051
2012		WNFH S1	8.3	0.11	3,255	0.700	0.022	19.9	0.79	65	0.501	0.102
	2014	WNFH S2	4.1	0.05	4,244	0.670	0.018	14.6	0.39	71	0.386	0.079
2013		WNFH S1	6.5	0.12	3,115	0.591	0.018	18.7	1.04	57	0.283	0.070
	2015	WNFH S2	6.3	0.08	4,586	0.588	0.011	21.5	0.44	110	0.187	0.017
2014		WNFH S1	9.3	0.14	4,659	0.590	0.011	23.9	0.70	100	0.203	0.018
	2016	WNFH S2	5.1	0.06	5,117	0.650	0.012	16.5	0.28	231	0.307	0.041
2015	2017	WNFH S2	4.6	0.06	4,873	0.673	0.015	13.4	0.73	56	0.431	0.130
2016	**2018**	**WNFH S2**	**3.9**	**0.04**	**3,457**	**0.681**	**0.019**	**13.6**	**0.54**	**41**	**0.491**	**0.138**
		Twisp[1]	**6.1**	**0.09**	**1,419**	**0.765**	**0.038**	**15.8**	**0.55**	**18**	*inf.*[2]	
Min.			**3.5**			**0.472**		**13.4**			**0.187**	
Max.			**16.7**			**0.777**		**27.2**			**0.501**	
Avg.			**7.0**			**0.648**		**20.4**			**0.343**	

[1]Direct-release sub-component of WNFH conservation program (not DPUD program). Release group was manually sorted to remove precocial parr and immature parr <140mm, resulting in apparent increased survival.
[2]Insufficient subsequent detections downstream of analysis location preclude survival estimates.

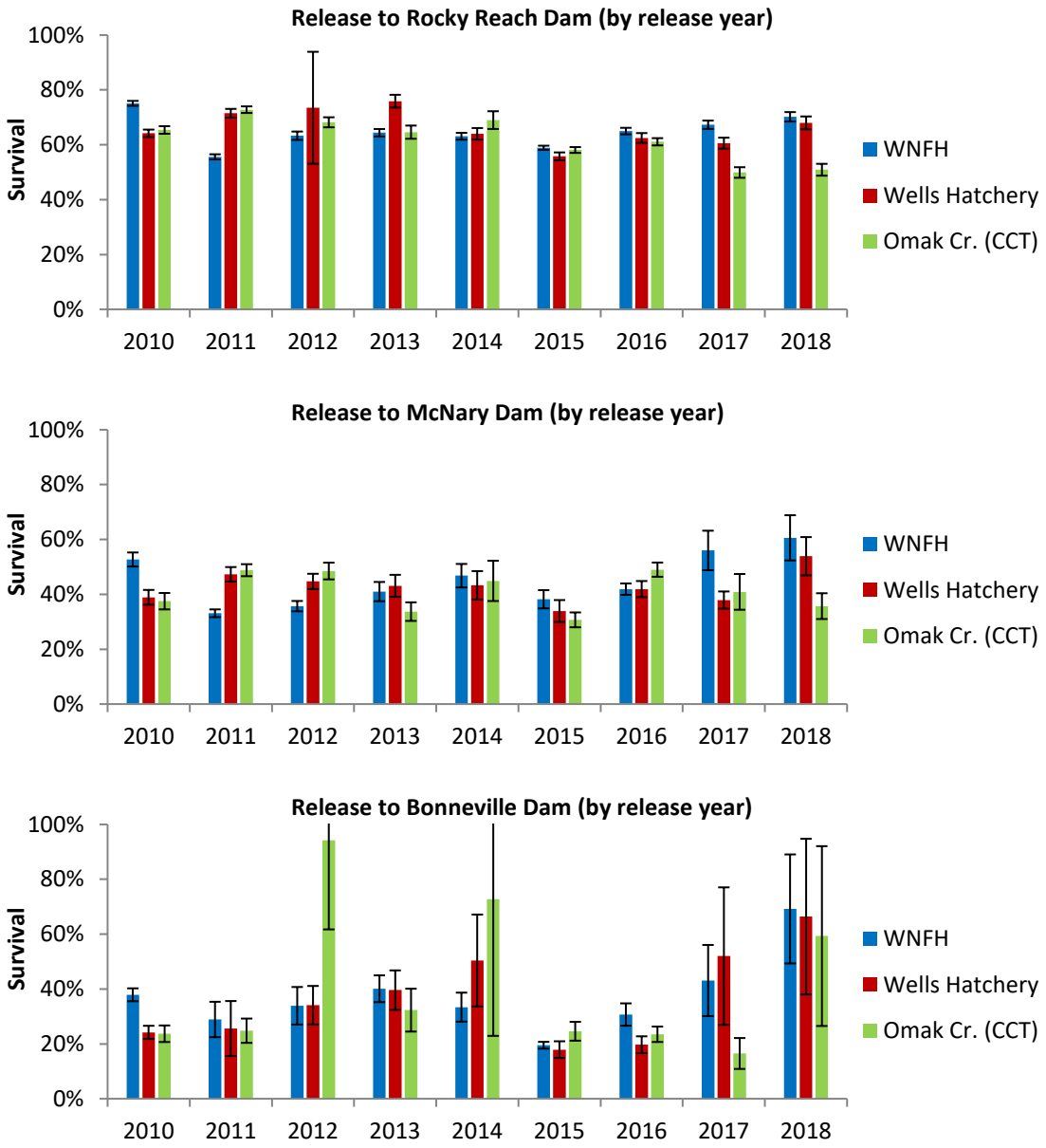

Figure 5. Comparative juvenile survival rates (error bars show SE) of Upper Columbia steelhead hatchery programs from release to Rocky Reach (top), McNary (middle), and Bonneville dams (bottom).

[1]Includes lumped broodyear and study groups, by release year.
[2]Includes lumped release sites within Methow Subbasin (excludes Wells Hatchery releases)
[3]Includes multiple release sites within Omak Cr. watershed since PIT releases were consistent across analysis period.

2017/2018 Adult Return

Run Forecasting

Upper Columbia summer-run steelhead returns to the lower Columbia River (i.e., to Bonneville Dam; Rkm 234) are closely monitored and afford upriver managers a relatively lengthy timeframe between mid/late-summer entry into the Columbia River, early fall arrival to Wells Dam, and eventual tributary

spawning from March to May the following year. PIT detection data at Bonneville and Wells dams between June and October of each year prior to spawning allows managers to generate fairly accurate return estimates, which can be used to guide adult management strategies that occasionally include implementation of conservation fisheries in the tributaries.

Natural-origin adult returns are more difficult to forecast since returns to Bonneville Dam are mixed stock, including co-migrating stocks with different run timing and behavior. Managers typically wait until these fish enter the DPS boundary (Priest Rapids Dam; PRD) to fully develop management strategies. Once natural-origin steelhead PIT tagged at PRD ascend their natal tributaries, their arrival timing to specific locations of interest can be retrospectively analyzed. Natural-origin adults that were tagged as juveniles are typically insufficient in sample size (and tagging ratio) to inform meaningful run forecasts.

PIT detections suggested that the 2017/2018 WNFH return above Bonneville Dam would be a minimum of 615 adult steelhead (Table 11) with an estimated 442 escapement to Wells Dam. The run was highly biased towards 1-salt adults from the BY14 (RY16) cohort since the 2-salt component, typically common in a return, experienced very poor survival likely due to poor estuary/ocean conditions in 2015.

Table 11. Pre-season WNFH steelhead forecast to above Wells Dam – 2017/2018.

Brood Year	Release Year	Unique PITs[1]	Tagging Ratio	Above Bonneville Minimum Estimated Adults[2]	Avg. Bonneville to Wells Dam Conversion[3]
2013	2015	1	5.1	5	4
2014	2015	10	1.3	13	9
2014	2016	92	6.5	596	428
		103		615	442

[1]Combined PITs detected at Bonneville, The Dalles, and McNary dams (collectively ~100% detection efficiency)
[2]Does not include lifetime PIT loss/failure rate; likely minimum run size estimate.
[3]Average conversion rate from Bonneville to Wells Dam, based on past years; see Run Conversion section.

Run Timing

Returning adult steelhead from WNFH are typically detected at Bonneville Dam (Columbia River Rkm 234) beginning in late June and the run is completed by early October. The 2018 run (fall 2017) was about a week late relative to the 2009-2016 average (Figure 6). The first few 2017 detections occurred around July 5, between 1 and 2 weeks later than usual. Half of the run had passed by August 20, about 10 days later than average. Most of the run (95%) had passed Bonneville Dam by September 19, earlier than average; however, the tail end of the WNFH run in 2017 fell off dramatically.

We cannot observe large samples of Methow-bound, natural-origin fish in-season, but those that eventually enter the Methow Subbasin can be retrospectively analyzed post-season. The 2017 natural and WNFH run timings were very similar and both later than average (Figure 6). The average (2009-2016) Bonneville Dam arrival timing of natural and WNFH fish is very similar. The first Methow-bound natural-origin fish in 2017 (2018 spawn escapement) was detected about two weeks after the first WNFH returned; however, low sample size (N=8) reduced the resolution of run timing.

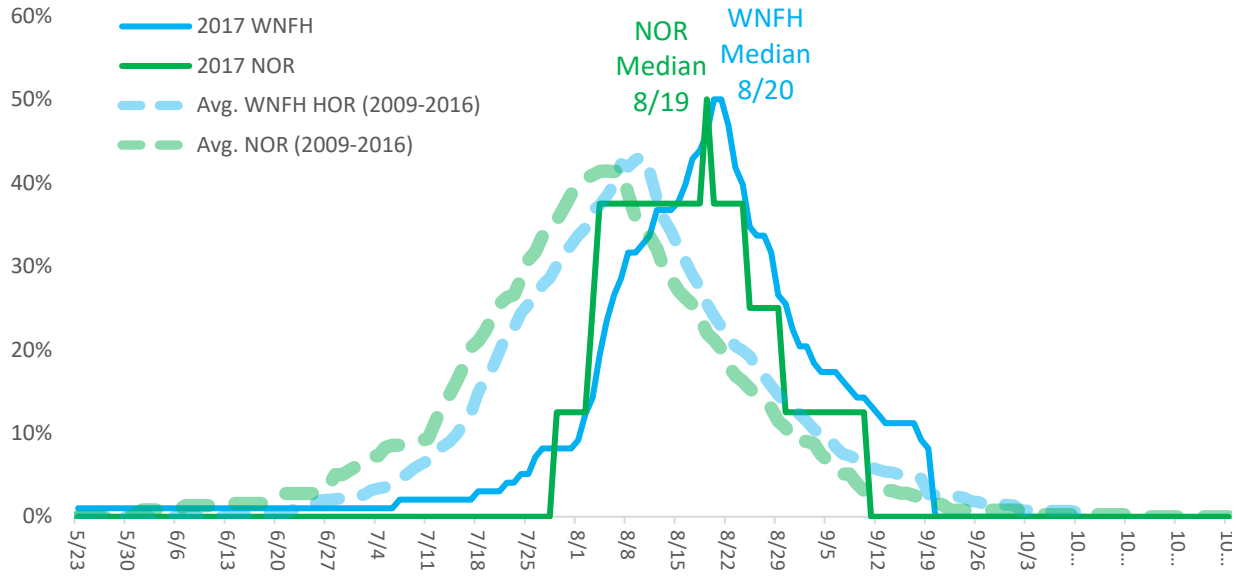

Figure 6. WNFH adult steelhead run timing at Bonneville Dam compared to previous returns – return year 2017 (2018 spawn escapement).

Most Upper Columbia DPS summer steelhead ascend to the lower reaches of their subbasin of origin to overwinter, though some remain in the Columbia River below (and in some cases overshooting) their tributaries of origin, then enter their spawning subbasin in the spring. Fuchs and Caudill (2018) found that roughly two-thirds of Methow Subbasin steelhead enter the Methow River the fall prior to spawning the next spring, while the remaining third enter from the Columbia River in the spring. This is similar to results found in the Okanogan and Wenatchee subbasins, but in contrast to the Entiat where all fish entered from the Columbia River in the spring prior to spawning. We report adult travel time from Bonneville Dam to Winthrop NFH for spring Chinook, but the extended and differential freshwater staging time of summer steelhead renders this specific reach-based analysis less meaningful for steelhead.

We track adult steelhead travel time from Bonneville to LMR (lower Methow River at Pateros), which indicates a return to the Methow Subbasin; however, arrival at Wells Dam may be a more appropriate comparison due to the variable tributary-entry timing noted above. Overall travel time for fish returning to Wells Dam in 2017 was very similar to the 2009-2016 average (Table 13), though 2017 travel time for the Bonneville-McNary reach was the slowest in 8 years of monitoring. Travel time from Wells Dam to the lower Methow (only about 15km) is likely affected heavily by environmental conditions and ultimately the proportion of the run at large that exhibits fall tributary entry versus spring tributary entry. Travel time from Wells Dam to the LMR site was 81.6 days, much longer than average and nearly the maximum reported travel time since 2009 – perhaps indicative that the population lingered longer in the Columbia River than in previous years.

Table 12. Winthrop NFH steelhead adult travel times (days) from Bonneville Dam to the Methow Subbasin.

Return Year	BONN > MCN[1]			MCN > PRD[1]			PRD > RIA[1]			RIA > Wells[1]			BONN > Wells[1]			Wells > LMR[1,2]		
	Avg.	SD	N =	Avg.	Avg.	N =	Avg.	SD	N =	Avg.	SD	N =	Avg.	SD	N=	Avg.	SD	N =
2009	15.7	14.7	72	5.8	1.9	72	4.8	2.9	72	5.2	2.3	72	31.1	16.3	72	32.5	62.1	72
2010	14.7	12.2	38	5.8	1.5	38	4.8	3.4	38	8.7	16.1	38	33.1	21.8	38	6.1	8.1	37
2011	10.4	6.1	230	10.5	8.1	230	5.8	4.2	230	6.4	3.9	230	33.0	13.4	230	85.2	80.0	230
2012	11.3	9.1	155	9.6	8.1	155	4.9	2.9	155	6.5	9.5	155	32.7	18.8	155	36.8	50.0	152
2013	15.5	13.8	183	6.4	3.2	183	5.4	4.7	183	5.7	4.0	183	32.6	15.9	183	12.1	32.5	183
2014	14.5	12.3	148	6.8	4.6	148	5.7	4.2	148	7.2	8.4	148	34.5	16.4	148	24.4	32.5	147
2015	12.6	10.0	177	6.7	5.0	178	5.3	4.2	177	5.4	5.6	177	30.1	13.3	178	26.5	37.0	178
2016	13.9	10.0	70	6.7	4.3	70	5.6	6.9	70	5.8	3.4	70	32.1	14.7	70	31.4	41.5	70
2017	18.9	12.1	98	5.0	1.4	98	5.7	7.0	98	4.2	2.1	98	34.5	13.3	98	81.6	69.9	98
Min[3]	10.4	6.1	38	5.8	1.5	38	4.8	2.9	38	5.2	2.3	38	30.1	13.3	38	6.1	8.1	37
Max[3]	15.7	14.7	230	10.5	8.1	230	5.8	6.9	230	8.7	16.1	230	34.5	21.8	230	85.2	80.0	230
Avg.[3]	13.6	11.0	134	7.3	4.6	134	5.3	4.2	134	6.4	6.6	134	32.4	16.3	134	31.9	43.0	134

[1]BONN – Bonneville Dam; MCN – McNary Dam; PRD – Priest Rapids Dam; RIA – Rock Island Dam; LMR – Lower Methow River at Pateros.
[2]Widely-ranging travel times to LMR may be associated with inconsistent operational periods due to ice damage, etc.
[3]Statistics calculated for 2009-2016 period.

Run Conversion

From Bonneville Dam, returning WNFH adults pass another seven dams before reaching Wells Dam, the last robust counting location prior to entering the Methow Subbasin. PIT tag detection efficiency at Bonneville Dam was reported to be >90% more than a decade ago (Burke et al 2006). Analysis of WNFH adult steelhead PIT ascending the Columbia River between 2009 and 2018 (using PTAGIS data) suggests detection efficiency has improved closer to 99% for both Bonneville and Wells dams. For the 2017/2018 run, about 71.4% of WNFH adults to Bonneville successfully made passage past Wells Dam (Table 13). Nearly all of these return to the Methow Subbasin (see Straying section). Subbasin returns across the years are not reported since individual PIT interrogation sites' operation timeframes and efficiencies vary widely across time and conversion rates are highly impacted by fishery closures/openings. Conversion of fish between mainstem projects in 2017/2018 was similar to the 2009-2016 average.

Table 13. WNFH steelhead passage success (conversion rate) from Bonneville Dam to Wells Dam.

Return Year(s)	Adjusted unique PIT detections[1,2]					Conversion efficiency by reach[3]				
	BONN	MCN	PRD	RI	WEA	BONN > MCN	MCN > PRD	PRD > RIA	RIA > WEA	BONN > WEA
09/10	72	54	54	53	53	75.0%	100.0%	98.1%	100.0%	73.6%
10/11	38	28	27	27	26	73.7%	96.4%	100.0%	96.3%	68.4%
11/12	230	183	181	178	176	79.6%	98.9%	98.3%	98.9%	76.5%
12/13	155	121	121	121	121	78.1%	100.0%	100.0%	100.0%	78.1%
13/14	183	134	134	130	129	73.2%	100.0%	97.0%	99.2%	70.5%
14/15	148	113	111	108	106	76.4%	98.2%	97.3%	98.1%	71.6%
15/16	178	139	137	135	133	78.1%	98.6%	98.5%	98.5%	74.7%
16/17	70	47	47	43	43	67.1%	100.0%	91.5%	100.0%	61.4%
17/18	**98**	**72**	**72**	**71**	**70**	**73.5%**	**100.0%**	**98.6%**	**98.6%**	**71.4%**
Avg.	130.2	99.0	98.2	96.2	95.2	75.0%	99.1%	97.7%	98.9%	71.8%
Min	38	28	27	27	26	67.1%	96.4%	91.5%	96.3%	61.4%
Max	230	183	181	178	176	79.6%	100.0%	100.0%	100.0%	78.1%

[1]Detection efficiency at mainstem projects adjust only by back-applying upstream detects to all downstream sites.
[2]BONN – Bonneville; MCN – McNary; PRD – Priest Rapids; RI – Rock Island; WEA – Wells; SCP – Spring Cr. (WNFH).

Harvest

WNFH steelhead are primarily subjected to mixed Columbia Basin fisheries; we lack evidence of ocean fishery interceptions via the Regional Mark Information System (RMIS.org), though anecdotal accounts of occasional ocean and estuary catches exist. There were no tributary conservation fisheries implemented targeting recent broodyears (BY14 and BY15). As such, estimated harvest rate for these groups lagged behind the BY07-13 average. Estimated harvest rate on BY14 (most recent complete cohort) was 8.3% of fish above Bonneville Dam, the lowest of all broodyears released in the recent history of the WNFH steelhead program (Table 14). Some tributary sport fishery CWT recoveries have not been expanded by effort/sampling rates, thus we consider these minimum recoveries/rates.

Table 14. Winthrop NFH steelhead estimated harvest rates.

Brood Year	Expanded Recoveries					Escapement above Bonneville Dam	Harvest Rate (%)
	Tribal - Combined Net	Sport - Columbia R.	Sport – Tributary[1]	Hatchery (combined)	Natural Spawners[2]		
2007	77	128	84	107	1,972	2,368	12.2%
2008	29	93	27	30	467	646	23.1%
2009	35	128	44	44	718	969	21.4%
2010	10	81	8	72	404	575	17.2%
2011	36	68	18	113	398	633	19.3%
2012	46	16	25	193	574	854	10.2%
2013	40	27	7	135	79	288	25.7%
2014	**24**	**31**	**0**	**120**	**486**	**661**	**8.3%**
2015[3]	16	26	0	N/A	N/A	300	14.0%
Avg.[5]	39	77	30	99	659	905	18.4%

[1]RMIS tributary sport fishery recoveries may not be expanded by sample rate, thus may under-report actual recoveries/rates.
[2]Natural spawner estimates do not include pre-spawn mortality or out-of-basin stray spawners.
[4]BY15 (release year 2017) return have not yet completed their lifecycle and reporting datastreams have not likely matured yet.
[5]Average values calculated for broodyears 2007-2013.

Straying

Hatchery stray rates are considered and analyzed from both genetic risk and homing perspectives. The WNFH steelhead program functions as an integrated conservation program with an explicit, recovery-focused goal to increase natural spawner abundance in the Methow Subbasin. Returns to the subbasin at large are intended and considered "homed", i.e. not strays. Returns to outside of the Methow Subbasin are considered strays, even those within the DPS (Okanagan, Entiat, etc.). These are undesirable and managed to a target total of <5% of the total cohort escapement. Further, the program is managed with a goal such that program strays should not comprise (additively with DPUD programs) >5% of any recipient population's population (NOAA 2017).

Since steelhead carcass recoveries are rare, PIT interrogation data are used to estimate stray and homing rates. Generally, final detection location was used to interpret presumed spawning location; however a number of assumptions and interpretations were made to assign a homing/straying status to a given fish. This method requires the assumptions that interrogation sites across the region have similar detection efficiencies and that interrogation coverage is similar in all areas where WNFH adults can potentially stray. In general, both timing and location indicative of straying were needed to assign stray status and ultimately some professional judgement was required by the biologist. Final tag detection inside the Methow Subbasin indicate a homed fish. Because we have observed substantial numbers of fish entering relatively colder tributaries (e.g., Deschutes and Wenatchee rivers) from the Columbia during summer/fall months, we discard most of these observations unless substantially upriver from the confluence (all summer/fall final detections discarded were routinely at the lowest site in a system; e.g., LWE at Rkm 2.7 on the Wenatchee River). PIT tagged steelhead from WNFH were analyzed beginning with BY07, through the most current cohort (BY16), which has not completed its lifecycle as 2-salt adults.

Estimated stray rates of WNFH releases have remained below the 5% permit maximum since BY07 (Table 15), with a maximum stray rate reported for BY14 (4.8%). Only one stray has been reported outside of the Upper Columbia Region (Clearwater River, Snake River Basin). Most strays observed each year occur in the nearby Okanogan Subbasin, with sporadic detections elsewhere. In general, nearly all WNFH adults return to the Methow Subbasin, with an average homing rate of >97% to the subbasin.

Table 15. Winthrop NFH steelhead stray and homing rates.

BY	Undetermined		Homed	Out-of-basin strays, by subbasin					Sample[3]	Rates (%)		
	Migr. Route[1]	Fall Dropout[1]	Methow Subbasin	Clearwater[2]	Entiat	Foster Cr.	Okanogan	Total Strays		Home	Stray	5y Avg.[4]
2007	77	0	42						42	100.0%	0.0%	1.5%
2008	135	0	73				2	2	75	97.3%	2.7%	1.3%
2009	197	0	106				2	2	108	98.1%	1.9%	1.9%
2010	126	2	115				1	1	116	99.1%	0.9%	2.8%
2011	122	6	94				4	4	98	95.9%	4.1%	3.1%
2012	114	2	87		1		3	4	91	95.6%	4.4%	3.7%
2013	71	2	92	1			3	4	96	95.8%	4.2%	3.5%
2014	100	2	119			1	5	6	125	95.2%	4.8%	2.7%
2015	**17**	**1**	**21**						**21**	100.0%	0.0%	2.2%
2016[5]	3	0	15						15	100.0%	0.0%	1.6%
Min[6]	71	0	42	1	0	0	0	0	42	95.2%	0.0%	1.3%
Max[6]	197	6	119	1	1	1	5	6	125	100.0%	4.8%	3.7%
Avg[6]	118	2	91	1	0	0	3	3	94	97.1%	2.9%	2.6%

[1]Final detections incapable of informing spawn location. Includes mainstem dams, fall detections in lower tributaries non-indicative of straying.
[2]Snake River Basin – only location outside of Upper Columbia DPS.
[3]Sample population with location/timing combinations indicative of final spawning location.
[4]5y-running average values for first and last few entries calculated using nearest available years' data.
[5]The lifecycle of BY16 steelhead from WNFH remains incomplete.
[6]Min./max./avg. values calculated from 2007-2014.

While the cohort-based stray rates reported in Table 15 are low, it is important to evaluate the potential impacts strays from WNFH can have on relatively small recipient populations, particularly in locations like the Entiat Subbasin, where there is no active steelhead supplementation. In these locations, even low stray rates from relatively large hatchery programs can genetically swamp the spawning grounds. PIT-based detections of WNFH steelhead in the Entiat Subbasin average <1 PIT/year (Table 14) – a discountable frequency and magnitude of genetic risk to the Entiat population. Total stray contribution to the Okanogan Subbasin steelhead population was estimated using PIT data allocated to spawn year. PITs were expanded by tagging ratio to estimate total WNFH strays in the Okanogan Subbasin, then comparing to total subbasin spawner escapement estimates reported by Miller et al. (2018). WNFH stray rates to the larger, actively supplemented Okanogan Subbasin (including the Canadian portion) were higher than in the Entiat Subbasin but have generally remained below 1% of the total spawning population, with the exception of 2016, when an estimated 1.7% of spawners were strays from WNFH (Table 15). Based on Columbia Basin PIT interrogation data, we suggest the stray risk of WNFH steelhead is highest in the Okanogan Subbasin, yet remains well below the 5% BiOp threshold.

Table 16. Estimated WNFH stray contribution to the Okanogan Subbasin total spawner escapement.

Spawn Year	Estimated WNFH strays	Okanogan Subbasin Spawner Escapement[1]	WNFH Stray Composition
2012	7	2802	0.2%
2013	5	1937	0.3%
2014	8	1356	0.6%
2015	4	1461	0.3%
2016	26	1566	1.7%
2017	7	1044	0.7%
2018	26	-	-

[1]Total subbasin escapement estimate from Miller et al. 2018.

Smolt-to-Adult Return (SAR) and Hatchery Replacement Rate (HRR)

The Smolt-to-Adult Return (SAR) is the primary post-release metric for evaluating hatchery program performance for a broodyear as it directly describes the number of adults produced from a juvenile release.

$$SAR = \frac{\#\ returning\ adults\ by\ broodyear}{total\ \#\ smolts\ released}$$

The Hatchery Replacement Rate (HRR) is a similar metric, which explains the number of adult returns (recruits) produced relative to the number of broodstock adults collected to produce them. The number of adults collected includes those fish used in spawning crosses, associated pre-spawn mortalities, and extras collected and spawned but later culled (e.g., expected disease risk-based culling, as is done with spring Chinook programs). Fish removed from the run for pHOS management or collected for inter-program transfers are not included in HRR because they are not specifically part of the program's fish culture plan. The metric is organized by broodyear and involves estimating returns in multiple spawn escapement years attributed back to a particular broodyear.

$$HRR = \frac{\#\ adult\ recruits}{\#\ broodstock\ collected}$$

For steelhead, populating these equations is done using hatchery release and spawn data and PIT-based escapement estimates. Because WNFH operates with dual objectives of recovery (increase natural spawners) and mitigation (contribute to fisheries) we consider adult returns to comprise escapement into

the Columbia River, including fishery recoveries. Notably, estimates of final successful spawner escapement for adults, by program, are very difficult to obtain; see Escapement Estimate/Summary section for more detail. Early-maturing life history varieties are not considered adults and their recoveries are excluded from these estimates. As discussed in the Straying section, some case-by-case interpretation is required, particularly for atypical PIT observations such as repeat-spawner steelhead kelts.

WNFH steelhead since broodyear 2007 have shown an average SAR of 0.63%, ranging from very poor (<0.1%) for groups released in 2015, to the highest value, 2.0%, for 2008 releases.

Hatchery Replacement Rate (HRR) have averaged 11.0 adults produced per adult removed for broodstock (Table 16), which compares very favorably against the Methow Subbasin's poor Natural Replacement Rates reported by Snow et al. (2019).

Table 17. Winthrop NFH steelhead smolt-to-adult return (SAR) and hatchery replacement rate (HRR) summary.

Brood year	Release Year	Rearing Group	Smolts Released	PITs @ BONN	Tag Ratio	Exp'd Adults[1]	SAR	Broodstock Used	HRR	NRR[3]
2007	2008	S1	116,897	101	23.4	2368	2.03%	N/A[2]		0.406
2008	2009	S1	102,418	15	20.5	307	0.30%	37	8.3	0.241
	2010	S2	29,170	161	2.0	318	1.09%	14	22.7	
2009		S1	71,208	146	4.8	701	0.98%	35	20.0	.282
	2011	S2	43,205	88	2.9	254	0.59%	16	15.9	
2010		S1	63,936	39	4.3	167	0.26%	29	5.8	0.245
	2012	S2	59,352	102	4.0	404	0.68%	30	13.5	
2011		S1	57,858	112	3.9	432	0.75%	N/A[2]		0.249
	2013	S2	57,894	48	3.9	189	0.33%	37	5.1	
2012		S1	53,827	118	3.7	436	0.81%	N/A[2]		N/A
	2014	S2	90,599	67	6.0	405	0.45%	46	8.8	
2013		S1	49,799	78	3.3	259	0.52%	N/A[2]		N/A
	2015	S2	76,078	3	5.1	15	0.02%	32	0.5	
2014		S1	19,405	13	1.3	17	0.09%	N/A[2]		N/A
	2016	S2	128,585	99	6.5	642	0.50%	66	9.7	
Avg.			68,015	79	6.4	461	0.63%	34.2	11.0	

[1]PIT expansions do not include some level of expected lifetime tag loss/bias that appears to occur and may reach 25%. As such, derivative metrics including SAR and HRR should be considered minimum values.
[2]Broodstock adults from Wells hatchery transfers was difficult to estimate for some years since transfers were eyed-egg stage.
[3]Natural Replacement Rate (NRR) values were taken from Snow et al. (2019).

WNFH steelhead SARs (by release year, for 2008-2014) averaged about 0.7%. Program performance was compared against two primary Wells Hatchery Complex release groups (Wells Hatchery on the Columbia River and Twisp River releases) using data from Snow et al. (2019). Wells Complex releases performed better than WNFH releases for all release-years analyzed (Figure 7). It is expected that Wells Hatchery releases would exhibit higher migration survival (and thus SARs) than WNFH releases since Wells Hatchery is located on the Columbia River mainstem about 100km downstream from WNFH. However, Wells Twisp River release groups share a similar migration distance to those from WNFH, yet out-performed WNFH release in all three years analyzed. We speculate this could be due to a combination of rearing and that the more optimal and consistent rearing conditions through the year at Wells Hatchery contribute to higher achievement of smoltification threshold, thus more successful migration.

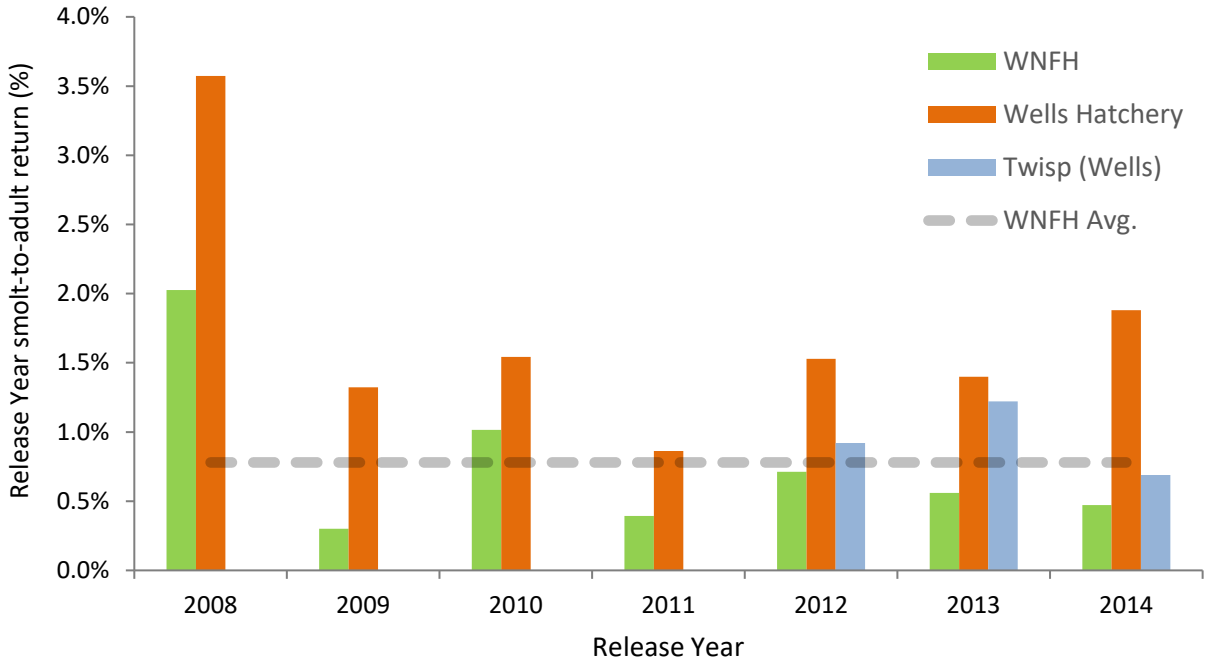

Figure 7. Winthrop NFH steelhead smolt-to-adult return (SAR) values (%) by release-year compared to Wells Hatchery programs.

2017/2018 Adult Management & Broodstock Collection

2017/2018 Environmental Conditions

Migratory conditions encountered by steelhead returning to the Methow Subbasin in summer/fall 2017 were characterized by slightly below-average flows as fish passed Wells Dam, transitioning to above-average flows (generally 125-150% of normal), including several significant events during the winter, and persisting into staging and spawning periods (Feb-May; Figure 8). Above average precipitation across the state, partly consistent with La Niña conditions in the tropical Pacific Ocean, helped to build snowpack late in the season (April). April weather recorded in Mazama, WA, was the 6th wettest on record (1950-2018; OWSC, 2018a), while May was recorded as the warmest on record at both Wenatchee and Republic, WA weather stations across 59 and 119 year periods of record (OWSC, 2018b). These conditions primed the subbasin for above-average summer flows during this spawning cohort's egg incubation period but likely below-average flows during early rearing.

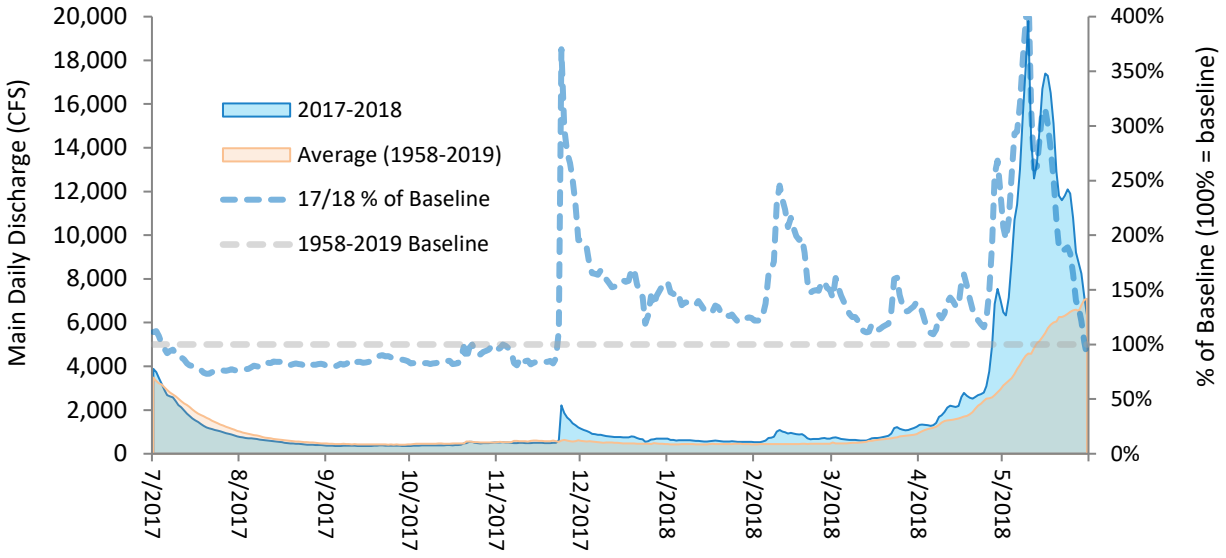

Figure 8. Methow River flow conditions experienced by 2017-2018 returning steelhead (USGS Station #12449950 at Pateros, WA).

2018 Broodstock and Adult Management-based Collection Effort

Steelhead broodstock collection for the WNFH and DPUD Twisp conservation and Wells Safety-net programs, as well as collective gene flow management objectives, is cooperatively accomplished between US Fish & Wildlife Service, DPUD, WDFW, and Yakama Nation. Prior to pre-season coordination, the Methow Subbasin's steelhead programs' Biological Opinion and permits had not been finalized. However, program operators and NOAA had been co-developing guidance for broodstock collection and adult management strategies in anticipation of final permit direction. These generally included broodstock collection targeting natural-origin adults via angling, removal of all encountered hatchery-origin returns for gene flow purposes and/or inclusion in the Wells Safety-net program, partial compositing of Twisp and WNFH conservation programs, and expanded spatial and temporal effort for angling-based broodstock collection. More detail on 2018 adult management efforts is available in Humling 2019a.

A total of 333 steelhead were removed from the run via combined sources and transferred to WNFH for holding (Table 18), excluding fish removed by WDFW for other purposes (see Spawner Composition and Gene Flow Metrics section). Most (N=260; 78%) steelhead collected in 2018 were angled from the run-at-large from February 6 to March 23, 2018; trapping at hatchery infrastructure increased in effectiveness (for removal of hatchery-origin adults) as the run moved upstream toward the hatcheries. Most collections occurred from March 23 to May 2, 2018. In total, hatchery traps captured 73 (22%) adults in 2018.

All fish were assigned preliminary origin (HOR/NOR). Hatchery-origin adults were also given a preliminary program based on external visual characteristics (e.g., adipose fin presence and dorsal fin condition) and presence of a CWT. Preliminary assignments were used in real-time to guide broodstock allocation and adult management objectives. Initial assignments were later verified through scale analysis or CWT identification. Post-spawn verification was then back-applied to collection summary data. Natural-origin returns (NORs) made up 40.2% (N=134) of the total collection (trapping and angling) while hatchery-origin returns (HORs) comprised 59.8% (N=199) of the total. Most NORs collected (92%) were caught by angling. All other NORs (N=11) were collected at the Twisp River weir. Only HORs were collected at the Spring Creek weir.

Steelhead retained and held at WNFH were ultimately used as broodstock (N=131), excessed for pHOS management (N=121), transferred to DPUD for use in the Wells Safety-net program (N=75), or returned to the river (NORs only) if excess to program needs (N=3). The final fate of all fish collected is described in Table 18.

Table 18. WNFH SST broodstock management ledger.

Broodstock management	Hatchery Origin		Natural Origin		Total Retained		Combined Total
	M	F	M	F	M	F	
Broodstock Collection and Brood Allocation							
Angling[1]	87	50	61	62	148	112	260
Spring Cr. Weir[2]	26	36	0	0	26	36	62
MFH Trap	0	0	0	0	0	0	0
Twisp Weir[3]	0	0	5	6	5	6	11
All sources	***113***	***86***	***66***	***68***	***179***	***154***	***333***
Pre-spawn mortality	0	2	0	1	0	3	3
Available at spawn	113	84	65	67	179	151	330
Spawning							
Lethal spawn	1	0	65	0	66	0	66
Live spawn > YN Kelt[4]	0	0	0	65	0	65	65
Transfers to DPUD[5]	44	31	0	0	44	31	75
Adult Management							
Excessed	68	53	0	0	68	53	121
Released to river (green)	0	0	1	2	1	2	3
Balance	***0***	***0***	***0***	***0***	***0***	***0***	***0***

[1]Excludes 8 fish angled and released upon capture.
[2]Spring Creek weir is in the WNHF outfall channel.
[3]Includes on those fish sent to WNFH. Additional fish were sent to Wells Hatchery or surplused on site.
[4]All NOR females live-spawned & transferred to YN Kelt program – figure does not include post-spawn mortalities.
[5]Live adult transfers to Wells Hatchery for use in Wells Safety-net Program.

The total 333 steelhead removed from the run in 2018 is the second highest since the local broodstock program began, and is demonstrative of the increased management effort associated with the WNFH program in the last few years (Table 19). Total adults spawned in 2018 at WNFH was also the largest number of steelhead ever spawned since the program began in 2008 – this is reflective of cooperative management and partial-compositing of the DPUD Twisp and WNFH conservation programs in 2018.

Pre-spawn mortality for combined adults held (i.e. inter-agency broodstock and fish ultimately surplused for pHOS management) in 2018 was 0.9%, comprising 3 adults (Table 18; Table 19). This low rate is consistent with the optimistic pre-spawn survival rate target of >99% (Appendix A). This has been achieved in only about a third of operational years; however, it must be noted that in three previous years when total collected adults was relatively low (2009, 2011, and 2013), single mortalities in each year resulted in statistical exceedance of the target rate (Table 19). Mortalities in any given year have been a mix of pond mortalities and hooking mortalities occurring during collection efforts.

Table 19. Winthrop NFH steelhead adult management summary, 2008-2018.

Brood year	Total Collected[1]	Pre-spawn mort. #H	#W	Total%	Spawned	Green, bad, spawned-out	Surplus	Return to River[2]	Transfer[3]
2008	14	0	0	0.0%	14		0	0	0
2009	29	1	0	3.4%	16		0	13	0
2010	78	2	0	2.6%	24		32	5	13
2011	38	1	0	2.6%	37		0	0	0
2012	114	0	0	0.0%	47		67	0	0
2013	64	1	0	1.6%	32		31	0	0
2014	106	2	0	1.9%	68		16	2	17
2015	193	2	0	1.0%	92		98	3	0
2016	221	6	2	3.6%	100	2	106	2	3
2017	416	5	0	1.2%	106		296	4	5
2018	**333**	**2**	**1**	**0.9%**	**131[4]**		**121**	**3**	**75**
Min[5]	14	0	0	0.0%	14	0	0	0	0
Max[5]	416	6	2	3.6%	106	2	296	13	17
Avg.[5]	127	2	0	1.8%	53.6	0	64.6	3	4

[1]Reflects fish handled/spawned at WNFH. Excludes fish transferred directly to Wells Hatchery.
[2]Generally wild fish excess to broodstock needs. Excludes fish immediately released during angling.
[3]Generally includes Twisp Conservation program adults and combined Twisp/Methow conservation adults for safety-net use.
[4]Increased total adults spawned reflects cooperative program management (DPUD Twisp & WNFH) conducted at WNFH.
[5]Time-series statistics calculated from 2008-2017 for comparison of 2018 program.

Following the successful collection of 333 adult steelhead, including the full pre-season target of 134 natural-origin adults, interagency managers were able to implement the HSRG hatchery Stepping Stone model effectively. This included allocating natural-origin adults to the WNFH and Twisp conservations programs, allocating substantial numbers of returning conservation program adults to the Wells Safety-net program, and surplusing remaining hatchery-origin returns (HORs) for gene flow management and tribal subsistence purposes. Table 20 displays final fate of carcasses.

Table 20. Summary of 2018 WNFH steelhead spawning final fish distribution.

Adult Steelhead Disposition	Carcass Fate	Total
Pre-spawn mortality	Buried	3
Lethal spawn[1]	Buried	63
Live-spawned	Transfer to YKRF[2]	69
Surplus	Subsistence Food[3]	60
Surplus	Education[4]	25[3]
Surplus	Buried	36
Transfer to Wells Hatchery	No Carcass	75
Excess to program needs	Return to River (live)	3
Total		333

[1]Males were lethally-spawned to obtain adequate fish health samples.
[2]All natural-origin females were live-spawned and transferred to the Yakama Nation Kelt Reconditioning Facility.
[3]Carcasses donated to the Colville Tribes' subsistence food program.
[4]Carcasses of inferior food quality donated to Cascade-Columbia Fisheries Enhancement Group for science in classroom use.

2018 Run Demographics

Broodyear (BY) 2013-2015 HORs and BY 2012-2015 NORs were expected to return to the hatchery and/or spawning grounds in the Upper Columbia for the 2018 spawn escapement. There is likely some level of bias in angling-collected and hatchery trap/weir collection but overall collection age structure of retained fish is shown in Table 21. For both HORs and NORs, the return was heavily skewed towards 1-salt returns; 94.9% of combined HORs and 88.8% of NORs were 1-salts and 2-salt adults were relatively scarce in 2018, due presumably to poor survival of smolts entering the ocean in spring 2015 (2-salts returning to the Columbia in summer 2017).

Table 21. Broodyear, Mark/CWT and Age-at-return of NOR and HOR steelhead by recovery source in 2018.

Origin	Brood year	Age	Mark	CWT	Collection Source			Total
					Angling	Spring Cr. Weir	Trap Twisp	
Hatchery-origin	2016	2.0	Ad-	NT[1]	1	0	0	1
	2015	1.1	Ad-	NT[1]	59	4[1]		63
			Ad+	636602	1			1
				636768	2			2
				636875	1			1
				NT[1]	2			2
	2014	1.2	Ad-	NT[1]	2			2
				054666	2			2
			Ad+	636545	3			3
		2.1	Ad-	055658	38	26		64
				055422	23	23		46
				LT[1]		3		3
				NT[1]	3	3[2]		6
	2013	2.2	Ad-	055684		3		3
HOR Totals					***137***	***62***	***0***	***199***
Natural-origin	2015	1.1	Ad+	No Tag[1]	3			3
	2014	2.1			87		7	94
	2013	2.2			7		1	8
		3.1			9			9
	2012	3.2			5			5
		4.1			1			1
	Unknown	R.1			9		3	12
		R.2			2			2
NOR Totals					***123***	***0***	***11***	***134***

[1]Age and origin of NT (non-tagged), LT (lost-tag), and NORs assigned based on stepwise process of mark condition, scale-reading, and age-at-length data, as necessary.

Whereas we report sex ratios for spring Chinook Salmon, we do not do so for collected steelhead. Collections in the field, transfers from MFH, and other sources, are inherently biased as efforts to collect broodstock shift across programs and seek to target specific groups. These data are inappropriate for run extrapolation and sampling from the run-at-large locations such as Wells and Priest Rapids dams is more

appropriate for such analyses. These data are available from WDFW (Snow et al. 2019; Truscott and See, unpublished)

The total 2018 collection consisted of about 40% natural-origin, 35% WNFH returns and 22% Wells Safety-net adults, not including about 2% Twisp Conservation program fish. These values do not include removals of adults at Wells Dam or hatchery ladder or any fish collected by WDFW/DPUD and transferred directly for Wells Hatchery programs. Values in 2018 are similar to average values reported since 2014; however, subbasin-wide steelhead program management has exhibited almost constant change even before 2008, when the first locally-collected steelhead were used for broodstock at WNFH. Notable in Table 22 are the overall increased total fish collected since 2014, increased collection of natural-origin adults since 2014, and recent increase in incorporation of Twisp hatchery-origin adults associated with program integration.

Out-of-basin strays appear to remain rare; however several assumptions have been made to support this: first, ad-clipped hatchery-origin adults that lack definitive CWTs or PITs identifying their stock/program cannot be positively eliminated as out-of-basin strays versus out-of-basin programs using the same mark strategy. Similarly, out-of-basin natural-origin adult inclusion in broodstock is possible. We retrospectively examined 415 pre-existing PIT tags over course of program evaluation (2008-2018) and discovered no PITs implanted into juvenile steelhead outside of the Methow Subbasin, supporting the claim that there are few natural-origin strays in these collections. We have also queried for out-of-basin natural-origin adults at the lower Methow River site (PTAGIS site LMR, formerly at Rkm 3, near the mouth) and found that some level of out-of-basin adult holding occurs in the lower Methow River. To reduce risk of possible inclusion of these into the programs, we introduced a best-management practice restricting collection to above Black Canyon (about Rkm 13), beginning in 2018.

Table 22. WNFH adult steelhead collections by origin/program/release location.

Return Year	Methow Subbasin Release Groups				Unknown	Out-of-basin strays			Total	Contribution to annual collection				
	Natural-origin	WNFH	Wells Hatchery Safety-net[1]	Wells Hatchery Twisp Conservation	Unknown hatchery-origin[1]	Pahsimeroi Hatchery[2]	Salmon River[2]	Yankee Fork[2]		Natural-origin	WNFH	Wells Hatchery Safety-net	Wells Hatchery Twisp Conservation	Out-of-basin
2010	9	10	5		1				25	0.36	0.40	0.20	0.00	0.00
2011	5	12	9		4				30	0.17	0.40	0.30	0.00	0.00
2012	11	15	27		3				56	0.20	0.27	0.48	0.00	0.00
2013	11	24	23		2	1			61	0.18	0.39	0.38	0.00	0.02
2014	64	14	9						87	0.74	0.16	0.10	0.00	0.00
2015	49	43	101	1		1	1	1	197	0.25	0.22	0.51	0.01	0.02
2016	84	50	85	1					220	0.38	0.23	0.39	0.00	0.00
2017	86	156	174	7					423	0.20	0.37	0.41	0.02	0.00
2018	134	118	74	7					333	0.40	0.35	0.22	0.02	0.00
Avg.[3]	71	66	92	3	0	0	0	0	232	0.39	0.24	0.35	0.01	0.00

[1]Wells Safety-net fish using adipose clip only (no CWT) leaving possibility that some are out-of-basin strays of unknown programs. Other unknown hatchery-origin fish through 2013 were due to insufficient data available.
[2]Pahsimeroi, Salmon River, and Yankee Fork programs are all located in the Snake River Basin.
[3]Average values computed from 2014-2017 to reflect current management approach.

Adult size-at-maturity data were examined, comparing groups organized by origin/program, sex, and salt-age. Hatchery-origin adults originating from both WNFH and Wells hatcheries were smaller than natural-origin adults of the same salt-age (Table 23); however, sample sizes for 2-salt hatchery-origin adults in 2018 were very low, likely due to poor ocean-entry conditions in spring 2015. Despite small samples sizes for some groups, observations in 2018 were consistent with previous years' data, for which natural-origin adults by sex and salt-age have been consistently larger than their hatchery-origin counterparts (2014-2018; Figure 9). In some years, natural-origin fish were determined to be significantly larger, in others, the difference was not significant.

Table 23. 2018 hatchery-origin adult return length-at-age compared to natural-origin steelhead.

Program/ Origin	Male						Female					
	1-salt			2-salt			1-salt			2-salt		
	Avg.	StDev	N =	Avg.	StDev	N =	Avg.	StDev	N =	Avg.	StDev	N =
WNFH	61.4	3.0	61	68.0	- -	1	59.4	2.4	54	69.3	3.1	4
Wells[1]	60.2	3.8	47	- -	- -	- -	58.9	2.4	24	71.0	- -	1
Wild	64.0	3.0	59	75.3	4.6	7	62.2	2.6	60	74.0	3.8	7

[1]Wells Hatchery origin determined by mark regime (Ad-clip, no-CWT) which may include small numbers of CWT-shed WNFH returns and/or other hatchery program returns. Salt-age determined using some scale results and previous years' age-at-length data.

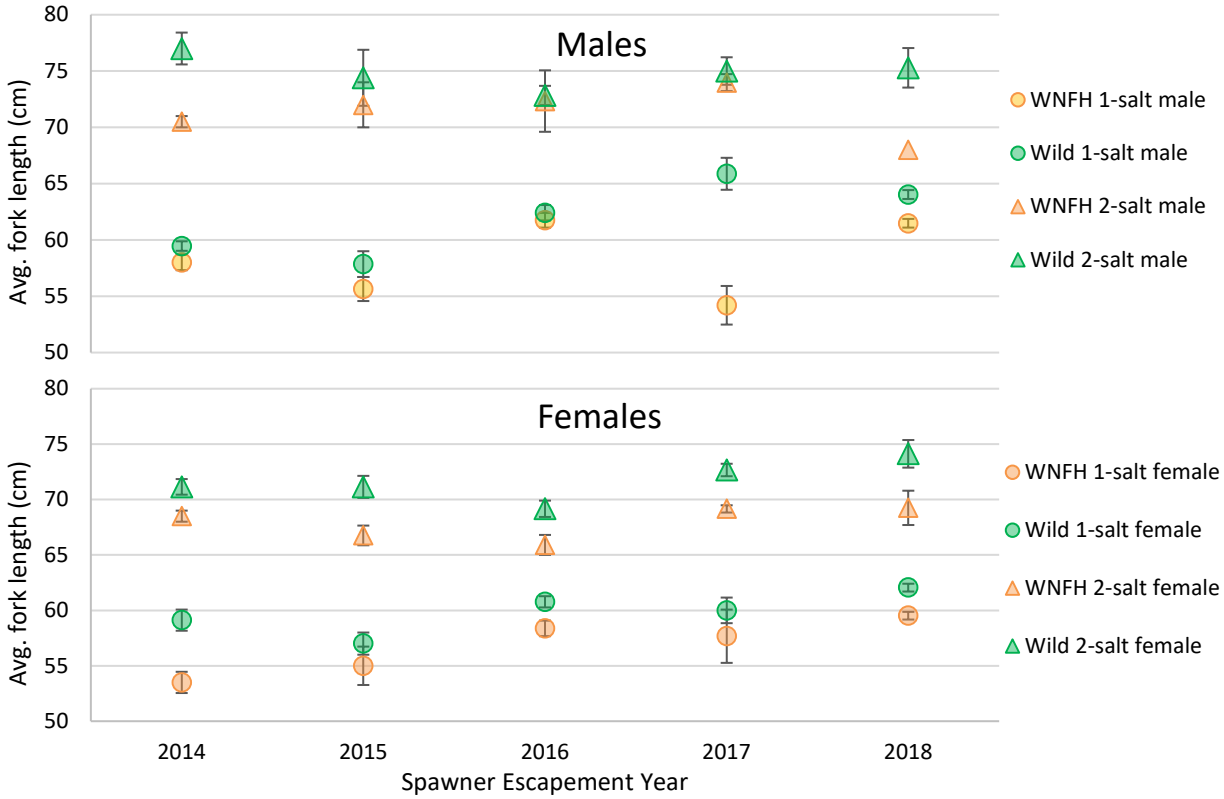

Figure 9. Comparison of returning adult WNFH conservation program steelhead and natural-origin length-at-salt-age (mean fork length; standard error).

Broodstock Allocation (BY18)

Steelhead adult collection continues beyond the first spawn day/egg-take and continues well into the natural spawning timeframe through the month of April via the Twisp and Spring Creek tributary trap locations. After all primary broodstock collection targets (with the exception of the Twisp Weir) had been met, a total of 61 additional steelhead adults (about 18% of total collection) were collected from the Spring Creek weir (all hatchery-origin) for adult management and Wells Safety-net program uses.

Following all transfers, pre-spawn mortalities, and all excessing events, WNFH allocated 131 preliminarily-identified natural-origin adults for use in the combined conservation program. These included one adult male incorrectly identified as natural-origin upon collection and later determined to be an unmarked hatchery return (via scale analysis). Using a simple broodstock total-based calculation, this equates to a program pNOB of 0.99, the highest reported pNOB in the history of the WNFH steelhead program. More detail on program pNOB and our recommended pNOB for BY18 pNOB in modeling applications is provided discussed in the 2018 Fecundity and Eggtake section.

Broodstock Fish Health Monitoring

To improve adult management and follow judicious use guidelines for antimicrobials as per FWS Fish Health Policy (2004), antibiotic injections of adult broodstock are not currently used as standard practice. However, held adults receive a prophylactic formalin treatment 3 days per week in the form of a one-hour flow-through treatment to prevent fungal infestations. The formalin treatments are not initiated until tribal surplus events have been completed.

Portions of the broodstock retained were tested for pathogens, including Viral Hemorrhagic Septicemia Virus (VHSV), Infectious Pancreatic Necrosis Virus (IPNV), and Infectious Hematopoietic Necrosis Virus (IHNV), and Oncorhynchus Masou Virus (OMV). Pathogen profiles for broodstock used were supplied by the Olympia Fish Health Center (USFWS). Protocols included testing broodstock through samples for bacteriology and virology on kidney/spleen samples (60 males) and virology testing on ovarian fluid (60 females).

Fecundity and Eggtake (BY18)

Fecundity data were collected from all fish spawned and compared by salt-age and program (Wells Hatchery data courtesy C. Frady; Table 25). Natural-origin females used in the BY18 program at WNFH had a mean fecundity of 5,281 green eggs, across combined salt-ages. Average fecundity in 2018 for both origin/program and salt-age groups was well above the average values over the previous few years.

Comparison of same-age NOR and WNFH program females not been done until recently. Using 2-sample T-tests as sample sizes allowed, we found returning 2-salt WNFH females in 2017 were statistically more-fecund than their natural-origin counterparts ($p=0.002$). Similarly, 2-salt WNFH females in 2018 were more fecund than their natural-origin counterparts, though samples size was small and the difference was not statistically different ($p=0.762$). In contrast, natural-origin 1-salt females spawned at WNFH were statistically more fecund than their WNFH counterparts in 2018 ($p=0.044$). While there is no obvious trend here, increased fecundity has been observed in domesticated hatchery stocks in the literature; large numbers of small eggs can be a selective advantage in a hatchery environment where egg/fry survival is very high (Heath et al. 2003). In this case, we believe this phenomenon may be due to sampling bias. First, we don't expect such rapid divergence in the first generation (F1) progeny of wild x wild crosses. Second, fecundity estimate methods at WNFH and Wells Hatchery, while similar, could vary sufficiently to impart non-random bias. Third, and perhaps most importantly, natural-origin females are live-spawned

at WNFH, whereas all WNFH adults are lethally spawned at Wells Hatchery. Variability in egg retention, staff experience, or other factors during live spawning may negatively skew natural-origin female fecundity estimates – we are hoping to examine this possibly further with additional research.

Table 24. Mean fecundity by salt-age for natural-origin steelhead used for the WNFH steelhead program compared to returning WNFH-origin adults.

Return Year	1-salt NOR			1-salt WNFH[1]			2-salt NOR			2-salt WNFH[1]		
	Avg.	StDev	N=	Avg.	StDev	N=	Avg.	StDev	N=	Avg.	StDev	N=
2011							6151	194	3			
2012	2546	1111	3				5005	2012	5			
2013	5452	2051	3				6391	337	3			
2014	4157	850	17				5584	1010	7			
2015	2909	957	2				5439	1132	14	6605	N/A	1
2016	3978	1086	21	1492	N/A	1	4722	1022	11	5760	N/A	1
2017	4198	892	3				5691	1015	48	6666	1103	19
2018	**5109**	**1012**	**57**	**4657**	**729**	**23**	**6513**	**1263**	**8**	**6806**	**154**	**2**

[1]Data for WNFH adults spawned at Wells Hatchery courtesy of C. Frady.

There was an overall positive (but low R^2 values) relationship between size (fork length) and fecundity for both 1-salt and 2-salt females (Figure 10). The relationship between size and fecundity of natural-origin females and returning WNFH 1-salt females (at Wells Hatchery) was similar at size (Figure 10), though hatchery-origin fish were slightly smaller on average, partly explaining the reduced fecundity. No comparison was made between 2-salt females as only one hatchery sample was available.

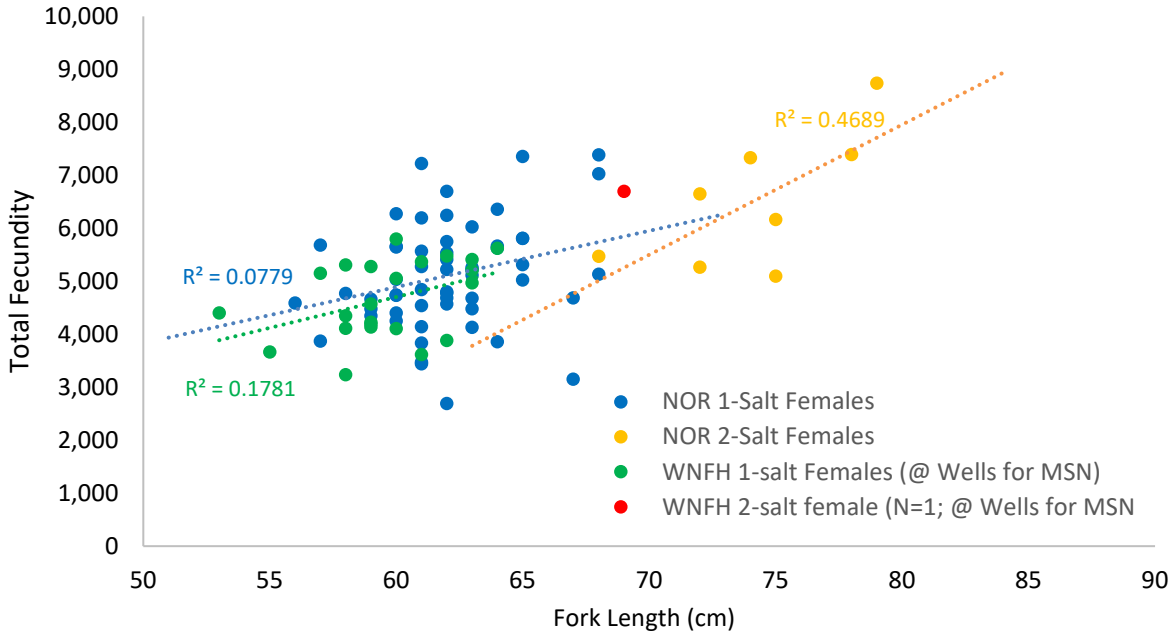

Figure 10. Fecundity by size (FL) and salt-age of 2018 WNFH steelhead broodstock.

Egg weight data (taken at eyed stage) were combined with fecundity estimates to estimate total gonadal mass for natural-origin females spawned at WNFH and returning WNFH females spawned at Wells Hatchery for the safety-net program (data courtesy C. Frady). Gonadal mass data were then plotted against size (fork length; Figure 11), displaying the expected positive relationship between the two

variables. This positive relationship is better pronounced (higher R^2) than the relationship between body size and fecundity, which supports the notion of variable egg size-based strategies. Comparison of the relationships between body size and gonadal mass (Figure 11) shows very similar relationship by origin/program (i.e. similar linear slope); however, it appears that returning WNFH 1-salt females have consistently lower gonadal mass at size than their natural-origin counterparts. This observation bears further investigation and may be associated with different methods for egg-weight estimates or other non-biological factors.

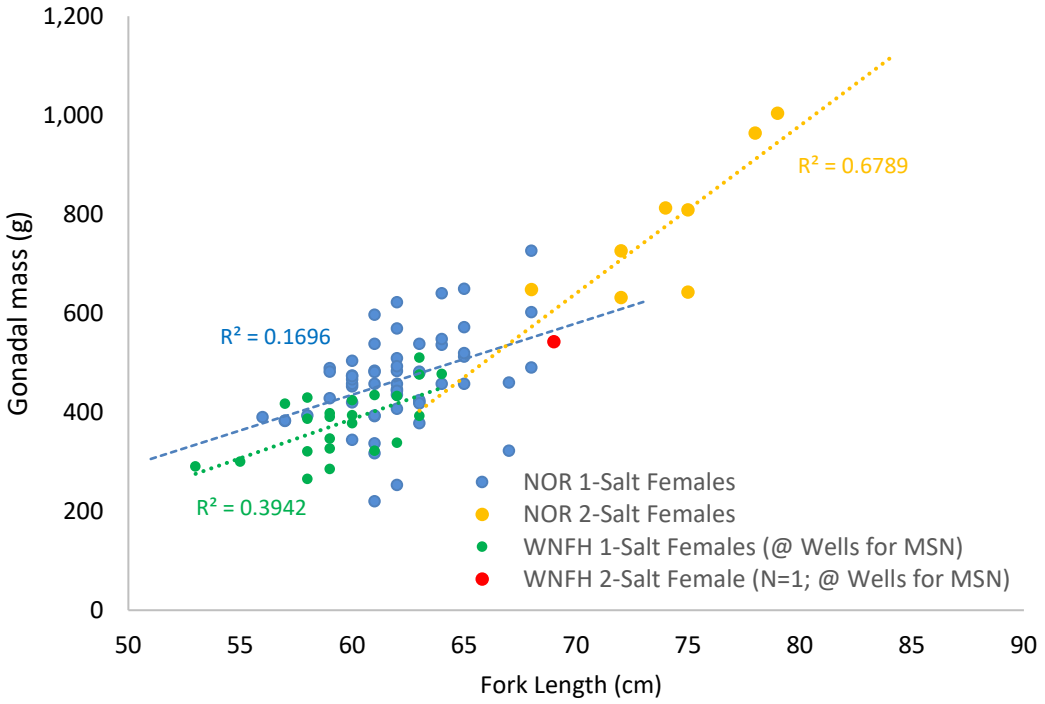

Figure 11. Gonadal mass by size (FL) and salt-age of 2018 WNFH steelhead broodstock.

The overall green eggtake for the combined BY18 conservation program, including DPUD/Wells Hatchery Twisp transfers and a small experimental group was estimated at 338,500 green eggs. This figure anticipated eyed egg transfers of approximately 55,000 (Twisp conservation) to Wells Hatchery and 30,000 to NOAA Manchester Laboratory for continuation of rearing duration studies. The remaining ~250,000 green eggs represented an approximate 10-11% overage of the 225,000 HGMP eggtake target (Appendix A), though this value is difficult to ascertain due to recent combined broodstock/eggtake strategies, alternate rearing strategies, and related rearing experiment goals. Concern over program eggtake overages was discussed at length post-season. Historic low pre-spawn mortality of broodstock adults, along with above-average fecundity in returning 1-salt females were considered in the decision to reduce broodstock collection targets to mitigate this concern beyond 2018.

Some natural-origin males were spawned twice to fertilize ovulated females when ready. A total of 130 effective parents contributed to 130 unique half-crosses via 2x2 factorial spawning. The simple, cross-based pNOB value was calculated at 0.992. To more accurately describe the release group, we also calculate fecundity (live egg)-weighted pNOB to account for relative contribution of families in the total juvenile release – using this methods we calculated a pNOB of 0.993 (Table 25). ***The fecundity-weighted pNOB value of 0.993 is recommended for future PNI calculations when BY18 adults return to spawn.*** This was the most successful year for the WNFH steelhead program as it achieved full program size,

within a strategic and collaborative management arrangement with DPUD/WDFW, at maximized pNOB of nearly 1.0, the highest since the program started (Table 29).

Table 25. Broodyear 2018 Methow conservation SST program spawn matrix summary with origin-cross and fecundity-weighted pNOB calculations.

Origin combinations (F x M)	Cross pNOB value	Simple pNOB calculations by origin-cross combinations			Fecundity-weighted pNOB calculation method		
		Sum of half crosses	% of effective brood	Contribution to NOB by crosses	Total eyed eggs	% of eggtake	Contribution to NOB by crosses
HxH	0.0	0	0.0	0.0	0	0.0	0.0
WxW	1.0	64	0.985	0.985	338,727	0.987	0.987
WxH	0.5	1[1]	0.015	0.008	4,567	0.013	0.007
Totals		65	1.0	**0.992**	343,294	1.000	**0.993**

[1]Broodstock adult preliminarily assigned as natural-origin but later determined possible hatchery-origin.

Table 26. WNFH steelhead release group percent natural origin broodstock (pNOB), 2014-2018.

Brood year	Total broodstock-based pNOB[1]	Effective Spawner pNOB[2]	Egg-weighted (live) pNOB[3,4]
2014	0.899	0.892	**0.900**
2015	0.575	0.663	**0.638**
2016	0.790	0.810	**0.782**
2017	0.764	0.804	**0.811**
2018	0.992	0.992	**0.993**

[1]Simple pNOB calculation defined by total number of natural-origin broodstock divided by total broodstock.
[2]Total number of natural-origin spawn crosses divided by total crosses, i.e. a male used twice counts as 2 effective fish.
[3]Same method as effective spawner pNOB but weighted by resulting live eggs – diff. egg survival/fecundity accounted for.
[4]Most precise pNOB value available for WNFH conservation release groups and recommended for use in PNI calculations.

2018 Natural Environment Monitoring

Escapement Estimate/Summary

Returning adult steelhead are inherently difficult to count and agencies are currently refining methods to apportion above-Wells Dam counts using multiple methods. WDFW staff in Wenatchee utilize a PIT-based escapement tool to estimate Upper Columbia DPS populations above Priest Rapids Dam (PRD), including major spawning populations in the Wenatchee, Entiat, Methow, and Okanogan subbasins (Truscott and See, unpublished data). These estimates are likely the most systematically-collected escapement estimates but they do not include in-season removals from specific areas (lower river pre-spawn mortalities, fishery removals, tributary broodstock/adult management removals, and hatchery swim-ins). WDFW staff in Twisp make these adjustments and estimate final spawner escapement in M&E reports for Wells Hatchery programs to DPUD (e.g., Snow et al. 2019).

Natural Spawner Composition and Gene Flow Metrics

WDFW estimates further expand the PRD estimates across the subbasin's tributary PIT antenna network. This method allows WDFW to apportion escapement into sub-components (conservation, safety-net, and natural-origin via mark strategy) distributed across a zone-based spatial scale described in the BiOp (NOAA 2017), including upper tributary conservation and mainstem management zones (Appendix C). PIT-based values are then adjusted by fishery and adult management removals and reported by Snow et

al., annually. The recent BiOp stipulates that by spawn year 2022 programs will have shared goals of basin-wide PNI of ≥0.67 with pHOS in the tributary conservation zone of ≤0.25, of which 0.20 (80% of allowable pHOS) can be combined conservation program spawners.

For 2018, Snow et al. (2019) estimated a subbasin PNI value of 0.59, insufficient to meet the 2022 BiOp target and HSRG (2009) guideline of ≥0.67 for integrated programs, but better than the interim target of ≥0.45 in the BiOp. Total pHOS in the conservation zone was 0.38, exceeding the maximum allowable in 2022; however, combined conservation program partial pHOS was 0.14, which was within allowable levels. Table 30 displays subbasin-wide and zone-based gene flow metrics for the recent five escapement years. Notably, PNI in 2018 is the highest value within the most recent 5-year period and conservation program partial pHOS has remained within allowable limits in all 5 years measured. These results are consistent with increasing coordination/effectiveness of adult management efforts and improved broodstock management (e.g., increasing conservation program pNOB).

Table 27. Methow Subbasin steelhead program gene-flow metrics for WNFH and Wells Hatchery programs (data courtesy of C. Snow).

Spawn year	Conservation Zone				Management Zone				Subbasin PNI
	NOR	ppHOS^{C,1}	ppHOS^{SN,1}	pHOS	NOR	ppHO^{C,1}	ppHOS^{SN,1}	pHOS	
2014	0.61	0.13	0.26	0.39	0.29	0.34	0.36	0.71	0.50
2015	0.54	0.14	0.32	0.46	0.17	0.11	0.71	0.83	0.46
2016	0.64	0.14	0.22	0.36	0.35	0.15	0.50	0.65	0.53
2017	0.39	0.18	0.44	0.61	0.25	0.19	0.56	0.75	0.43
2018	0.62	0.14	0.24	0.38	0.49	0.46	0.06	0.51	0.59

[1]ppHOS^{C} = partial program pHOS for combined conservation programs; ppHOS^{SN} = partial program pHOS for safety-net program.

Non-target Taxa Monitoring

Non-target Taxa Encounters, by Activity

The primary activity associated with the WNFH steelhead program during which non-target fish taxa (NTT) are encountered is angling-based broodstock collection. WDFW-maintained fish exclusion screens restrict entrance by NTT into WNFH ponds so all phases of fish production in the hatchery are isolated from NTT. The NTT of greatest concern are Bull Trout (*Salvelinus confluentus*) which are ESA-listed and subject to take limits (allowance of up to 40 non-lethal captures) and reporting requirements. Bull Trout allowances have never been exceeded; however, in 2016, captures were trending towards the allowable 40 adults captured (Table 28). Crews adopted a policy requiring them to leave site if two Bull Trout were caught and, since adopting this strategy, incidental capture has declined.

Table 28. Summary of non-target fish taxa incidental captures during inter-agency angling-based steelhead broodstock collection efforts.

Year	Bull Trout	Westslope Cutthroat Trout	Mountain Whitefish	*O. mykiss*[1]
2014	8	2	11	- -
2015	16	2	12	- -
2016	31	3	22	- -
2017	18	3	13	2
2018	11	9	3	1[2]

[1]Natural-origin (non-verified field identification), resident-form Rainbow Trout.
[2]Natural-origin (non-verified field identification), resident-form Rainbow Trout captured in WNFH outfall weir trap.

Remaining activities associated with the steelhead program that have potential to encounter NTT include electrofishing efforts associated with residualized steelhead in the vicinity of the hatchery. NTT encountered during these efforts included sculpins (*Cottus* spp.), Westslope Cutthroat Trout (*O. clarkii lewisi*), naturally-produced Chinook and Coho salmon and steelhead, Mountain Whitefish (*Prosopium williamsoni*), and Brook Trout (*S. fontinalis*). These electrofishing efforts last occurred in 2016 and are not further reported on.

Discussion of Performance against Program Targets

Broodstock Collection Objectives

Broodstock collection goals center on achieving locally-collected, high pNOB broodstock. WNFH has successfully met its local broodstock goal for the five previous broodyears through 100% local collection of high pNOB broodstock (Table 18; Table 25). Program partners were able to fully implement the pNOB/production sliding scale at the full production level (200K) while maximizing pNOB (0.993). Broodstock pNOB results for BY18 reflect continued improvement in broodstock management over the last few years (Table 26).

Juvenile Rearing/Fish Culture Objectives

Steelhead eggtake goals have varied for previous broodyears during the development of a finalized Biological Opinion and associated permit. US v OR obligations considered the uncertainty of tributary broodstock collection and allowed flexibility for smolt releases between 100-200K during the experimental shift from Wells-based to locally-based broodstock collection. The finalized BiOp, based on several years' experience, formalized a sliding pNOB/production target scale with set production targets between 100-200K, based on managers' ability to achieve broodstock pNOB targets.

Table 29 reflects estimated green eggtake for recent broodyears relative to specific broodyear smolt release and associated green eggtake targets.

Table 29. Summary of Winthrop NFH steelhead program green eggtake totals relative to program goals.

Brood year	Smolt release goal & associated mgmt. direction	Green eggtake		
		Target[1]	Actual	% of goal
2014	100K-200K (*draft* HMGP)	117K – 233K	153,627	N/A
2015	100K-200K (*draft* HMGP)	117K – 233K	268,364	N/A
2016	200K (*draft* HMGP)	233K[2]	243,340	+4.4%
2017	200K (*draft* HMGP) + 48K DPUD[3]	289K[2]	295,417	+2.2%
2018	200K (final BiOp) + 48K DPUD[3]	289K[2]	310,853	+7.6%
2019	200K (final BiOp pNOB sliding scale) + 48K DPUD[3]	289K[2]	YTBD	

[1]Formal eggtake targets are not published; values are back-calculated using 95% survival rate targets through each of green>eyed, eyed-fry, and fry>smolt stages.
[2]Eggtake goals are adjusted up to full production target (200K) based on strength of natural-origin run, and cooperative broodstock collection with DPUD Twisp Program.
[3]Interim management strategy including partial incorporation of DPUD Twisp and alternative release strategies.

Green eggtake has remained successful for all recent years. Slight over-collection of green eggs has occurred (about 2-8%). To address the risk of over-collection of natural origin spawners, managers and evaluation biologists balanced have made small reductions in total adult collection targets.

Eye-up rate for BY16 was 94.5%, just a below the target of >95%. Eye-up rates have averaged about 96.3% since 2008, when the program began spawning on site (Table 1). Similarly, rearing survival (fry to smolt) was similar at 93.5% compared to a goal of 95%.

Juvenile Release Objectives

Steelhead releases since 2014 have consistently met release number targets and fish have been >99% adipose-marked with CWT-tag rates generally in the high 90-percent range, in compliance with US v OR mitigation obligations (Table 6). Release totals in recent years have increased towards maximum sliding-scale production level (200K smolt release target), with about 220K released in 2017 and 150,392 released in 2018 (Table 6). Depending on the source of the error (egg enumeration, undocumented pond mortality pre-tagging, and/or other), fewer eggs would have been discarded and the 200K smolt release may have nearly achieved in 2018; however, it's noteworthy that the smaller release total was well within the interim 100-200K target.

Volitional release effectiveness analysis continues to evolve for the WNFH steelhead program. Smolt index-based residualism estimates support that residualism remains below 10%; however, we are continuing to refine our expanded juvenile release sampling methods to incorporate GSI (and perhaps other tools) to assess likelihood of residualism. Residualism remains a focal area of evaluation due to concerns about ecological/gene-flow impacts and mitigation intent of the program and its indirect effects to other performance metrics. Migrants from WNFH generally show as good, or better, outmigration performance to observable points on the Columbia River (e.g. Rocky Reach Dam) when compared to similar Upper Columbia steelhead programs (Figure 5). Residualism or incomplete smoltification may play some role in the paradox of the WNFH steelhead program's superior juvenile survival rates and inferior SAR rates.

Fishery Contribution and Harvest Objectives

There are no identified fishery contribution and/or harvest targets and much of these would be beyond the direct control of Winthrop NFH or Mid-Columbia FWCO staff. Fishery contribution values are summarized in the Harvest Contributions section. Recent harvest contribution through the latest complete cohort of fish (BY14) has averaged about 18% but we have concerns about the reliability of creel estimates in deriving these rates. More importantly, harvest rates for Methow River steelhead are highly dependent upon implementation of conservation fisheries above Priest Rapids Dam and in the Methow River. Immediate mitigation obligations were met fully through successful high marking/tagging rates.

Adult Management Objectives

More than 121 hatchery-origin steelhead, more than half of which were Wells Safety-net HORs, were removed from the spawner escapement during activities directly related to conservation program operations in 2018 (additional HORs were removed at Wells Hatchery). Since no tributary conservation fisheries have occurred above Priest Rapids Dam during the last several runs, fish removed by program cooperators (e.g., removals during broodstock collection and at Wells Dam) have remained the only hatchery-origin fish removed for gene flow purposes.

Collective efforts to reduce pHOS and increase PNI have effected slow, steady progress (Table 27). In 2018, some gene flow targets were achieved. Subbasin PNI was estimated at 0.59, meeting the interim target of >0.45 but not the 2022 target of >0.67. Conservation program (WNFH and Twisp) pHOS goals have been met in the conservation zone since 2014, though conservation zone and overall pHOS total rates have remained sufficiently high to preclude attainment of 2022 PNI goals at the subbasin scale.

In summary, significant progress has been made in the last decade; however, because all pHOS and PNI targets are not currently being fully achieved (in comparison to the 2022 target), long-term adult management objectives are not yet being fully met (Table 27). Selective pressures may likely continue to favor the hatchery environment. We expect continued improvement associated with adult and broodstock/gamete management that will not be fully realized until 2021-2022.

Stepping Stone Implementation and Inter-agency Coordination Objectives

Coordinated broodstock collection and adult management efforts are improving gene flow metrics on the spawning grounds and in the conservation and safety-net programs through inter-hatchery management. Escapement-based targets may be tracking towards meeting BiOp goals in 2022; however, much depends on the size and composition of future return cohorts, particularly natural-origin run strength. Following are recommendations for maximizing the ability to achieve gene flow goals in future years:

1) As feasible within allowance of the BiOp and details of the US v OR agreement, maximize pNOB in the Conservation Program broodstock, with bias towards lower production/maximum pNOB vs. maximum production/compromised pNOB.
2) As feasible within allowance of the BiOp and details of the US v OR agreement, maximize proportion of conservation program adults in the safety-net broodstock.
3) Maximize removal of Wells Safety-net adults via fisheries and aggressive adult management during broodstock collection and via hatchery infrastructure
4) Under some run scenarios, proceed with caution when removing Conservation Program returns - removal of more Conservation Program adults than necessary could hinder the ability to attain safety-net partial pHOS targets, even in situations where PNI targets are theoretically attained or approached.
5) Continue collaborative inter-agency coordination, planning, and implementation of Methow Subbasin programs. Improve holistic reporting of performance and risk metrics since none of the conservation programs or safety-net programs can function independently.
6) Investigate feasibility and value of DPS-wide escapement analyses to include all subbasins above PRD.

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Appendix A. WNFH Steelhead Program Monitoring Goals & Objectives.

Stage	Monitoring Attribute	Operational Criteria/Target	Source of Criterion/Target
Broodstock Collection & Management	*Stock & DPS*	Methow Subbasin, Upper Columbia Summer DPS	HGMP
	Strategy	Integrated Conservation, supports Stepping Stone	HGMP
	Collection locations	Primarily angling, Methow Subbasin	HGMP
	Ladder operation	N/A, angling collection throughout run	HGMP, BiOp
	Broodstock collection target	Up to NOR[1] 62 pairs, including DPUD Methow/Twisp.	US v OR
	Prophylaxis	Formalin treat ADHP	Washington State Co-managers Disease Control Policy
	Adult holding temperature	<52°F (<11°C)	Facility-specific operational detail
	Adult pre-spawn survival	>99%	Facility-specific operational detail
	Adult sampling	Generally 100%, representative sub-sample in high escape.	HEP
	Adult monitoring	Origin/sex/age/length/external mark/Tag ID	HEP
Spawning	*Spawner M:F ratio*	2 x 2 factorial	HGMP
	Fish Health Monitoring	100% ovarian virology females; bacteriology/virology males	Washington State Co-managers Disease Control Policy
	Adult sampling	100%	HEP
	Adult monitoring	Origin, sex, age, length, mark, CWT	HEP
	Jack (age-3) males in brood	N/A	HGMP
Eggtake, inclubation, & Gamete Management	*Green egg target*	289,000 (includes DPUD portion)	HGMP
	Prophylaxis	Disinfect, water harden	WA Co-managers Disease Control Policy
	Incubation units	Heath trays	Facility-specific operational detail
	Water source	Well/Infiltration galleries	Facility-specific operational detail
	Water quality monitoring	Temperature, flow rate, & gases if suspect	Facility-specific operational detail
	Culling	N/A unless virology concerns (e.g. IPN)	HGMP
	Post-cull egg total	N/A	Facility-specific operational detail
	Shocking	Eggs kept at 1 female per tray	Facility-specific operational detail
	% green-to-eyed egg	≥95%/216,000 + 48,000 to Twisp/Alt. program	HGMP
	% eyed-to-fry	≥95% /205,000 fry	Facility-specific operational detail

[1]NOR pairs are maximized. Some HOR adults from Conservation programs can be included on sliding scale.

Appendix A. Continued

Early Rearing Parameters	*Rearing units*	Starter tanks	Facility-specific operational detail
	Water source	Well/Infiltration Galleries	Facility-specific operational detail
	Water quality monitoring	Temperature, flow rates, dissolved gases when needed	Facility-specific operational detail
	Feed type	Bio Oregon Starter Feeds	Facility-specific operational detail
	Feed frequency	6-8 times/day	Facility-specific operational detail
	Feed amount (%BW/Day)	1.0-2.5%	Facility-specific operational detail
	Cleaning frequency	Daily	Washington State Co-managers Disease Control Policy
	Monthly monitoring	Len/wt./K/CV	Facility-specific operational detail
Pre-Tagging Rearing Parameters	*Rearing units*	8 x 80 raceways	Facility-specific operational detail
	Water source	Well/infiltration gallery, river (winter)	Facility-specific operational detail
	Water quality monitoring	Temperature, dissolved gases when needed, & flow rates	Facility-specific operational detail
	Feed type	Bio Oregon Feeds; Vita, Bio Pro 2, Bio Clarks Fry	Facility-specific operational detail
	Feed frequency	2-4 times/day	Facility-specific operational detail
	Feed amount (%BW/Day)	1.0-2.0%	Facility-specific operational detail
	Feed application	Hand	Facility-specific operational detail
	Cleaning frequency	1-3x per week	Washington State Co-managers Disease Control Policy
	Mass marking	100% Ad-clip + CWT, including 20K PIT	US v OR (marking), HEP describes PIT use/objectives
	Monthly monitoring	Monthly fish health & biometrics, CWT & PIT retentions	Washington State Co-managers Disease Control Policy, HEP

Appendix A. Continued

Post-Tagging Rearing Parameters	*Rearing units*	8 x 80 raceways	Facility-specific operational detail
	Water source	Well/Infiltration Galleries/River	Facility-specific operational detail
	Water quality monitoring	Temp., dissolved gases when needed, & flow rates	Facility-specific operational detail
	Feed type	Bio Clark, BioSupreme	Facility-specific operational detail
	Feed frequency	Variable: Daily to 3x/week	Facility-specific operational detail
	Feed amount (%BW/Day)	1.0-2.0%	Facility-specific operational detail
	Feed application	Hand	Facility-specific operational detail
	Cleaning frequency	Brushed 1-2x/wk	WA Co-managers Disease Control Policy
	Monthly monitoring	Monthly fish health & biometrics	WA Co-managers Disease Control Policy
	Water temperature	<60°F	Facility-specific operational detail
	Dissolved O_2	<80% saturation & 5ppm	Facility-specific operational detail
	Turnover rate	≤ 1/hour	Facility-specific operational detail
	Density Index	≤ 0.20	Facility-specific operational detail
	Flow Index	≤ 1.0	Facility-specific operational detail
Smolt Release	*Condition factor (K)*	1	Facility-specific operational detail
	Size (FPP)	5-6	HGMP
	Early maturation (% males)	<10%	BiOp (pending)
	Release type	Volitional	HGMP
	Release time	3rd week of April	HGMP
	Release Goal	100,000 - 200,000, pNOB/Production sliding scale	US v OR and BiOp (sliding scale)
Survival and Escapement Metrics	*Green egg to smolt survival*	85%	Facility-specific operational detail
	Green egg to fry survival	90%	IHOT, HGMP
	Fry to smolt survival	95%	IHOT, HGMP
	Smolt to adult survival	0.50%-2.0%	Facility-specific operational detail
	Hatchery return rate (HRR)	>2, see BiOp: dependent on pNOB/pHOS/PNI	BiOp
	Partial pHOS on spawn. grnd.	0.2, cons. prog. total w/sliding scale in mgmt. zones	BiOp
	Subbasin PNI	≥0.45 (through 2021); ≥0.67 (starting in 2022)	BiOp
	Stray rate to other subbasins	<5% of total escapement (HSRG *guideline*)	BiOp (in Permit 18927)

Appendix B. Section 4(d) Limit 5 Reporting Requirement Summary.

NMFS's Section 4(d) Limit 5 authorization (NOAA 2019) for the Winthrop NFH steelhead program includes authorization/provision of direct and incidental take as well as reasonable and prudent measures (RPMs), implementation terms and conditions (T&Cs), and conservation recommendations (CRs).

Direct and indirect take associated with Methow steelhead programs are assessed through indirect surrogates discussed throughout this report. This summary appendix accompanies the WNFH annual report to directly address the RPMs, implementation T&Cs, and CRs, and is consistent with activities through completion of the BY16 steelhead release period, summer 2018.

RPM 1. The USFWS implement the hatchery program and operate the WNFH facility as described in the Proposed Action (Section 1.3) and in the submitted HGMP.

RPM 1 was maintained for this operational period. The only major modification to the HGMP, as proposed, was incorporation of Winthrop NFH and Twisp conservation programs and associated release locations. These resulted in no net change across combined Methow Subbasin programs. Modification of the programs was discussed and vetted in the Wells HPC Hatchery Committee and notification/consultation included NOAA Fisheries representatives.

RPM 2. The applicant provide reports to Sustainable Fisheries Division (SFD) annually for the WNFH program, and associated RM&E.

Through the submission if this annual report (the first published), RPM 2 is satisfied.

T&C 1.a. Provide advance notice to NMFS of any change in hatchery program operation (including early releases) that potentially increases the amount or extent of take, or results in an effect of take not previously considered

No major changes in operation requiring notification except that noted for RPM 1 occurred during the operational period.

T&C 1.a. Provide notice if monitoring reveals an increase in the amount or extent of take, or discovers an effect of the Proposed Action not considered in this opinion

No major observations during monitoring suggest substantial increases in the amount/extent of take occurred. We are actively continuing to monitor the incidence of residualism on juvenile release groups, are actively pursuing research in this area, and are in discussion with NOAA, as 5y average rates begin to materialize.

T&C 1.c. Allow NMFS to accompany any employee or representative field personnel while they conduct activities covered by their biological opinion

NOAA/NMFS representatives are encouraged to join USFWS in any field activity at any time.

T&C 1.d. Develop a marking scheme, in coordination with the HCP Hatchery Committee and US v Oregon processes, to be implemented before fish are marked for the 2019 release, with the

goal of facilitating adult management, broodstock collection, and assessment of hatchery escapement into the wild

No changes to the marking scheme for WNFH conservation program steelhead have been implemented as of 2019. The current mark combination is (external) 100% adipose-clip and (internal) 100% unique CWT along with a high PIT-tag mark rate (avg. 20K/year). These allow for adequate M&E activities to be implemented. The primary disadvantage currently is lack of ability to implement a mark-selective fishery on differentially-marked conservation and safety-net adults by anglers. The HCP Hatchery Committee has discussed this issue. Program managers have been reluctant to impose a ventral fin clip due to added cost, concern of regeneration, and conflicting findings in the literature about survival – USFWS is of the opinion this mark should not be used for any WxW conservation program steelhead, particularly when alternative removal methods can be used.

Appendix C. PIT Interrogation Locations where WNFH Juvenile Steelhead were detected in 2018 in relation to management and natural production emphasis areas.