United States Department of the Interior
Fish and Wildlife Service
Mid-Columbia Fish & Wildlife Conservation Office

Main Office:
7501 Icicle Road
Leavenworth, WA 98826
Ph 509-548-7573 Fax 509-548-5743

Winthrop Field Station:
PO Box 429
Winthrop, WA 98862
Ph 509-996-2204 Fax 509-996-3207

MEMORANDUM

TO: Interested Parties

FROM: Michael Humling and Natalie Scheibel, MCFWCO

DATE: Jan 4, 2017

RE: 2016 WNFH Steelhead Broodstock Collection and Adult Mgmt Summary

SUMMARY

This memo discusses the 2016 Winthrop National Fish Hatchery (WNFH) summer steelhead (*Oncorhynchus mykiss*) program, from broodstock collection through spawning and egg disposition at the hatchery. Detailed information is presented on inter-agency broodstock transfers, spawning disposition and demographics of collected adults, use of hatchery-origin adults in a National Oceanic and Atmospheric Administration (NOAA) relative reproductive success (RRS) study, and success as measured by program goals. This memo is meant to summarize data specific to 2016 operations and capture intricacies and nuances of the 2016 season from which recommendations can be drawn to improve operations in subsequent years. It is not meant to capture data/performance metrics across brood- or escapement years; these data will be presented in annual summary data tables.

INTRODUCTION

The Upper Columbia River (UCR) steelhead distinct population segment (DPS) was first listed as Endangered under the ESA in 1997 (63 FR 43937), was twice reclassified, and has been classified as Threatened since 2009 (74 FR 42605). Biological Opinions associated with the operation of the Federal Columbia River Power System (FCRPS) include a number of Reasonable and Prudent Alternative (RPA) actions including many operation-specific actions associated with programs across the range of Biological Opinion species and activities. Specific to Winthrop NFH is an RPA Action (RPA 40) that directed the program to implement measures to transition to local broodstock and to manage the number of WNFH-produced adult steelhead on the spawning grounds. Prior to broodyear (BY) 2008, all steelhead released from WNFH were obtained from Wells Hatchery as eyed eggs and reared to smolt size at WNFH. Broodstock collected for this strategy were a composited stock of hatchery fish collected from the mainstem Columbia River, including fish from the Methow and Okanogan subbasins, as well as hatchery fish from a range of other tributaries, some outside the Upper Columbia. To better integrate the natural-origin and hatchery populations, WNFH transitioned to 100% locally-collected (see Appendix A) broodstock over the BY2008-BY2014 period and has successfully used angling as the primary collection method to target natural-origin adults, which do not home to the hatchery. WNFH continues to use this strategy, in cooperation with Washington Department of Fish & Wildlife (WDFW), Douglas Co. Public Utility District (DPUD), Yakama Nation (YN), and other partners to achieve multiple program goals.

BROODSTOCK COLLECTION

The 2016 WNFH broodstock collection targets approximately 55 local pairs from the Methow River, attempting to maximize the proportion of natural-origin broodstock (pNOB; >0.5), for a full program release of 200,000 smolts. The US Fish & Wildlife Service (USFWS), YN, WDFW, and NOAA staff, as well as volunteers, collected broodstock via coordinated angling efforts from 22 February through 12 April, 2016. Adult steelhead were simultaneously trapped at Methow Fish Hatchery (MFH) in coordination with WDFW staff, at the WNFH fish ladder, and Spring Creek trap (at WNFH). Basic biometrics including; size, mark, fin condition, sex, CWT/PIT presence, origin, and capture location were recorded for retained adults. Steelhead retained were Floy® and PIT-tagged for later identification and held at WNFH until ready to spawn.

A total of 219 summer steelhead were collected from the Methow River in 2016 including 84 natural-origin returns (NOR) and 135 hatchery-origin returns (HOR; Table 1). Fish collected were either used as broodstock, incorporated in a relative reproductive success study (“NOAA RRS study”), or excessed to manage the proportion of hatchery-origin spawners (pHOS) and geneflow dynamics (PNI) on spawning grounds in the Methow Subbasin; final fate of all collected fish is described in Table 3.

NOR steelhead were primarily collected in the first half of the collection period, while the number of HOR steelhead collected lagged slightly behind, but steadily increased around mid-March (Figure 1). NOR steelhead were difficult to obtain later in the season, as they may have moved further up the Methow River or into tributaries to seek out spawning habitat. Another possibility for HOR-biased collection during the later portion of the season was bias introduced due to restricted fishing conditions under the rising hydrograph; NOR collections declined to negligible levels about the week of 27 March (Table 1), coinciding with the increasing flows in the Methow River (Figure 2). As angling conditions degraded, crews increasingly relied on angling locations in closer proximity to the hatcheries, likely biasing catches towards hatchery-origin returnees.

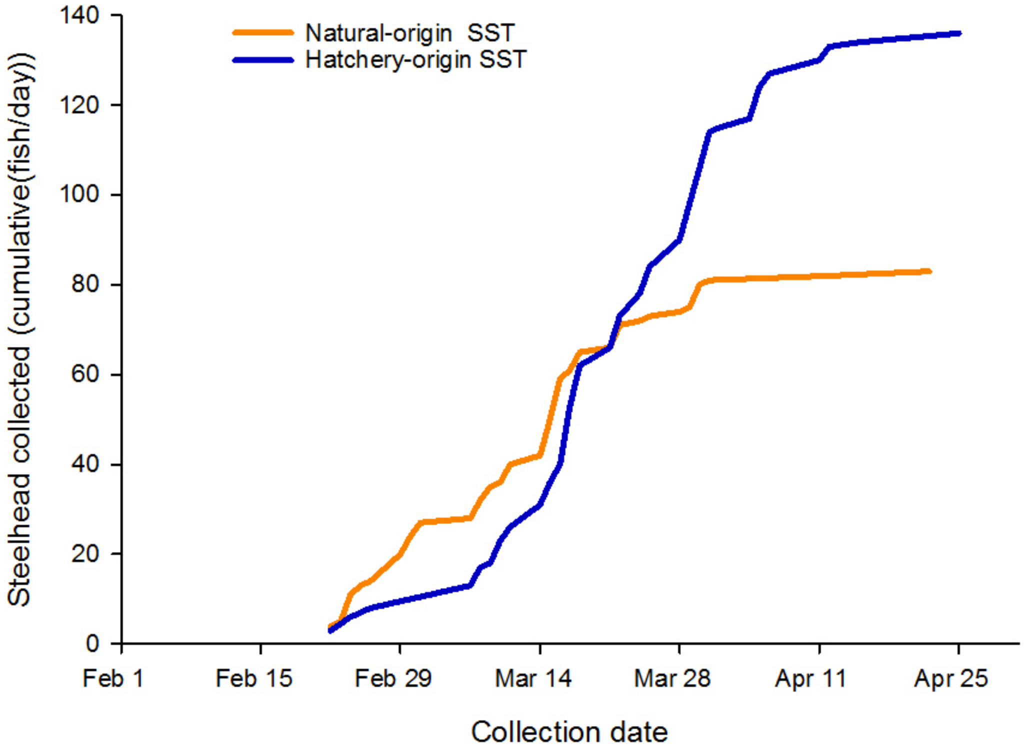

Figure 1. Cumulative natural- and hatchery-origin steelhead collected via all methods from February to April 2016 for the WNFH program.

Angling

The majority (93%; *N*=203) of the 219 steelhead retained were collected via angling. Angling occurred upstream of the Twisp River to reduce interceptions of both WDFW/DPUD Twisp Program returnees and Twisp natural-origin steelhead. The majority (72%) of steelhead collected were obtained just below the Winthrop Bridge (*N*=92; RM 49.9), near Methow Fish Hatchery (MFH; *N*=34; RM 51), and a productive location near RM 48.3 (*N*=32).

Table 1. Weekly numbers of adult steelhead collected via all sources in 2016.

Week Beginning	Angling				WNFH Ladder		WNFH Trap		Trap MSFH				All Sources			
	HOR		NOR		HOR		HOR		HOR		NOR		HOR		NOR	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
21-Feb	6	1	7	8	-	-	-	-	-	-	-	-	6	1	7	8
28-Feb	2	1	10	3	-	-	-	-	-	-	-	-	2	1	10	3
6-Mar	9	6	11	2	-	-	-	-	-	-	-	-	9	6	11	2
13-Mar	22	13	18	7	-	-	-	-	-	1	-	-	22	14	18	7
20-Mar	14	8	4	4	-	-	-	-	-	-	-	-	14	8	4	4
27-Mar	14	17	-	7	-	-	-	-	-	-	-	1	14	17	0	8
3-Apr	2	4	-	-	1	3	2	-	-	-	-	-	5	7	0	0
10-Apr	-	3	-	-	2	1	-	1	-	-	-	1	2	5	0	1
17-Apr	-	-	-	-	-	1	-	-	-	-	-	1	0	1	0	1
24-Apr	-	-	-	-	-	-	-	1	-	-	-	-	0	1	0	0
Totals	69	53	50	31	3	5	2	2	-	1	-	3	74	61	50	34
Combined	203 (92.7%)				12 (5.5%)				4 (1.8%)				219			

Effort, CPUE, and Success

Between 22 February and 12 April, personnel dedicated about 42 angler-days and a collective 387 angler-hours towards broodstock collection. Catch-per-unit-effort (CPUE) was estimated at 0.5 steelhead/angler-hour across the collection timeframe, compared to 0.3 steelhead/angler-hour in 2015 and 0.4 steelhead/angler-hour in 2014. CPUE likely ranges according to many variables including environmental conditions, angler experience and availability.

Methow River flows were well above average and historical maximums this spring, which reduced angling success after the first week of April (Figure 2). Nearly all fish were caught under stable or decreasing flow conditions, whereas periods of increasing hydrograph were characterized by high turbidity, increased debris load, and generally poor and/or unsafe angling conditions. Please note that angling effort was not equally applied across the timeframe displayed in Figure 2.

Hatchery Trapping and Transfers

Additional broodstock collection efforts occurred simultaneously at WNFH (ladder and Spring Creek tributary trap) and MFH through collaborative efforts with WDFW staff. A total of four steelhead was collected at MFH and transferred live to WNFH. Three of these were natural-origin and one was hatchery-origin. Twelve steelhead were collected at WNFH (5.4% of total collection), of which eight were collected as ladder swim-ins and four were collected in the Spring Creek trap. All steelhead collected at WNFH were of hatchery-origin. Combined 2016 hatchery collections, including fish collected at MFH, comprised about 7.4% of all fish collected, which is less than in 2015 when about 28.5% of all steelhead were collected at combined hatchery locations.

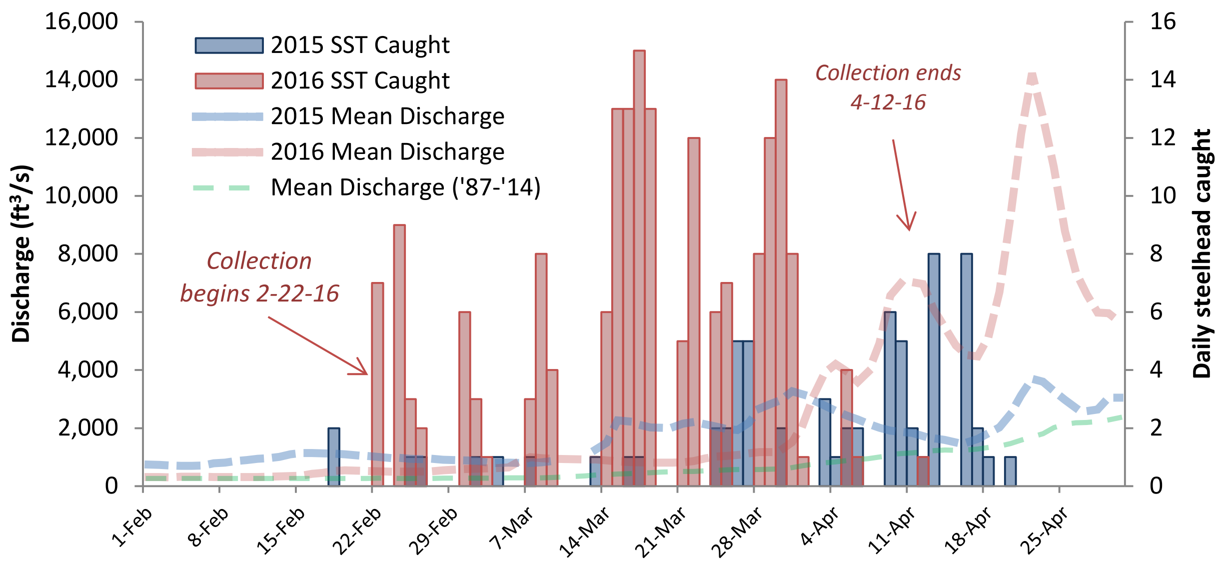

Figure 2. Steelhead WNFH broodstock captures in 2016 and 2015 in comparison to Methow River discharge statistics (at Winthrop; USGS 12448500).

Other Broodstock Collection Methods

In late 2014, MCFWCO staff investigated the possibility of installing a temporary tributary trap near the mouth of Spring Creek to intercept a larger portion of the outfall returns and attempt to reduce natural spawning of hatchery-origin steelhead. Ideal trapping sites exist on private land, which are currently unavailable for trap installation. Since 2014, staff have worked with the landowner to attain the ability to install a temporary tributary trap and these efforts are ongoing.

Tangle netting was attempted in Spring Creek in 2015, with no success, and was not repeated in 2016. It may still be an option considered in future years subject to permitting authorization, available/distribution of fish, and other management needs.

Non-target Taxa

Fifty-six non-target taxa (NTT) were encountered representing three species while angling in 2016: 22 Mountain Whitefish (*Prosopium williamsoni*), 3 Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*), and 31 Bull Trout (*Salvelinus confluentus*). None of these species were encountered in USFWS-conducted trapping efforts. All NTT were carefully released unharmed without observed injury or post-release mortality concerns (i.e. no bleeding, hooks in eyes, sustained loss of equilibrium, failure to resuscitate, etc.). Angling gear was consistent with the open recreational fishery (i.e., single, barbless hooks and no bait) in order to prevent such injuries or mortalities. Cold water temperatures (5-6°C) during collection efforts likely contributing to high post-release survival. All Bull Trout encountered were fluvial sized (estimated ≥150mm). Almost half of Bull Trout (48%; *N*=15) caught were encountered in the first two weeks of sampling (15 Feb – 1 March), however this is also a crucial time for collecting NOR steelhead, as about one-third (*N*=33) of all NOR collected were collected during this short early period. This early collection time for steelhead is essential since high water levels increasingly limit and could completely curtail broodstock collection success towards April.

The USFWS Ecological Services Division (ES) authorized take of ESA-threatened Bull Trout through the Section 7 consultation process (USFWS 2016). The Biological Opinion and associated take permit allowed for sub-lethal take of up to 40 adult/sub-adult Bull Trout and lethal take of up to 3 adult/sub-adult Bull Trout. Catch rates in the first half of broodstock collection trended towards exceeding the sub-lethal limit (no mortality was observed or expected). FWCO staff worked closely with the Central Washington ES Office through the broodstock collection period to ensure that near-real-time take values were communicated and remained within existing allotted levels. All terms and conditions and precautionary measures were maintained during angling. Bull Trout catch rates decreased during the latter half of the collection period and take limits were not exceeded.

Inter-agency Coordination and Volunteers

An extensive amount of effort goes into broodstock collection efforts in order to meet collection goals, manage pHOS, and meet goals of our partners' programs. The combined efforts of volunteers and employees from other agencies made up a large portion (46%) of the effort this year (Figure 3). Twenty-two individual volunteers, who included local guides and community members, contributed a total of 119 hours (31% of total effort) towards broodstock angling in 2016. Yakama Nation staff were once again instrumental in helping to collect steelhead for the WNFH program and find quality volunteers. Both entities share the mutual benefit of collecting wild female steelhead, which contributes to the NOR broodstock goal and to YN's Kelt Reconditioning program. Live-spawned females collected from WNFH provided 45% of all females incorporated into the YN kelt reconditioning program in 2016 (M. Abrahamse, pers. comm.).

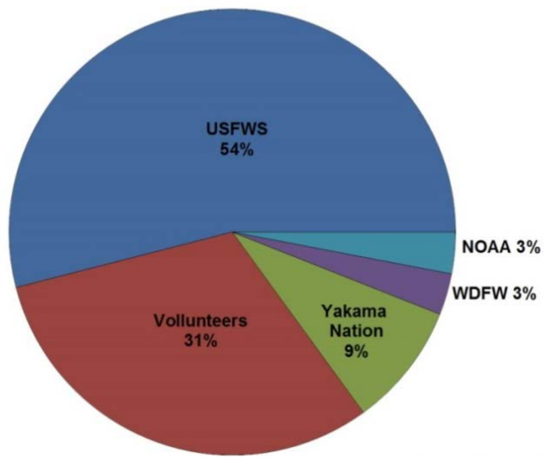

Figure 3. Effort (percent of angler-hours) contributed towards 2016 WNFH broodstock collection project partners.

Small-scale Steelhead Movements in Spring Creek

Several temporary PIT tag antennas were installed in and near the WNFH fish ladder to monitor fine-scale steelhead movements within proximity of the hatchery and provide insight for future adult management efforts (i.e., RPA 40 2^{nd} objective). Antennas were installed at the bottom and top of the fish ladder and approximately 60 meters below the ladder (Figure 4). These detection data, along with data from the Spring Creek MUX (about 250 meters below the ladder), show a clear "fall-off" in numbers of adult hatchery-origin steelhead from the mouth upstream to the WNFH ladder (Table 2). This fall-off progressing up the creek, in the context of the estimated ~250 spawning adults (redd-based estimate), suggests that there may be an ephemeral opportunity to maximize steelhead adult management in Spring Creek and that a location in lower Spring Creek would provide maximized effectiveness.

Table 2. Small-scale steelhead movement analysis in Spring Creek.

Location	Distance (m) above mouth	Estimated	Unique PITs (% of total)
Est. Spawn Escapement[1]	Accessible extent	250	*No detection near mouth*
Spring Creek MUX[2]	630	240[2]	90 (100%)
Flex Antenna[2]	780	112[2]	42 (46.7%)
Lower Ladder[2]	860	64[2]	24 (26.7%)
Upper Ladder[2]	920	37[2]	14 (15.6%)
Adult Pond Swim-ins	925	8[3]	3 (3.3%)

[1]Approximate spawning escapement in Spring Creek assuming fish/redd ratio of 2.5.
[2]Expanded unique adults (mostly HOR) based on *very approximate* observed tag rates in mixed hatchery stock.
[3]Estimated total based on expanded PIT recoveries was 13 fish; however 8 actual fish were volunteered to pond.

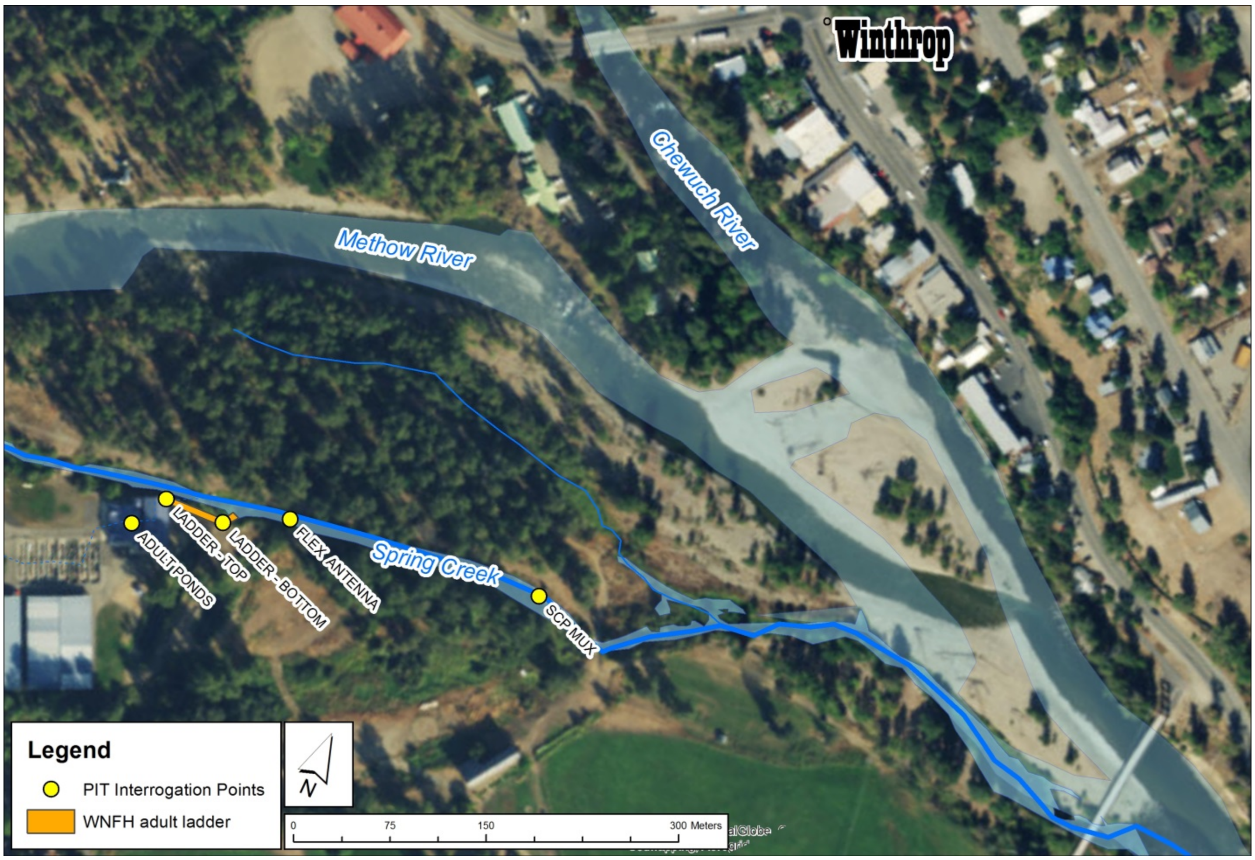

Figure 4. Fine-scale steelhead PIT interrogation in WNFH Spring Creek in 2016.

Discussion and Broodstock Collection Recommendations for 2017

Angling again proved to be a successful method for obtaining both natural-origin broodstock and hatchery-origin steelhead, despite another high runoff year and difficult angling conditions. Collection-related program goals were achieved without the need for additional hatchery infrastructure such as weirs or additional traps, though pHOS/PNI goals that are currently being developed would not likely have been achieved due to high numbers of naturally spawning hatchery fish in Spring Creek and in the river.

The Methow Subbasin integrated steelhead population is managed under a conservation/safety-net (genetic reserve) stepping stone model within which WNFH steelhead are managed as an integrated program maximizing natural-origin broodstock while Wells Hatchery Complex releases in the subbasin are managed using hatchery-origin broodstock only but maximizing incorporation of WNFH and Twisp River conservation program adults. This “safety-net” component is approximately two generations removed from natural-origin parents and would support the population during years of poor overall escapement, but would be targeted for removal during years of high escapement. Heightened need for WNFH-returnees will continue for the last year of the NOAA RRS study in 2017 and allocation/transfer to the Wells Safety Net Program will continue to be a priority in the future. Collection of these fish in excess of WNFH broodstock needs will certainly play a supporting role in adult management efforts in the subbasin.

The following recommendations are included for the 2017 broodstock collection effort:

- Continue angling efforts as the major method of broodstock collection.
- Continue and expand cooperative transfers between WDFW/Douglas PUD efforts for mutual benefit of all associated programs.
- Continue collaborating with Yakama Staff to target and collect additional NOR broodstock for mutual benefit of WNFH and YN kelt programs.
- Continue to partner with local guides, volunteers, and anglers to collect steelhead.
- Continue to work with partners (particularly DPUD, WDFW and NOAA) to develop a pHOS/proportionate natural influence (PNI) management strategy and a more robust adult collection agreement involving fishery managers and technical staff to broaden collection effort to include support for the DCPUD/WDFW safety-net program using excess WNFH returns.
- Seek opportunities to get technical support for reconstruction of improved tributary trap in lower Spring Creek or on FWS land downstream of the ladder.
    - Review a range of options, sites available, etc.
    - May also be ideal location for engineered flume, hydrologic measurement equipment, removable trap, or other possibilities.
- Continue efforts with landowner along Spring Creek and re-visit potential support for temporary, seasonal picket weir in lower Spring Creek for more effective collection of hatchery steelhead and control of pHOS.
- Explore additional up-river collection locations on the Chewuch and Methow rivers, where increased NOR interceptions may occur later in collection period.

SPAWNING

Broodstock Management Summary

Of the 219 steelhead retained from 2016 broodstock collection efforts, eight were pre-spawn mortalities (96.3% pre-spawn survival). The majority of the HOR fish were excessed and nearly all NOR fish contributed to the program (Table 3). Two NOR steelhead, a male and female, that were not sexually mature, were released in the Methow River at Winthrop after the last spawn event. Maintaining high prespawn survival rates is important, not only to meet production goals, but in order to maintain the genetic variation among the broodstock, since mortality may not be random with regards to genetic composition, age-structure, and run timing distribution (Hulett et al. 2004).

Table 3. WNFH steelhead broodstock management ledger.

Broodstock Collection	H-origin		N-Origin		Total		Total
	F	M	F	M	F	M	
Angling	53	69	31	50	84	119	**203**
WNFH Ladder	5	3	0	0	5	3	**8**
WNFH Trap	2	2	0	0	2	2	**4**
MFH Trap	1	0	3	0	4	0	**4**
All sources	***61***	***74***	***34***	***50***	***95***	***124***	***219***
Pre-spawn Mortality	***0***	***6***	***1***	***1***	***1***	***7***	***8***
Avail. at spawn	***61***	***68***	***33***	***49***	***94***	***117***	***211***
Spawning at WNFH							
Lethal spawn	**21**	**0**	**1**	**47**	**22**	**47**	**69**
Live > YN Kelt	**0**	**0**	**31**	**0**	**31**	**0**	**31**
Released	0	0	1	1	1	1	2
Excessed	16	41	0	1[1]	16	42	58
Trans. to MFH	0	2	0	0	0	2	2
To NOAA channel	24	25	0	0	24	25	49
Balance	*0*	*0*	*0*	*0*	*0*	*0*	*0*

[1]One possible NOR male was surplused. FWS Biologists considered it HOR due to dorsal fin erosion; however WDFW scale readers identified it as NOR, with the recognition that determination of multi-freshwater rearing strategy in the hatchery environment (i.e., WNFH S2) scales can sometimes be difficult to discern from natural-origin 2-year scale patterns (A. Claiborne, pers. comm.).

NOAA Spawning Channel

NOAA continued its relative reproductive success (RSS) study at WNFH in 2016. Beginning in 2014, NOAA and FWS collaborators used returning hatchery-origin steelhead adults to compare the RRS of two different rearing/release strategies (yearling-release (S1) and 2-year smolt release (S2)). Pairs of mature and maturing steelhead were stocked into two artificial spawning channels. Twenty-four HOR steelhead were stocked into each pond at attempted 1:1 ratios of S1 and S2 adults (Table 4). The first spawning channel was fully stocked on 13 April and the second channel was fully stocked a week later on 20 April. Steelhead were tagged prior to stocking with Peterson disk tags, each with a unique number and color, for visual identification during observations. Following stocking, spawning behaviors were observed and fish remained in the pond until senescence. Male dominance hierarchal relationships were constructed from observations of aggression among males and male order-of-entry during spawning events. These metrics will be analyzed against pedigree data to describe the relative reproductive success of two rearing groups (S1 and S2). CWT- and scale-based (when needed) rearing strategies were verified post-mortem.

Table 4. Summary of steelhead by sex, hatchery/program origin, and smolt rearing strategy (S1 and S2) incorporated into the 2016 NOAA RSS study.

Spawning Channel	Date stocked	Sex	Origin	S1	S2	S1:S2 Ratio	Total
1	4/13/2016	**Male**	WNFH	4	6		
			Wells	2	0		
		Total		6	6	**6:6**	12
		Female	WNFH	5	7		
			Wells	0	0		
		Total		5	7	**5:7**	12
2	4/20/2016	**Male**	WNFH	2	5		
			Wells	5	0		
		Total		7	5	**7:5**	12
		Female	WNFH	4	6		
			Wells	2	0		
		Total		6	6	**6:6**	12

Spawning initiated the day following stocking and continued for two to three weeks in each pond. High flows in April caused turbid conditions in both channels, making several days of observation very difficult. Channel flows remained constant after spawning was complete. Eggs were left undisturbed and allowed to hatch. Emergent fry were first observed in Channel 1 on 17 June and in Channel 2 on 21 June, after approximately 915 ATUs (accumulated thermal units; 481 °C ATUs) had accumulated in each pond.

Once fry emergence was complete in each pond, NOAA and USFWS staff collected and enumerated fry using multiple-pass seining and subsampled fish for subsequent DNA/pedigree analysis. The Leslie Regression Model (Leslie and Davis 1939) was used to estimate the fry population estimates at 34,978 (95% CI = 31,983-37,973) and 10,683 (95% CI = 9,201-12,164) in channels 1 and 2, respectively. This equates to averages of 2,915 and 971 emerged fry/female in channels 1 and 2. Results from this study will be compiled and analyzed along with 2017 data and are expected to be published in scientific journals. FWCO, NOAA and WNFH are currently evaluating low relative production in channel 2 vs channel 1.

S1/S2 Visual Evaluation

The pre-study strategy for obtaining adult steelhead of known rearing strategy for use in the RRS study was dependent on recovering PIT-tagged adults for immediate assignment and pre-spawn determination of stocking rates. As in prior years, PIT-tagged fish recoveries alone proved to be insufficient to fully stock RRS ponds in 2016. Instead, rearing strategy and by initial mark combination, then further visual assessment of fin condition, was used again in 2016 (Figure 5) with post-mortem verification (and scale analysis when required).

Of the 48 adult steelhead allocated to the study in 2016, four were PIT-tagged, allowing for real-time feedback on rearing strategy. Visual fin condition assessments and rearing strategy calls, when conducted in combination with external mark, were 86% accurate (5 incorrect, *N*=35) in 2016. Accuracy has remained similar across years; 84% and 92% in 2015 and 2014 respectively. Results will help provide direction for the last year of this study and may be applicable to adult management efforts elsewhere in the future.

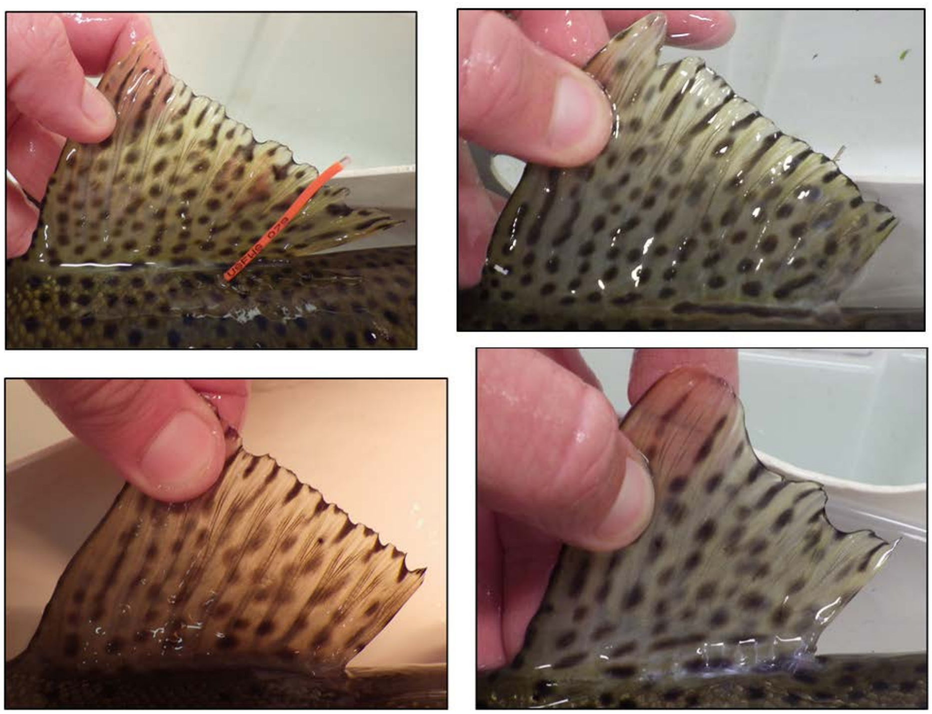

Figure 5. Natural-origin fin (top left), Wells-origin S1 (top right), WNFH-origin S1 (bottom left), and WNFH-origin S2 (bottom right).

Live Transfers to Yakama Nation Kelt Reconditioning Program

A total of 31 NOR females were live-spawned and transferred to the YN kelt reconditioning program. One NOR female, intended for transfer, died during spawning and was counted as lethal spawn. WNFH and MCFWCO cooperated to make preliminary origin assessments based on dorsal fin condition and mark presence/absence. Initial *in situ* visual origin determinations suggested that all 31 females sent to the YN Kelt Program were natural-origin steelhead. These findings were subsequently verified by the WDFW ageing lab in Olympia.

Biological and Return Data

Coded-Wire Tag recoveries

Of 219 total steelhead adults collected in 2016, 135 (61.6%) were determined HOR and 84 (38.4%) were determined NOR. Coded-wire tags were recovered from 55 of the HORs, all but one of which was adipose-clipped. An additional 80 HOR adults lacking CWTs were collected. The majority of these were most likely Wells Program yearling release steelhead from MFH and perhaps Wells Hatchery releases; 76 of the 80 were adipose-clipped and lacked CWT, reflective of the mark strategy of Wells Program steelhead releases (Table 6).

Length-at-age

Simple T-tests were run to compare mean size (fork length) of steelhead sampled in 2016, by origin and salt-age (Table 5). Natural-origin male 1-salt steelhead were significantly larger than their hatchery-origin counterparts (p<0.01), whereas there was no significant difference in size between natural- and hatchery-origin 2-salt males (p=0.29). Natural-origin female 1-salt steelhead were significantly larger than their hatchery-origin counterparts (p<0.01). Natural-origin 2-salt females had a greater mean fork length than hatchery-origin 2-salt females; this difference was found to be statistically significant (p=0.03).

Table 5. Mean fork length (cm [N; SD]) by salt-age, sex, and origin for steelhead collected at WNFH.

Sex	1-Salt		2-Salt	
	HOR	NOR	HOR	NOR
Male	60.4 (67; 3.3)	62 (37; 3.5)	72.3 (7; 3.6)	73.2 (13; 3.1)
Female	57.7 (38; 3.3)	60.8 (22; 2.4)	66.9 (23; 3.7)	69.2 (12; 2.6)

Table 6. Age-at-return of natural (NOR) and hatchery origin (HOR) steelhead and CWT recoveries collected via all methods in 2016.

Origin	CWT	Ext. Mark	Age[2]	Broodyear	Collection Source				Total
					Angling	WNFH Trap	WNFH Ladder	MFH Trap	
HOR	NT (Wells)[1]	Ad-	1.1	2013	62	1	1	-	64
	NT (unk)	Ad+			3	-	-	-	3
	055489	Ad-			8	-	3	-	11
	NT (Wells)[1]	Ad-	1.2	2012	9	1	2	-	12
	NT (unk)	Ad+			1	-	-	-	1
	055421	Ad-			7	-	-	1	8
	636387	Ad+			1	-	-	-	1
	LT	Ad-			1	-	-	-	1
	055425	Ad-	2.1	2012	23	-	2	-	25
	053567	Ad-	2.2	2011	1	1	-	-	2
	053792	Ad-			3	1	-	-	4
	LT	Ad-	U.1	Unk.	2	-	-	-	2
	LT	Ad-	U.2	Unk.	1	-	-	-	1
	HOR Total				**122**	**4**	**8**	**1**	**135**
NOR		Ad+	1.1	2013	1	-	-	-	1
			2.1	2012	47	-	-	2	49
			2.2	2011	18	-	-	1	19
			3.1		4	-	-	-	4
			3.2	2010	5	-	-	-	5
			4.1		2	-	-	-	2
			?.1	Unk.	4	-	-	-	4
	NOR Total				**81**	**0**	**0**	**3**	**84**

[1]NT = no CWT present, consistent with Wells Program release mark strategy; LT = Lost Tag, i.e. CWT was present but lost during dissection/reading.
[2]Euro age convention: # left of decimal = no. winters in freshwater; # right of decimal = no. winters in ocean.

Fecundity and Gonadal Mass

Fecundity data were collected from all fish spawned at the eye-up stage and compared across salt-age and origin (Table 7; Figure 6). As expected, there were positive relationships between size and fecundity for all sample groups; however these relationships weren't strong (R^2 values ranged from 0.09-0.56). Fecundity varied widely by fish size, but hatchery-origin females were generally more fecund at size than their wild counterparts at both salt-ages. We adjusted for egg retention occurring during the live-spawning event (only NOR females are live-spawned and transferred to the YN Kelt Program). Investigations (FWS/YN unpublished, 2011) found that egg retention during live-spawning averaged ~6.0% in the early stages of the YN Kelt Reconditioning Program. Technique and experience in live-spawning adult steelhead has likely improved since the evaluation so it is possible that egg retention is now less than 6%. Nonetheless, adjusting for egg retention explained some origin-based fecundity differences (see gonad mass discussion, below, for more details).

Table 7. Mean fecundity by salt-age and origin for 2016 WNFH steelhead program.

Origin	1-Salt			2-Salt		
	Mean	N	SD	Mean	N	SD
HOR	4,336	12	1,147	6,204	9	1,178
NOR	4,155	19	868	4,722	11	1,022

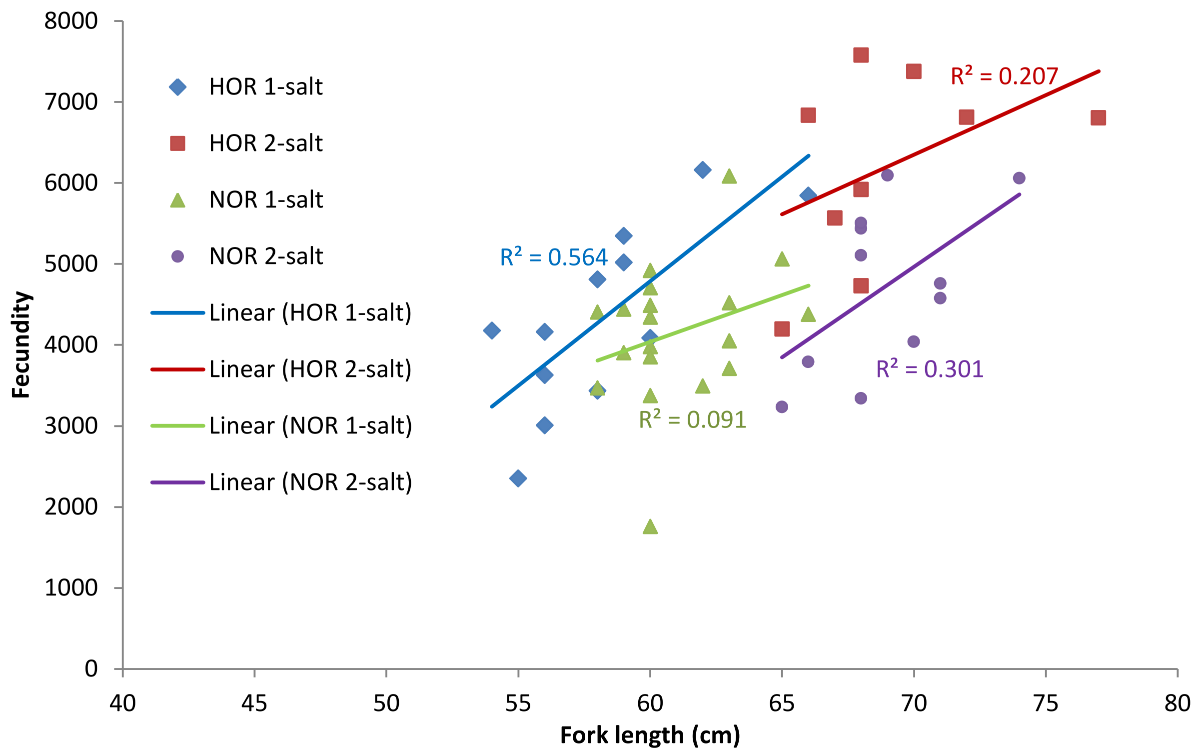

Figure 6. Fecundity by length, origin, and salt-age of fish collected for 2016 WNFH steelhead program.

Egg weight data taken at the eyed stage were combined with fecundity estimates to estimate total egg mass for females spawned at WNFH. Gonadal mass data were then plotted against length and compared by origin (Figure 7). There were much stronger relationships between gonadal mass and fork length than fecundity alone. As expected, larger fish produced larger egg masses. Initially, it appeared that hatchery-origin females produced more gonad mass than natural-origin females of similar size; however the groups were compared using an Analysis of Covariance (ANCOVA) and were not found to be significantly different. Adjustment for estimated egg retention during live-spawning of natural-origin females helped to explain some of the (non-significant) difference in the relationship between length and gonad mass between natural- and hatchery-origin females at WNFH. While we noticed that egg size was positively correlated with female body size (Fleming and Gross 1990; Beacham and Murray 1993), similar comparison (using ANCOVA) did not reveal any significant differences by origin, as others have seen (i.e., smaller egg sizes in domesticated populations; Leblanc 2011).

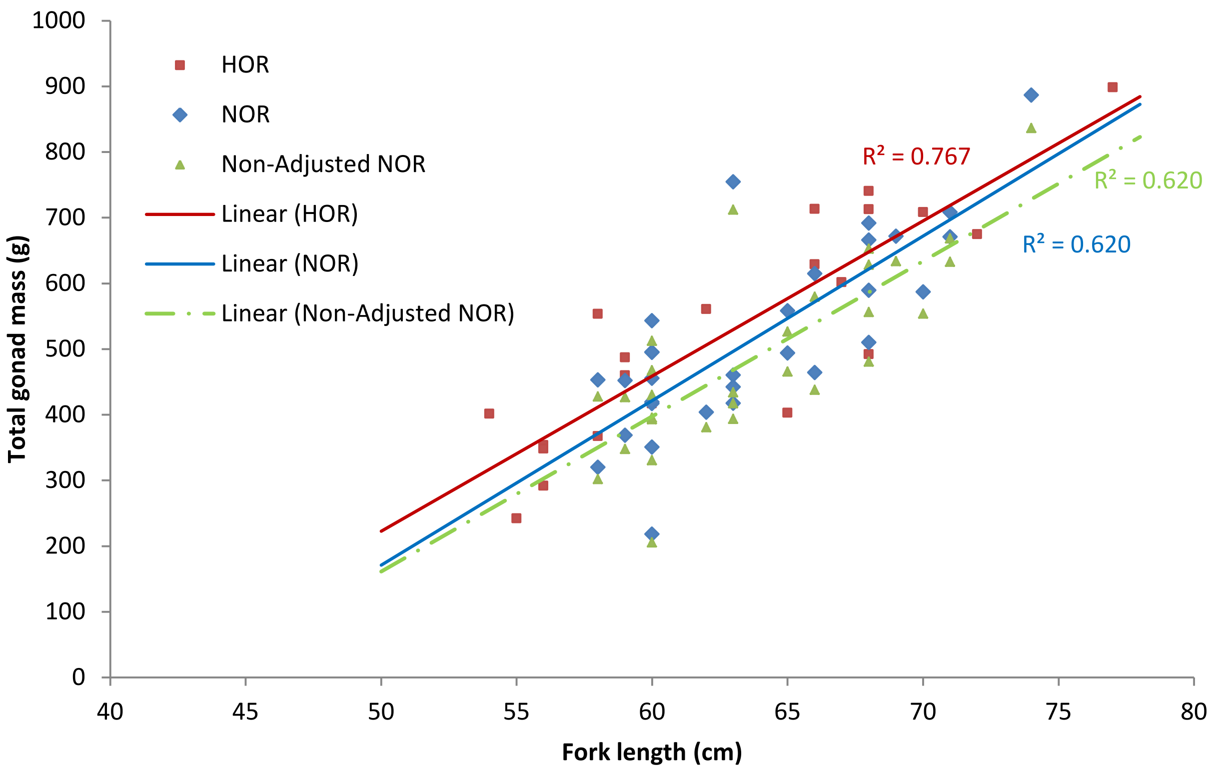

Figure 7. Gonadal mass by length and origin of females spawned in the 2016 WNFH steelhead program.

Migration Timing

Adult return timing for WNFH S1 and S2 adults, as well as combined Wells Program adults, was compared to assumed Methow Subbasin natural-origin returns (only adults with subsequent detections in the Methow Subbasin were considered in this analysis). In the 2015/2016 return year, WNFH S2 returns arrived approximately 3 weeks later, on average, than natural-origin steelhead; conversely, WNFH S1 returned slightly earlier than the natural-origin average. Combined Wells Program S1 adults returned similarly to WNFH S2 adults, though slightly earlier and closer to the natural-origin average (Figure 8). This is at least partially explained by the run composition specific to each program; Figure 9 shows the common phenomenon where older sea-age salmonids return earlier than younger sea-age fish. This pattern was observed at all mainstem Columbia River dams where PIT data were available. In this case, overall 2-salt WNFH arrived at Wells Dam 3 weeks earlier than 1-salt adults. Salt-age was more evenly split across returns from WNFH S1 program (about 60:40 1-salt:2-salt returns) compared to the S2 program which was biased towards 1-salt returns (80:20). The heavy weighting of the S2 program run composition towards 1-salt escapees pushed their combined run timing back for the 2015/2016 escapement year. Interestingly, 2-salt WNFH adults arrived only about 7 days earlier to Bonneville Dam (50% of total arrival by 14 August) than 1-salt WNFH adults (50% of total arrival by 20 August), suggesting faster ascension rates by larger 2-salt adults versus smaller 1-salt adults. It is uncertain whether this trend will hold true over time; we will continue to track this observation in subsequent annual reporting and across escapement years.

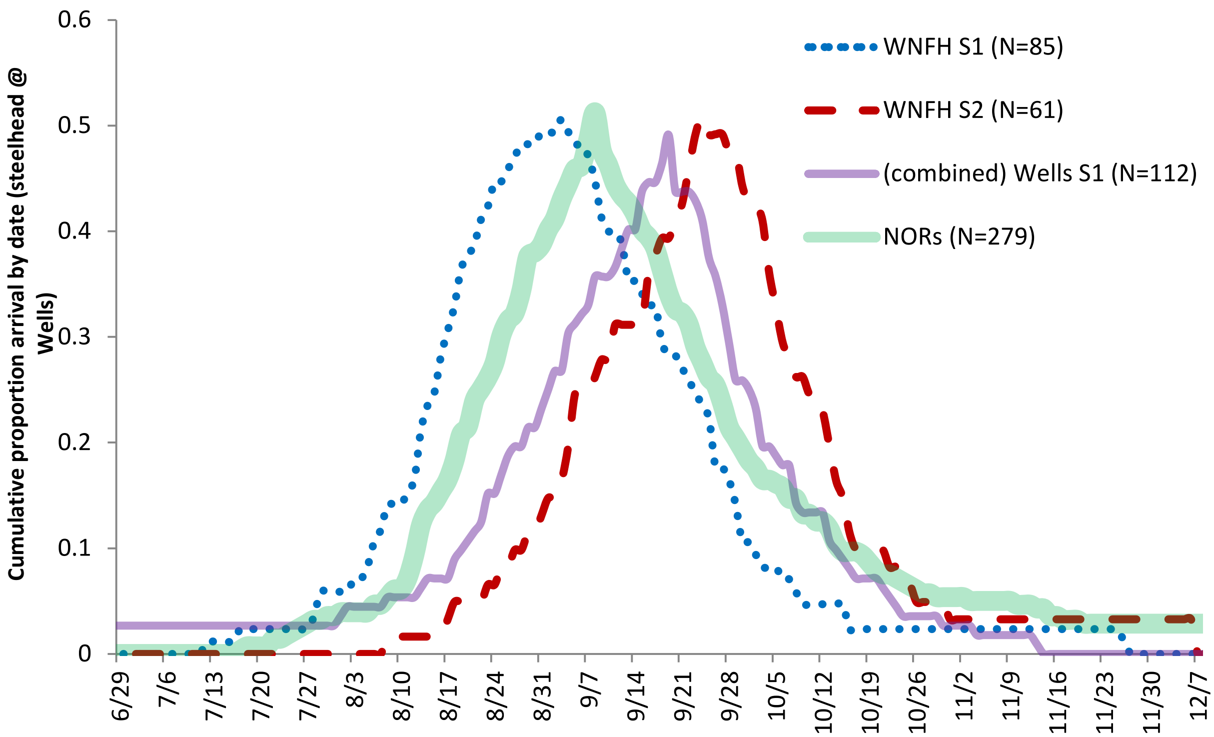

Figure 8. Comparison of 2015/2016 migration timing (arrival to Wells Dam) of Upper Columbia steelhead programs/populations.

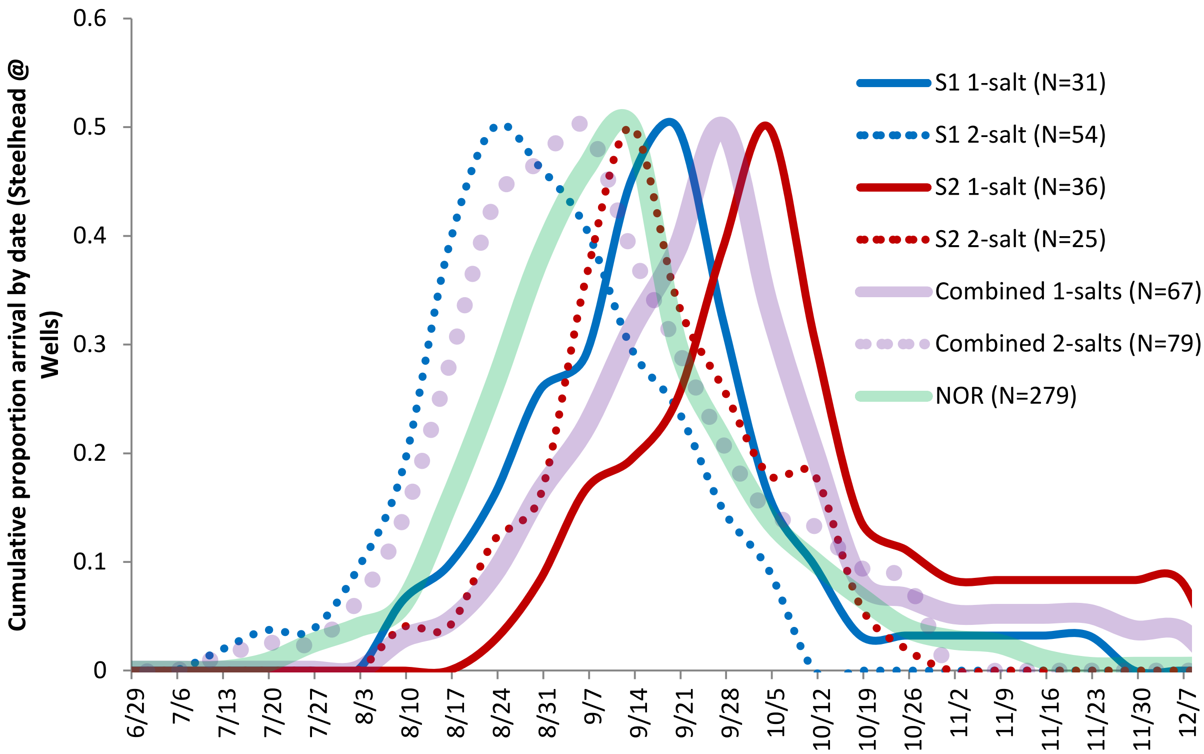

Figure 9. Comparison 2015/2016 WNFH steelhead adult run migration timing (arrival to Wells) by rearing strategy and salt-age.

Gamete Disposition and Goal: Hatchery Production and pNOB

The 2016 WNFH broodstock collection goal was 55 locally-collected pairs (Methow River, above Twisp) with a maximized pNOB (minimum 0.5), for a program smolt release of 100K-200K (range permits ability for maintaining pNOB goals under range of escapement scenarios).

After all spawn events were complete, fertilized gametes from two Wells stock females were discarded to minimize inclusion of Wells S1 fish and to maximize program pNOB. The spawning matrix for the broodyear 2016 program included 31 WxW crosses, 19 HxW crosses, and 0 HxH crosses, for a total of 217,473 eyed eggs in incubation at WNFH. A total of 100 effective parents (some NOR males were used multiple times) contributed to 50 crosses (Table 8). The resulting pNOB of the release group, as a whole, based on parental crosses was 0.810. A value for pNOB was also calculated using number of eggs produced by cross type. Fecundity-based pNOB for the 2016 program was calculated at 0.782 due to lower mean fecundity for NOR than HOR females (Table 9).

Table 8. WNFH 2016 Steelhead program spawn matrix summary and pNOB calculation calculated by spawning crosses.

Cross origin	Number	pNOB of Cross	Proportion of effective brood	Contribution of NOB
H x H	0	0.0	-	0.000
H x W	19	0.5	0.38	0.190
W x W	31	1.0	0.62	0.620
Total	50		1.0	**0.810**

Table 9. WNFH 2016 Steelhead program spawn matrix summary and pNOB calculation calculated by final eyed egg estimates.

Cross origin	Total eyed eggs	pNOB of Cross	Proportion of effective brood	Contribution of NOB
H x H	0	0	-	0.000
H x W	94,965	0.5	0.437	0.219
W x W	122,508	1.0	0.563	0.563
Total	217,473		1.0	**0.782**

WNFH successfully met its goal for the 2016 broodyear program by locally collecting sufficient broodstock for full production at an approximate pNOB of 0.8.

Goal: Locally-collected Broodstock

WNFH has successfully met its local broodstock goal for the 2016 and previous two brood year programs by collecting 100% of broodstock in the upper Methow Subbasin while simultaneously maintaining production and pNOB goals.

Based on results in broodstock pNOB since 2014 (Table 10); we expect pNOB >0.5 will be achievable in most years using the current broodstock collection strategy. However, long term we expect pNOB will typically remain <1.0 due to variation in NOR abundance, inherent challenge in achieving 100% accuracy *in-situ* origin determinations, in-river brood collection success, and the need to sometimes balance conflicting pNOB and production goals. If the NOR proportion maintains or decreases in future returns, WNFH-origin S2 returns will be prioritized (over Wells S1 returns) to maximize subbasin PNI while backfilling production requirements. This would result in reduction in broodstock pNOB but the production goal flexibility of 100K-200K allows for some balancing of the two goals to occur. Recent efforts associated with managing subbasin PNI on the spawning grounds for Methow Subbasin steelhead (Mackey and Humling 2016) describe the challenges in attaining optimal PNI values on the spawning grounds in the absence of an effective adult removal structure. Beyond adult management, broodstock pNOB maximization remains the sole effective tool. As such, to maximize the probability of attaining subbasin PNI goals, it may eventually become necessary to identify pNOB=1 as the primary broodstock collection goal and only incorporating hatchery-origin broodstock when production may drop below 100,000 smolts, to meet US v OR production obligations.

Table 10. WNFH steelhead broodstock S1→ S2 transition.

Broodyear	Release Year	Rearing Strategy	Total by Strategy	Release Year Total	% via Local Brood	pNOB
2007	2008	S1	116,897	116,897	0	0.0
2008	2009	S1	102,418	102,418	0	0.500
2008	2010	S2	29,170	100,378	29%	0.0
2009		S1	71,208			0.0
2009	2011	S2	43,205	107,141	40%	0.325
2010		S1	63,936			0.500
2010	2012	S2	59,352	117,210	51%	0.500
2011		S1	57,858			0.500
2011	2013	S2	57,894	111,721	52%	0.1464
2012		S1	53,827			0.500
2012	2014	S2	90,599	140,398	65%	0.219
2013		S1	49,799			0.500
2013	2015	S2	76,078	95,995	78%	0.153
2014		S1	19,917			0.0
2014	2016	S2	128,585	128,585	100%	0.894
[1]2015	2017	S2	*200,000*	*200,000*	100%	0.638 – 0.663[2]
[1]2016	2018	S2	*200,000*	*200,000*	100%	0.782 – 0.810[2]

[1]Approximate numbers for juveniles currently on-station.
[2]Range displayed: based parental crosses and resulting eggtake(2) by cross disposition.

Goal: Adult Management Including pHOS and PNI Goals

In 2016, WNFH and its partners continued efforts to reduce the number of HOR spawners by removing HOR adult steelhead encountered during broodstock collection efforts. Subbasin-scale adult management is less effective for steelhead than it is for spring Chinook because spring Chinook return to hatchery release locations with much higher fidelity and readily enter hatchery ladders. The Methow Subbasin lacks effective steelhead adult management infrastructure above Wells Dam that allows tributary-specific adult management (with the exception of the Twisp River Watershed). Recreational fishing in the tributaries and mainstem upper Columbia River is probably the most effective tool currently being used for removal of returning hatchery-origin adult steelhead. However, under the current management framework, recreational fisheries do not open when overall escapement is low, and are limited in other years by natural origin fish encounter rates.

Combined WNFH operations collectively removed 135 individual HOR fish from the naturally-spawning population in 2016. This included some fish that were spawned and incorporated into 2016 broodyear program at WNFH (*N*=21) and two possible Twisp program fish that were transferred to WDFW. A total of 112 adults were either excessed, spawned but later discarded, used in the NOAA RRS study, or died during holding.

Additional adult management conducted by WDFW in other locations is not discussed but is reflected in the adult management (pHOS) effectiveness summary (Table 11). HOR adults removed during this effort provided a small but measurable effect in reducing pHOS at the subbasin scale; however resulting pHOS was still high and additional management tools will likely need to be employed in the future to meet more aggressive PNI and pHOS goals.

Table 11. 2016 Methow Subbasin steelhead adult management (pHOS) effectiveness summary.

Run estimate (to Methow)[1]				Adult management					Effectiveness on spawning grounds estimate		
Total	HOR	NOR	pHOS	Broodstock[2]		Rec. Fishery[1]		Surplus[2]			
				HOR	NOR	HOR	NOR	HOR	HOR	NOR	pHOS
7,059	5,811	1,248	0.823	-27	-91	-722	-25	-267	4,955	1,140	0.809

[1]Preliminary fishery/escapement data courtesy R. Fortier, WDFW. Snow et al., will conduct subsequent above-Wells steelhead escapement analysis but this is not yet available.
[2]Includes post-fishery adult management by WDFW and USFWS.

Although co-managers/operators were able to remove 1,016 HOR adults via collective adult management efforts in the Methow Subbasin, pHOS dropped only very slightly from 0.823 to 0.809. If there had been no adult management other than broodstock collection (i.e., no fishery or removal of HORs during broodstock collection), pHOS would have seen a slight increase to 0.833. If no broodstock were removed and the conservation fishery was conducted, pHOS would have dropped only to 0.806. These comparisons help to convey that, in high HOR and low NOR escapement scenarios, pHOS will remain relatively high under status quo management activities and all but extreme adult removal scenarios.

Methow Subbasin pHOS and PNI management goals are currently being developed between NOAA, WDFW, DPUD, and USFWS. PNI and subbasin-scale pHOS will be developed jointly and will need to incorporate data that is beyond the scope of this memo. Given the high pHOS on the spawning grounds in 2016, we expect that the anticipated PNI targets would not have been achieved in the 2016 spawning escapement.

The following recommendations are included for the 2017 and future pHOS/geneflow management efforts:

- Continue to collaborate with interagency partners to maximize adult steelhead collection and removal efforts at all hatchery infrastructure locations
- Continue retaining 100% of HOR steelhead, particularly Wells Safety Net releases, during combined broodstock collection efforts
    - During all but very high natural-origin escapement scenarios or under extreme management decree scenarios, ensure HRR remains >1 to avoid “NOR mining”
- Increase coordination/collaboration with WDFW/PUDs to support collection of WNFH-origin S2s for incorporation into Wells Safety Net Program
    - 24 WNFH-origin S2 (11 males, 13 females) went to NOAA program in 2016. Post study, it is expected that most of these fish will be available for Wells Safety Net Program

- Build upon fine-scale PIT interrogation study of fish movements in Spring Creek and continue work with landowner to implement temporary adult collection structures/weir in lower Spring Creek
    - Work with WDFW Hatchery Evaluation Program to investigate need/feasibility of installing similar temporary weir in lower MFH outfall channel for similar purposes
- Work with WDFW Fisheries Management to provide support with steelhead creel surveys and/or develop improved understanding of WNFH:Wells removal rates in recreational fisheries to help validate assumed pHOS/PNI rates.

Natural-origin Broodstock Extraction Rate

The updated WNFH steelhead program HGMP (USFWS 2012) stipulates that "NOR brood extraction will never exceed 35% of the NOR run." Developing guidance from NOAA Fisheries also provides hints at how programs may be required to monitor for the risk of broodstock "mining" in the future; in the draft Biological Opinion for WNFH Spring Chinook Salmon (in development), it is noted that ""mining" of natural-origin fish will not occur as long as the remaining number of hatchery-origin fish on the spawning grounds exceeds the number of fish (natural-origin and hatchery-origin combined) used as broodstock." That is, recruits-per-spawners should not fall below one recruit per natural-origin broodstock adult unless the run composition and developing management guidance requires it. Given the high number of naturally-spawning HOR adults and high resulting pHOS on the spawning grounds, we do not consider unacceptable broodstock "mining" to be occurring. It is difficult to determine exactly how many WNFH- or Wells-origin steelhead are on the spawning grounds, but in 2016, almost 5,000 HOR steelhead were estimated to spawn in the river. Considering the small number of NOR adults used as broodstock for these releases, the recruits-per-spawner ratios for these release groups greatly exceed 1:1. The NOR broodstock collected for the WNFH program represents 6.8% of the NOR spawning population (which is smaller than the "NOR run").

Future direction in this area may incorporate reduced relative reproductive success rates of hatchery-origin adults that originate from conservation programs. Existing management direction for incorporating this into broodstock mining analysis does not exist but is of continued interest.

REFERENCES

Abrahamse, M. Fish Biologist, Yakama National, Kelt Reconditioning Program, Twisp WA. Personal communication.

Claiborne, A. Fish Biologist, Washington Department of Fish & Wildlife, Fish Ageing Laboratory, Olympia, WA. Personal communication.

Fortier, R. Fisheries Biologist, Washington Department of Fish & Wildlife, Twisp, WA. Personal communication.

Hulett, P. L., C.S. Sharpe, and C.W. Wagemann. 2004. Critical need for rigorous evaluation of salmonid propagation programs using local wild broodstock. In *Propagated Fish in Resource Management*, Symposium 44, Edited by: Nickum, M.J., P.M. Mazik, J.G. Nickum and D.D. MacKinlay. 253-262. American Fisheries Society, Bethesda, MD.

Leblanc, C.A. 2011. The importance of egg size for the diversity of salmonids, *Ph.D. dissertation*, Oregon State University, Corvallis.

Leslie, P.H. and Davis, D.H.S. 1939. An attempt to determine the absolute number of rats on a given area. J. Animal Ecol., 8: 94-113

Mackey, G. and Humling, M. 2016. Methow Steelhead Programs Response to NMFS Management Information Request Under Consultation for ESA Permits for the Wells HGMP and WNFH HGMP. Memo to NOAA Fisheries from Douglas County PUD and USFWS MCFWCO. October 24, 2016.

US Fish & Wildlife Service. 2012. (Revised) Hatchery and Genetics Management Plan for the Winthrop National Fish Hatchery Summer Steelhead Program. Leavenworth Hatchery Complex, Leavenworth, WA.

US Fish & Wildlife Service. 2016. Biological Opinion for the Operation and Maintenance of the Winthrop National Fish Hatchery. USFWS Reference number 01EWFW00-2015-F-1041. USFWS Ecological Services Central Washington Field Office, Wenatchee, WA.

Appendix A. Primary Broodstock Collection Locations for 2016.