MID-COLUMBIA COHO REINTRODUCTION

MONITORING AND EVALUATION

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SECTION 1: INTRODUCTION

By the end of the 20th century, indigenous populations of coho salmon (*Oncorhynchus kisutch*) in the mid and upper-Columbia River basins were largely decimated in their native range (Wenatchee, Entiat and Methow rivers; Mullan 1983). Primary causes of this extirpation were the construction of impassible dams, unscreened irrigation diversions, unchecked harvest in the lower-Columbia River, and unsound land management practices leading to significant habitat degradation. Historically within the purview of the Yakama Nation (YN)'s "usual and accustomed places," the prospect of returning viable coho salmon populations to the Methow and Wenatchee River Basins presented the tribe an opportunity to revitalize an invaluable cultural and environmental resource. Initial feasibility studies exploring the potential viability of an upper-Columbia River coho restoration effort began in 1996. The potential for programmatic success was based on two central criteria: 1) that the domesticated lower-Columbia parent stock would be able to adapt and proliferate despite the rigors of a greatly-increased travel distance from ocean to natal stream, and 2) that the actions of the restoration effort could be executed effectively while having minimal interspecific interactions with ESA listed spring Chinook (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*). Completion of the feasibility study in 2006 determined that the aforementioned criteria had been met. The resulting Mid-Columbia Coho Reintroduction Program (MCCRP) currently seeks to achieve the biological objective of developing a ***locally-adapted, naturally spawning stock in the Wenatchee and Methow River subbasins capable of supporting harvest*** by 2028.

As outlined in the MCCRP Master Plan (2017), the framework of both Wenatchee River and Methow River restoration efforts is based on a sequential multi-phase approach. Broodstock Development Phase (BDP) 1 focused solely on the establishment of a purely upper-Columbia derived stock of coho, such that lower-Columbia stocks were no longer relied upon to sustain the program. BDP 2 then shifted the focus to selecting for individuals of the newly-developed upper-Columbia broodstock that show the highest level of adaptation to the increased upstream journey. This was done by putting a greater emphasis on upstream broodstock collection points, therefore favoring fish with proven long-range capability. The Natural Production Implementation Phase (NPIP) seeks to decrease domestication selection, and push locally-adapted stocks in target areas of identified optimal habitat. NPIP will initially include the program's largest releases of smolts, as an attempt shift returns from hatchery settings to target tributaries. Lastly, Natural Production Support Phases (NPSP) 1 & 2 will further local adaptation and naturalization, while drawing down hatchery-origin contributions to broodstock.

Programmatic monitoring and evaluation (M&E) allows managers gauge the result of the reintroduction efforts, producing information that can in-turn guide management practices and minimize negative ecological impacts. The MCCRP Master Plan designates ten specific Project Performance Indicators as metrics relevant to gauging the success of both hatchery-origin and naturally-produced populations. It is these indicators that will be determined on an annual basis, and used in the adaptive management of the program.

They include:

1. *In-pond survival*
2. *Pre-release fish condition*
3. *Volitional release run-timing and tributary residence*
4. *Release-to-McNary Dam smolt survival*
5. *Egg-to-emigrant survival rates*
6. *Spawning escapement and distribution*
7. *Natural smolt production*
8. *Smolt-to-adult survival*
9. *Adult-to-adult productivity*
10. *Harvest rates*

In this document, we will describe the MCCRP's monitoring efforts in the Wenatchee and Methow River Basins for the performance period of February 2016 to January 2017, and how they address the above indicators. Note* Harvest rates will not be covered in this report.

SECTION 2: SUMMARY OF METHODS

2.1 BROODSTOCK COLLECTION AND SAMPLING

Broodstock collection in 2016 was performed at multiple collection points throughout both the Wenatchee River and Methow River Basins, as well as the mainstem Columbia River. Broodstock for the Wenatchee program were collected at Priest Rapids Dam, Dryden Dam, Tumwater Dam, and Entiat National Fish Hatchery (NFH). In-basin locations (Dryden Dam and Tumwater Dam) were the primary intended points of collection, although Priest Rapids Dam was used in 2016 in light of a poor estimated escapement to the Wenatchee River. Collections at Entiat NFH were opportunistic, and performed by United States Fish and Wildlife Service (USFWS) personnel as a courtesy to YNF; further use of Entiat NFH as a point of collection is unlikely. Broodstock for the Methow program were obtained at Wells Dam East and West Ladders, Methow Hatchery, and Winthrop NFH. Wells Dam acted as the primary collection point, allowing representative run-at-large origin (hatchery/wild) representation. Hatchery intake traps at Methow Hatchery and Winthrop NFH were passively-operated to supplement collections at Wells Dam. Differential markings allowed the respective collection point of each MCCRP fish to be tracked through spawning. All of MCCRP's 2016 coho collection activities were in accordance with the guidelines set forth by the relevant National Marine Fisheries Service (NMFS; NMFS-WCR-2015-3778) and USFWS (USFWS- 01EWFW00-2013-F-0272-R001) Section 7 Biological Opinions. See **Attachment A** for the full 2016 MCCRP ESA-Compliance report.

Sampling of broodstock was performed at the time of spawning. Each coho successfully spawned is identified by a differential marking made at collection as well as a head-pin used to identify male-female pairings. Measurements taken included sex, fork length (FL; cm), and post-orbital to hypural length (POH; cm). A genetic sample via caudal fin clip was taken to facilitate parentage-based-tracking (PBT). Tissue samples were taken immediately following sacrifice to avoid cross-contamination though the exchange of blood and milt during the spawning process. In the event that a coded-wire-tag (CWT) was located with a metal-detecting wand, the snout was taken for later extraction and reading of the tag. Each fish was also scanned for an un-coded wire tag located in the adipose-fin region; another form of differential marking used in hatchery-origin fish. To identify the age and origin of fish that cannot be identified via PBT or CWT, and supplement existing methodologies, scale samples were taken from each fish spawned. Additionally, each fish was scanned with the portable transceiver to identify the presence of passive-integrated-transponder (PIT) tags. All measurements were eventually combined with corresponding information from tag and scale data to determine the age, origin, rearing location, and potential parentage of each fish spawned. Broodstock sampling by MCCRP personnel was concurrent with sampling by a USFWS Fish Health Department biologist to determine the presence of disease within the coho spawned.

2.2 SPAWNING & INCUBATION

Spawn-pairings were recorded via head pin number and linked to incubation tray numbers to allow tracking from parent(s) to progeny. During incubation, YN personnel assessed eggs for percent viability (i.e., ova that successfully develop into eyed-eggs). Non-viable or unfertilized eggs were removed by both automatic egg-sorters (Jensorter), and hand-picking. Viable and non-viable eggs were quantified by weighing subsamples of 100 eggs per group, and comparing to the total weight of each sample. Numbers of viable and non-viable eggs are then added to determine total number of green eggs initially taken at spawning. Overall fecundity was calculated as the total number of green eggs taken for a year's spawn divided by the total number of females spawned. Females taken that were devoid of a large portion of eggs (overripe) or spawned prematurely but still had viable eggs were designated as partials and given an arbitrary 0.5, so not to influence brood fecundity.

2.3 ACCLIMATION

2.3.1 In-Pond Survival

In-pond survival was calculated by using passive integrated transponder (PIT) tags to estimate total mortality incurred between initial entry into rearing raceway/pond (post-transport) and release. A minimum of 4,500 PIT tags were distributed throughout release groups with which this estimation methodology was used. Mean tag rate (% PIT tagged) for all release groups in 2016 was 6.9%. Rearing sites with PIT tags were monitored using mobile antennas at all outflow channels for the entire acclimation period (i.e., point of release into the pond, to visual confirmation that all coho had vacated). While operational, all antennas were checked daily to ensure proper functioning. The antennas provided constant monitoring during forced and volitional releases, as well as a means of enumerating escapees.

Percent in-pond survival, S_i, was estimated using the following formula:

$$S_i = \left(\frac{N_i^{out}}{\hat{\hat{e}}_i} \right) \Big/ \left(N^{PIT} - N^{mort} \right)$$

Where N_i^{out} = the number of unique detections at release location for period *i*;

$\hat{\hat{e}}_i$ = the estimated mean detection efficiency at the release location for period *i*;

N^{PIT} = the total number of PIT tags at initial introduction to pond;

N^{mort} = known number of PIT tags lost during acclimation;

Detection efficiency, $\hat{\hat{e}}_i$, for the outlet antennas was calculated using a mark-recapture formula:

$$\hat{\hat{e}}_i = \left(\frac{\sum_{k=1}^{i} r_k}{\sum_{k=1}^{i} m_k} \right)$$

Where r_k = total common detections between upper and lower antennas during period *i*;

m_k = total detections at the lower antenna for the period *i*.

2.3.2 Predation Assessment

Predator hazing and documentation efforts were performed in both the Wenatchee and Methow basins during the entirety of their acclimation periods. As a practice, YN personnel regularly noted predator behavior including species, number, approximate size, behavioral anomalies, and time of sighting. Although human presence was not constant at all sites, ponds were visited at regular intervals, with increased vigilance during periods of noted high predator presence (dawn and dusk). Common predators included North American river otters (*Lontra canadensis*), common mergansers (*Mergus merganser*), American mink (*Neovison vison*), belted kingfishers (*Megaceryle alcyon*), great blue herons (*Ardea herodias*), hooded mergansers (*Lophodytes cucullatus*), and mallards (*Anas platyrhynchos*). The relative impact of each species ranged from potentially high in voracious predators such as otters and mergansers, to low in opportunistic piscivores such as mallards. Consumption rates were based both on previously-conducted studies, and anecdotal estimations based on size and feeding behavior relative to similar species (Beckel 1982, Stephenson et al. 2004).

To estimate the total number of coho consumed per predator species ($\widehat{N}_j^{cons}$), the following equation was used:

$$\widehat{N}_j^{cons} = \left[\left(\overline{w}_j * \bar{c} \right) N_j^{Pred} \right] t$$

Where, $\overline{w}_j$ = mean daily weight (kg) of prey consumed by predator species *j*;

$\bar{c}$ = mean number of coho per kg during the acclimation period;

N_j^{Pred} = number of predator *j* observed during the acclimation period;

t = number of days in which predator *j* was observed at each location.

2.3.3 Pre-Release Condition

Coho juveniles reared in both hatchery, and remote-acclimation sites were sampled weekly to measure growth rate and determine degree transition to the smolt stage. At each location, a

subsample of 100 juveniles collected via cast net were measured for both fork-length (FL; mm) and weight (g). Individual measurements were used to calculate fish-per-pound (FPP) and mean K-factor for each location. The average degree of smoltification of each pond was determined by visually assessing each fish based on a set of established physical criteria. The resulting gradation applied a numerical rating of 1 through 5; 1 representing a complete lack of smolt characteristics, and 5 representing a full degree of smoltification. Weekly growth and condition measurements were submitted to hatchery personnel in order to guide feeding regimes and release timing.

2.4 NATURAL JUVENILE PRODUCTION

Natural juvenile production was monitored in both the Methow and Wenatchee basins via the use of rotary smolt traps. In the Methow basin, Washington Department of Fish and Wildlife (WDFW) operated both 1.5 m and 2.4 m smolt traps at river kilometer (rkm) 18 of the Methow River. In the Wenatchee basin, WDFW operated tandem 2.4 m smolt traps at rkm 8.3 of the Wenatchee River and the YN MCCRP program operated a single 1.5 m smolt trap at rkm 0.3 on Nason Creek.

Though the traps were operated differently based on the unique circumstances of each location, core collection and estimation methodologies were largely standardized. During periods of operation, coho were enumerated daily at each trap. Daily coho counts were expanded via flow-efficiency regression models unique to each location to determine overall emigrant abundances past each trap:

Seasonal juvenile migration, N, was estimated as the sum of daily migrations, N_i, i.e., $N = \sum_i N_i$, and daily migration was calculated from catch and efficiency:

$$\hat{N}_i = \frac{C_i}{\hat{e}_i}, \qquad \textbf{(1)}$$

where C_i = number of fish caught in period *I*;

$\hat{e}_i$ = trap efficiency estimated from the flow-efficiency relationship, $\sin^2\left(b_0 + b_1 flow_i\right)$,

where b_0 is estimated intercept and b_1 is the estimated slope of the regression.

The regression parameters b_0 and b_1 are estimated using linear regression for the model:

$$\arcsin\left(\sqrt{e_k^{obs}}\right) = \beta_0 + \beta_1 flow_k + \varepsilon, \qquad \textbf{(2)}$$

where e_k^{obs} = observed trap efficiency of Eq. 2 for trapping period *k*;

β_0 = intercept of the regression model;

β_1 = slope parameter;

ε = error with mean 0 and variance σ^2.

In Equation 2, the observed trap efficiency, e_k^{obs}, is calculated as follows,

$$e_k^{obs} = \frac{r_k + 1}{m}. \tag{3}$$

The estimated variance of seasonal migration is calculated from daily estimates as:

$$Var\left(\sum_{i=1}^{n} \widehat{N}_i\right) = \underbrace{\sum_i Var(N_i)}_{Part\ A} + \underbrace{\sum_i \sum_j Cov(N_i, N_j)}_{Part\ B}$$

or, **(4)**

$$Var\left(\sum_{i=1}^{n} \widehat{N}_i\right) = \underbrace{\sum_i Var\left(\frac{(C_i+1)}{\hat{e}_i}\right)}_{Part\ A} + \underbrace{\sum_i \sum_j Cov\left(\frac{(C_i+1)}{\hat{e}_i}, \frac{(C_j+1)}{\hat{e}_j}\right)}_{Part\ B}$$

Part A of equation 4 is the variance of daily estimates. Part B is the between-day covariance. Note that the between-day covariance exists only for days that use the same trap efficiency model. If, for example, day 1 is estimated with one trap efficiency model, and day 2 estimated from a different model, then there is no covariance between day 1 and day 2. The full expression for the estimated variance:

$$\widehat{Var}\left(\sum_{i=1}^{n} \widehat{N}_i\right) = \underbrace{\sum_i \widehat{N}_i^2 \left(\frac{N_i \hat{e}_i (1-\hat{e}_i)}{(C^i+1)^2} + \frac{4(1-\hat{e}_i)}{\hat{e}_i} \widehat{Var}(b_0 + b_1 flow_i)\right)}_{Part\ A}$$
$$+ \underbrace{\sum_i \sum_j 4\left(\widehat{N}_i(1-\hat{e}_i)\right)\left(\widehat{N}_j(1-\hat{e}_j)\right) \cdot \left[\widehat{Var}(b_0) + flow_i flow_j \widehat{Var}(b_1)\right]}_{Part\ B}$$

where $\hat{Var}(b_0 + b_1 flow_i) = \hat{MSE}\left(1 + \frac{1}{n} + \frac{(flow_i - \overline{flow})^2}{(n-1)s^2_{flow}}\right)$, and $\hat{Var}(b_0)$ and $\hat{Var}(b_1)$ are

obtained from regression results. In Excel, the standard error (SE) of the coefficients is provided. The variance is calculated as the square of the standard error, SE^2.

In cases when there was no significant flow-efficiency relationship (i.e., low correlation), then a pooled, or average trap efficiency will suffice for the stratum. The estimator is calculated as follows:

$$\hat{\bar{e}} = \frac{\sum_{j=1}^{k} r_j}{\sum_{j=1}^{k} m_j}$$

where $\hat{\bar{e}}$ = the average or pooled trap efficiency for the stratum;

m_j = the number of smolts marked and released in efficiency trial j for the stratum;

r_j = the number of smolts recaptured out of m_j marked fish in efficiency trial j.

Abundance for a trapping period is estimated as:

$$\hat{N}_i^{pooled} = \frac{C_i}{\hat{\bar{e}}},$$

,and total stratum abundance is:

$$N^{pooled} = \sum_i \hat{N}_i^{pooled}.$$

The variance of seasonal abundance takes into account the variability in catch numbers that are a result of binomial sampling (Part A), the pooled variance of trap efficiency, $\hat{\bar{e}}$ (Part B), and the covariance in daily estimates that arises from using a common estimate of efficiency across all trapping days (Part C):

$$Var\left(\sum_{i=1}^{n} \hat{N}_i^{pooled}\right) = \underbrace{\left(\sum_i \frac{\hat{N}_i(1-\hat{\bar{e}})}{\hat{\bar{e}}}\right)}_{Part\ A} + \underbrace{\frac{Var(\hat{\bar{e}})}{\hat{\bar{e}}^2}\sum_i \hat{N}_i^2}_{Part\ B} + \underbrace{\frac{Var(\hat{\bar{e}})}{\hat{\bar{e}}^2}\sum_i\sum_j \hat{N}_i\hat{N}_j}_{Part\ C}$$

The Part B and Part C terms are combined in the calculation as a new Part B:

$$Var\left(\sum_{i=1}^{n}\widehat{N}_i^{pooled}\right)=\left(\sum_{i}\frac{\widehat{N}_i(1-\hat{\hat{e}})}{\hat{\hat{e}}}\right)+\frac{Var(\hat{\hat{e}})}{\hat{\hat{e}}^2}\left[\sum_{i}\widehat{N}_i^2+\sum_{i}\sum_{j}\widehat{N}_i\widehat{N}_j\right]$$

The variance of $\hat{\hat{e}}$ is calculated as:

$$V\hat{a}r\left(\hat{\hat{e}}\right)=V\hat{a}r\left(\frac{\sum_{k=1}^{n}r_k}{\sum_{k=1}^{n}m_k}\right)=\frac{\sum_{k=1}^{n}\left(r_k-\hat{\hat{e}}_k m_k\right)^2}{\overline{m}^2 n(n-1)}$$

where $\overline{m}$ is the average release size across all efficiency trial, $\frac{\sum_{k=1}^{n}m_k}{n}$.

Confidence intervals were calculated using the following formulas:

$$95\%\text{ confidence interval} = 1.96\times\sqrt{\sum \text{var}\left[\bar{N}_i\right]}$$

The single M-R estimator of abundance carries a set of well documented assumptions (Everhart and Youngs 1981; Seber 1982),

1. The population is closed to mortality.
2. The probability of capturing a marked or unmarked fish is equal.
3. Marked fish were randomly dispersed in the population prior to recapture.
4. Marking does not affect probabilities of capture.
5. Marks were not lost between the time of release and recapture.
6. All marks are reported upon recapture.
7. The number of fish in the trap, C, is fully enumerated and known without error.

2.5 SPAWING/CARCASS SURVEYS

Surveys to document natural coho spawning were conducted either by foot, raft, or pontoon boat depending on the size of waterway and flow conditions. Foot surveys were conducted by two

staff members on opposing banks. Raft surveys were performed by three people; one rower, one primary surveyor, and one staff member accompanying in a pontoon boat. Data recorded during each survey included number of new redds, live and dead fish, redd coordinates, survey duration, and stream temperature. Individual redds were either recorded on an aerial map or flagged in the field by tying surveyor's tape to nearby riparian vegetation. Each marker flag listed the date, redd location, identification number, agency, and the surveyor's initials. Global positioning (GPS) was used to record the exact location of individual redds on all surveys. A complete list of Wenatchee and Methow Basin survey reaches can be found in Table 1.

Table 1. Spawning ground survey reaches for the Wenatchee and Methow river sub-basins in 2016

Reach Designation	Reach Description	Reach Location (RK)
Wenatchee River Basin		
	Icicle Creek	
I1	Mouth to Hatchery	0.0 - 4.5
I2	Hatchery to Head Gate	4.5 – 6.2
I3	Headgate to Leavenworth NFH intake	6.2 – 8.0
	Nason Creek	
N1	Mouth to Coles Corner	0.0 - 7.0
N2	Coles Corner to Butcher Pond	7.0 - 14.3
N3	Butcher Pond to Rayrock	14.3 – 20.0
N4	Rayrock to Whitepine Creek	20.0 – 22.0
	Wenatchee River	
W1	Mouth to Cashmere Park	0.0 – 13.4
W2	Cashmere to Dryden Dam	13.4 – 28.0
W3	Dryden Dam to Boat Ramp	28.0 – 38.0
W4	Boat Ramp to Leavenworth Bridge	38.0 – 41.7
W5	Leavenworth Br. to Tumwater Bridge	41.7 – 56.2
W6	Tumwater Bridge to Plain Bridge	56.2 – 69.2
W7	Plain to Lake Wenatchee	69.2 – 86.0
	Beaver Creek (WEN)	
BV1	Mouth to Acclimation Pond	0.0-2.4
	Brender Creek	
BR1	Mouth to Mill Road	0.0 - 0.3
	Chiwaukum Creek	
CW1	Mouth to Hwy 2 Bridge	0.0 – 1.0
	Chiwawa River	
CH1	Mouth to Weir	0.0 – 1.0
	Chumstick Creek	
CM1	Mouth to North Road	0.0 – 0.5
	Mission Creek	

M1	Mouth to Residential Area	0.0 – 1.0
	Peshastin Creek	
P1	Mouth to YN Office	0.0 – 3.5
P2	YN Office to Mountain Home Road	3.5 – 8.0
P3	Mountain Home Rd. to Valley High Bridge	8.0 – 13.3
	Roaring Creek	
R1	Mouth to split channel	0.0 – 0.5
	Methow River Basin	
	Methow River	
M1	Mouth to Steel Bridge	0.0 –7.2
M2	Steel Bridge to Lower Burma Bridge	7.2 – 14.9
M3	Lower Burma Bridge to Upper Burma Bridge	14.9 – 23.8
M4	Upper Burma Bridge to Lower Gold Creek Bridge	23.8 – 33.7
M5	Lower Gold Creek Bridge to Carlton	33.7 – 46.9
M6	Carlton to Holterman's Hole	46.9 – 64.6
M7	Holterman's Hole to MVID dam	64.6 – 74.6
M8	MVID dam to Red Barn	74.6 – 83.7
M9	Red Barn to Wolf Creek Confluence	83.7 – 88.1
M10	Wolf Creek Confluence to Rip Rap	88.1 – 92.7
M11	Rip Rap to Weeman Bridge	92.7 – 98.6
	Chewuch River	
CR1	Mouth to Co. HWY 1613	0.0 – 4.0
CR2	Co. Hwy 1613 to East County Junction	4.0 –15.3
CR3	East County Junction to Eight Mile Ranch	15.3 – 20.2
	Twisp River	
TR1	Mouth to Lower Poorman Bridge	0.0 – 2.9
TR2	Lower Poorman Bridge to Upper Poorman Bridge	2.9 – 7.8
TR3	Upper Poorman Bridge to Twisp River Weir	7.8 – 11.4
TR4	Twisp River Weir to Newby Creek Bridge	11.4 –13.2
TR5	Newby Creek Bridge to Buttermilk Creek Bridge	13.2 – 21.1
TR6	Buttermilk Creek Bridge to War Creek Bridge	21.1 – 28.5
	Spring Creek	
SPC1	Mouth to Winthrop NFH adult weir	0.0 – 0.4
	WDFW/ Methow Hatchery Outfall	
MFH1	Mouth to hatchery adult weir	0.0 – 0.5
	Hancock Spring Creek	
HS1	Mouth to Source	0.0 – 1.5
	Suspension Creek	
SUS1	Mouth to 250 meters upstream	0.0 – .25
	Wolf Creek	
WC1	Mouth to Wolf Creek Acclimation Ponds	0.0 – 1.6

WC2	Wolf Creek Acclimation Ponds to Foot Bridge	1.6 – 3.0
	Beaver Creek (MET)	
BC1	Mouth to Hwy. 153 Culvert	0.0 – 0.4
BC2	Hwy. 153 Culvert to Hwy. 20 Bridge	0.4 – 3.0
	Libby Creek	

Fork length (FL) and post-orbital-hypural (POH) lengths measured to the nearest centimeter were recorded on all carcasses collected during surveys. Snouts were removed from all carcasses for subsequent CWT analysis. Sex of each carcass was recorded, if discernible at the time of sampling. Intact females (i.e., without tearing of the abdominal wall) were checked for egg retention by estimating the number of eggs present in the body cavity. Egg voidance was expressed as a percentage of the average fecundity of each basin's broodstock. To prevent re-sampling, removal of the caudal fin served as a visual indicator of prior handling.

2.6 LIFE HISTORY MONITORING

2.6.1 Smolt-Smolt Survival

Smolt-to-smolt survival was calculated as the proportion of marked (PIT) smolts from a given release group that successfully survived the outmigration to McNary Dam. Initial mark-groups were composed of fish that were detected at a pond's outlet upon release; ensuring that PIT tags lost during the acclimation period through predation, mortality, or shedding were excluded. In the event that a) outlet detection efficiencies were poor or b) outlet detection capabilities were not present at the location, pre-acclimation (prior to transport) enumeration of PIT tags was substituted. Subsequent detections at McNary dam were compiled by release group and expanded by the estimated detection efficiency of the juvenile PIT tag detection systems there. Detection efficiency was calculated using the same mark-recapture methodology described in section 2.3.1, with detections downstream of McNary Dam (Dalles Dam and/or Bonneville Dam) establishing a mark group.

2.6.2 Adult Escapement

For coho returning to the Wenatchee River basin, we estimated adult abundance using four methods:

1) Dryden Dam counts expanded by linear regression for non-trapping days, plus redd counts downstream from Dryden Dam

2) Broodstock collected at Dryden Dam plus all redd counts

3) Broodstock collected at Dryden Dam, Tumwater Dam counts, and redds counted downstream of Tumwater Dam

4) Mainstem dam counts (Rock Island Dam – Rocky Reach Dam).

In the Methow River, the number of coho returning to the basin was calculated using two methods:

1) Redd counts plus broodstock collected

2) Wells Dam counts plus broodstock collected at Wells Dam

Redd counts were used to estimate escapement by multiplying total redds by the basin run-at-large fish-per-redd (FPR). FPR for the Wenatchee-basin was determined at Dryden Dam, while the Methow-basin ratio was determined at Wells Dam.

2.6.3 Smolt-Adult Survival

Smolt-to-adult survival (SAR) was determined as the proportion of smolts released from a given release group that successfully return to their home-basin to spawn. Estimation of SARs for hatchery fish were based primarily on CWT recovery or PBT, which allow for a comparison of survival between brood origins, rearing hatchery, and release sites. In both the Wenatchee and Methow River basins, we used scale analysis to verify the origin and age of any coho without CWTs. SARs for naturally produced coho were based on an estimate of the number of natural origin adults returning to the basin and an estimate of smolt emigration from the basin for the same brood year. Estimates natural origin smolt emigration were provided by WDFW from data collected via rotary smolt traps operated in both basins.

2.6.4 Adult-Adult Replacement

Hatchery-origin replacement rates (HRRs) were calculated as the number of hatchery-origin returns (HORs) produced by each hatchery-spawned fish in the previous generation. HOR was calculated as the total number of coho counted over Rock Island Dam for the Wenatchee-basin, and total over Wells Dam for the Methow-basin. Natural-origin replacement rate (NRR) was calculated as the number of natural-origin returns (NORs) produced by adults of the previous generation that did not spawn in the hatchery (i.e, in the natural environment). The total number of fish spawning outside of hatcheries was calculated as the total number of redds documented during spawning ground surveys times the in-basin FPR.

SECTION 3: WENATCHEE-BASIN MONITORING AND EVALUATION

3.1 WENATCHEE-BASIN BROODSTOCK COLLECTION AND SAMPLING

In 2016, the Wenatchee program collected total of 1,241 coho; 1,025 of which were successfully spawned (Tables 2&3). Pre-spawn mortality was 4.2%; below the program's running 16-year mean. A total of 12.9% of fish collected were eventually released back into the Icicle Creek as excess. Broodstock collected by the Wenatchee program was comprised primarily of fish collected at Priest Rapids Dam, with smaller contributions from Dryden Dam, Tumwater Dam, and Entiat NFH (Table 4). Collection at Priest Rapids Dam has been seen as a precautionary measure when forecasted escapement to each basin of origin is expected to be inadequate to sustain the program. Despite a low Wenatchee River adult escapement, aggressive collection at Priest Rapids Dam resulted in a broodstock total greater than the 16-year mean (Table 3). Excessive collection by the Wenatchee program was intentional, and necessary to supplement the poor return to the Methow River basin.

Table 2. Wenatchee program Coho salmon and incidentals handled during trapping, 2016

Location	Coho (*broodstock*)[1]	Steelhead	Sockeye	Summer Chinook	Bull Trout
Priest Rapids Dam	568 (544)	N/A	N/A	N/A	N/A
Dryden Dam	436 (417)	39	29	157	0
Tumwater Dam	282 (278)	N/A	N/A	N/A	N/A
Entiat NFH	2 (2)	N/A	N/A	N/A	N/A

[1] Parenthesized number denotes fish retained for broodstock at collection location

Table 3. Summary of coho broodstock collection and retention, return years 2000-2016

Return year	Handled	Collected	Pre-spawn Mortality	Released	Total Spawned
2000	921	921	87	10	824
2001	1,303	1,199	148	0	1,051
2002	247	213	5	0	208
2003	2,693	1,706	237	50	1,419
2004	1,539	1,450	119	0	1,331
2005	1,437	1,406	72	0	1,334
2006	1,755	1,329	50	81	1,198
2007	2,859	1,015	20	11	984
2008	1,194	927	29	0	898

2009	3,088	1,056	54	0	1,002
2010	1,929	1,008	14	0	940
2011	2,515	916	27	61	828
2012	2,325	905	35	0	870
2013	1,084	963	19	68	876
2014	4,012	1,025	198	31	796
2015	1,233	1,224	227	124	873
2016	1,288	1,241	52	164	1,025
Average	**1,848**	**1,088**	**82**	**35**	**968**

Table 4. Percent annual broodstock collections by collection point, return years 2000-2016

Return Year	Total Broodstock Collected[1]	Mid-Columbia River				
		Priest Rapids	Dryden Dam	Tumwater Dam	ENFH	LNFH
2000	921	0.0%	94.9%	0.0%	0.0%	5.1%
2001	1,219	1.6%	94.9%	0.0%	0.0%	3.5%
2002	213	0.0%	100.0%	0.0%	0.0%	0.0%
2003	1,706	0.0%	97.0%	0.0%	0.0%	3.0%
2004	1,457	0.0%	89.6%	0.9%	0.0%	9.5%
2005	1,406	0.0%	95.0%	4.8%	0.0%	0.1%
2006	1,329	0.0%	92.5%	0.1%	0.0%	7.4%
2007	1,015	0.0%	71.7%	23.2%	0.0%	5.1%
2008	927	0.0%	62.6%	8.8%	0.0%	28.6%
2009	1,056	0.0%	52.0%	35.1%	0.0%	12.9%
2010	954	0.0%	36.0%	35.0%	0.0%	29.0%
2011	858	0.0%	40.8%	54.5%	0.0%	4.7%
2012	905	0.0%	27.8%	52.4%	0.0%	19.8%
2013	963	26.7%	40.9%	18.1%	0.0%	14.3%
2014	1,025	0.0%	57.2%	42.8%	0.0%	0.0%
2015	1,224	25.0%	62.4%	10.9%	0.0%	1.7%
2016	1,241	43.8%	33.6%	22.4%	0.2%	0.0%

[1] Collections by MCCRP only, does not include LCR supplementation

3.1.1 Wenatchee-Basin Broodstock Age/Origin

Both BY2013 and BY2014 coho were taken into the broodstock. The majority (97.9%) of fish spawned were BY2013 ocean-reared adults. BY2014 jacks comprised 2.1% of the total broodstock, and 4.2% of all males spawned. BY2013 reservoir-reared fish also comprised a small portion (0.2%) of the brood. The classification "reservoir-reared" refers to coho that have reared to maturity in fresh water (upriver of Bonneville Dam) in lieu of a normal term at-sea.

We suspect the increased prevalence of reservoir-reared fish returning 2016 was due to low-flow conditions coinciding with the outmigration of 2015.

Fish originating from Wenatchee-basin juvenile releases comprised 85.4% of the total broodstock (table 5). Of these, 30.9% originated from Leavenworth NFH forced releases, while 54.5% were from upper-basin volitional releases. Contribution to the broodstock by Methow-origin fish was elevated due to broodstock collections at Priest Rapids Dam; fish originating from both programs were retained there without sorting due to a lack of differentiating tags or marks. Broodstock contribution by hatchery origin fish that could not be positively identified (unknown hatchery origin) was also higher than usual due to issues regarding PBT sample collection; the early collection protocol allowed for an unexpectedly high incidence of cross-contamination resulting multiple unreliable DNA sequences. Alterations to the sampling protocol have been made to minimize further such contamination.

Table 5. Rearing and origin of coho spawned at Leavenworth National Fish Hatchery, 2016

Juvenile Release Location		BY2013	BY2014	Percentage of Brood by Release Site
Leavenworth NFH	*Leavenworth NFH - SFLs*	72	7	7.7%
	Leavenworth NFH - LFL 1 (Wenatchee Stock)	180	0	17.6%
	Leavenworth NFH- LFL 2 (Tanner Cr. Stock)	58	0	5.7%
Upper Wenatchee River Basin	*Coulter Cr.*	89	3	9.0%
	Beaver Cr.	318	3	31.3%
	Rohlfing's Pond	47	0	4.6%
	Butcher Pond	98	1	9.7%
MCCRP Methow-Basin Origin		73	0	7.1%
Unknown Hatchery Origin		63	8	6.9%
Unknown Origin		2	0	0.2%
Natural Origin		3	0	0.3%
Total		**1,003**	**22**	**100.0%**

3.1.2 Wenatchee-Basin Broodstock Length Data

Natural-origin BY2013 ocean-reared adults had greater FL than their hatchery-reared counterparts; a trend commonly observed in the past 15 years of broodstock sampling (table 6). Overall, BY2013 age 1.1 adults were average in FL in comparison the running 15-year mean. BY2014 Jacks were larger than the 15-year mean FL, while BY2013 reservoir-reared broodstock were smaller than average.

Table 6. Mean fork length and age of coho broodstock, return years 2002-2016

Return Year	Origin	Fork Length (cm)								
		Age 1.0			Age 1.1			Age 2.0		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
2002	Natural	-	0	-	-	0	-	-	0	-
	Hatchery	37	37	3.0	67	76	8.0	53	73	6.0
2003	Natural	-	0	-	67	22	5.2	-	0	-
	Hatchery	-	0	-	67	122	6.5	-	0	-
2004	Natural	-	0	-	72	39	6.2	-	0	-
	Hatchery	33	2	2.8	68	457	7.0	48	9	3.0
2005	Natural	-	0	-	70	16	6.9	-	0	-
	Hatchery	37	4	3.3	69	1,238	6.1	48	5	4.0
2006	Natural	-	0	-	71	33	5.6	-	0	-
	Hatchery	38	16	3.8	68	1,059	6.4	50	1	-
2007	Natural	-	0	-	66	40	6.8	-	0	-
	Hatchery	45	1	-	64	933	6.0	-	0	-
2008	Natural	-	0	-	74	37	5.3	-	0	-
	Hatchery	36	8	3.5	70	840	6.5	53	7	4.0
2009	Natural	-	0	-	66	29	6.7	-	0	-
	Hatchery	31	2	0.7	64	968	6.1	-	0	-
2010	Natural	-	0	-	73	24	5.1	-	0	-
	Hatchery	36	27	2.8	68	882	5.9	-	0	-
2011	Natural	-	0	-	65	15	4.8	-	0	-
	Hatchery	-	0	-	67	803	5.4	-	0	-
2012	Natural	-	0	-	66	22	4.4	-	0	-
	Hatchery	32	2	2.8	63	835	5.3	-	0	-
2013	Natural	-	0	-	66	5	8.7	-	0	-
	Hatchery	36	10	2.9	64	859	5.7	-	0	-
2014	Natural	-	0	-	65	30	5.6	-	0	-
	Hatchery	-	0	-	64	763	5.6	-	0	-
2015	Natural	-	0	-	59	17	6.7	-	0	-
	Hatchery	-	0	-	59	853	5.4	-	0	-
2016	Natural	-	0	-	68	12	4.6	-	0	-
	Hatchery	38	25	3.5	66	980	5.8	46	2	0.7
Average	***Natural***	**-**	**0**	**-**	**68**	**23**	**5.9**	**-**	**0**	**-**
	Hatchery	**35**	**9**	**2.9**	**66**	**778**	**6.0**	**50**	**6**	**3.5**

3.2 WENATCHEE-BASIN SPAWNING & INCUBATION

Seven spawns were performed between October 11, and November 22 yielding a total of 1,398,413 green eggs (Table 7). Egg collections exceeded the target green egg take of 1,358,410 eggs (Wolfe 2016). Target egg collections were based on the Broodstock Development Phase II (BDPII) goal of 1,000,000 smolts released in the spring of 2018 (YNFRM 2017). Though the Wenatchee-basin met its egg take quota, total smolts released in 2018 will be less than desired amount, since many of the progeny of the 2016 Wenatchee spawns will be used to supplement the Methow program, which fell well-below its desired broodstock collection quota.

Average fecundity in 2016 was slightly higher than both the 17-year average and median values (Table 8). The percent eye-up rate for eggs collected by the Wenatchee program was also higher than running average and median values.

Table 7. Spawn dates, number of eggs collected, and eye-up rate at Leavenworth NFH and the PIF, 2016

Spawn Date	Incubation Location	Rearing Location	Females Spawned	Total Eggs Taken	Mean Fecundity	Viable Eggs	Mean Viable Eggs / Female	% Viable Eggs
11-Oct	Leavenworth NFH	Willard NFH	7	17,365	2,481	14,185	2,026	81.7%
18-Oct	Leavenworth NFH	Cascade Hatchery	11	33,270	3,025	28,224	2,566	84.8%
25-Oct	Leavenworth NFH	Cascade Hatchery	38	108,299	2,850	98,386	2,589	90.8%
1-Nov	Leavenworth NFH	Cascade Hatchery	78	231,769	2,971	213,033	2,731	91.9%
8-Nov	Leavenworth NFH	Willard NFH	29	76,204	2,628	67,954	2,343	89.2%
		Cascade Hatchery	84	246,458	2,934	226,557	2,697	91.9%
		Willard NFH[1]	16	48,754	3,047	44,965	2,810	92.2%
15-Nov	Leavenworth NFH	Willard NFH	127	349,259	2,750	316,698	2,494	90.7%
		Winthrop NFH	21	58,935	2,806	53,551	2,550	90.9%
22-Nov	PIF	Willard NFH	84	228,100	2,715	213,045	2,536	93.4%
Total			**495**	**1,398,413**	**2,821**	**1,276,598**	**2,534**	**91.3%**

[1]Second group of fertilized eggs transferred to Willard from 8-Nov spawn

Table 8. Total eggs taken and viability, return years 2000-2016

Return Year	Females Spawned	Green Eggs	Mean Fecundity	Eyed Eggs	% Eye -up
2000	407	1,107,934	2,722	844,467	76.2%
2001	502	1,288,612	2,567	911,951	70.8%

2002	66	175,723	2,662	150,647	85.7%
2003	687	1,664,295	2,423	1,361,227	81.8%
2004	638	1,967,746	3,084	1,666,545	84.7%
2005	636	1,821,726	2,864	1,536,556	84.3%
2006	585	1,785,062	3,051	1,577,540	88.4%
2007	478	1,253,363	2,622	1,118,889	89.3%
2008	439	1,436,443	3,272	1,133,679	78.9%
2009	471	1,260,959	2,677	1,105,415	87.7%
2010	441	1,504,517	3,412	1,377,736	91.6%
2011	393	1,232,870	3,137	1,075,455	87.2%
2012	406	1,117,276	2,752	1,019,425	91.2%
2013	379	1,045,859	2,763	882,653	84.4%
2014	420	1,058,610	2,521	620,499	58.6%
2015	402	837,821	2,084	617,425	73.7%
2016	495	1,398,413	2,825	1,276,598	91.3%
Average	**459**	**1,291,602**	**2,791**	**1,075,100**	**83.2%**
Median	**441**	**1,260,959**	**2,752**	**1,105,415**	**84.7%**

3.3 WENATCHEE-BASIN ACCLIMATION

Acclimation in the Wenatchee Basin occurred at both Leavenworth NFH as well as four earthen ponds in the upper-basin. Throughout acclimation and release, performance metrics were recorded via several means including daily observation, predation assessment, growth sampling, and tracking with PIT tags.

3.3.1 Wenatchee-Basin Release Location and Marking

In total, 709,107 BY2015 coho smolts were released into the Wenatchee-basin in 2016 (Table 9). Marking of Wenatchee-basin fish was limited largely to PBT, while LCR (Tanner Cr. and Nez Perce origin) fish were marked with CWTs. PIT tags were implanted into volitionally, and forced-released fish as well as LCR-origin smolts. Approximately half of the smolts were acclimated in upper-basin earthen ponds and released volitionally, while the other half were acclimated at Leavenworth NFH and forced-released (Table 10). Despite a basin-release total markedly below the 17-year average, total PIT tags released was the highest on record.

Table 9. Summary of Wenatchee-basin Coho Releases, release year 2016

Location	Release Date	Release Number	Mark	No. PIT Tags
Beaver Creek	27-Apr	75,307	PBT	5,065
Coulter Creek	26-Apr	40,816	PBT	5,660

Rohlfing's Pond	26-Apr	106,828	PBT	5,822
Butcher Creek	26-Apr	128,419	PBT	-
Leavenworth NFH LFL 1	25-Apr	107,397	PBT, BWT	5,688
Leavenworth NFH LFL 2 (Tanner Cr.)	25-Apr	73,720	CWT	4,058
Leavenworth NFH SFL's	19-Apr	74,473	PBT	5,686
Leavenworth NFH SFL's (Nez Perce)	19-Apr	102,147	CWT, BWT	-
Wenatchee Total		**709,107**		**31,979**

Table 10. Wenatchee-basin coho released and PIT tag rate by release type, release years 2000-2016

Brood Year	Release Year	Release Type	Total	No. PIT Tags	% PIT Tags
1998	2000	Forced	0	0	-
		Volitional	968,738	7,947	0.8%
		All	968,738	7,947	0.8%
1999	2001	Forced	0	0	-
		Volitional	1,000,040	8,758	0.9%
		All	1,000,040	8,758	0.9%
2000	2002	Forced	0	0	-
		Volitional	993,200	24,801	2.5%
		All	993,200	24,801	2.5%
2001	2003	Forced	0	0	-
		Volitional	911,422	24,969	2.7%
		All	911,422	24,969	2.7%
2002	2004	Forced	125,168	3,980	3.2%
		Volitional	1,015,020	20,728	2.0%
		All	1,140,188	24,708	2.2%
2003	2005	Forced	769,164	14,469	1.9%
		Volitional	178,237	13,927	7.8%
		All	947,401	28,396	3.0%
2004	2006	Forced	737,635	12,360	1.7%
		Volitional	332,904	16,959	5.1%
		All	1,070,539	29,319	2.7%
2005	2007	Forced	594,111	12,078	2.0%
		Volitional	490,269	18,021	3.7%
		All	1,084,380	30,099	2.8%
2006	2008	Forced	571,192	11,697	2.0%
		Volitional	418,316	12,012	2.9%
		All	989,508	23,709	2.4%
2007	2009	Forced	562,085	17,924	3.2%

		Volitional	412,293	11,687	2.8%
		All	974,378	29,611	3.0%
2008	2010	Forced	567,425	10,796	1.9%
		Volitional	458,197	11,705	2.6%
		All	1,025,622	22,501	2.2%
2009	2011	Forced	470,419	11,159	2.4%
		Volitional	401,548	17,879	4.5%
		All	871,967	29,038	3.3%
2010	2012	Forced	530,141	6,095	1.1%
		Volitional	415,691	20,345	4.9%
		All	945,832	26,440	2.8%
2011	2013	Forced	509,246	9,023	1.8%
		Volitional	389,999	16,345	4.2%
		All	899,245	25,368	2.8%
2012	2014	Forced	616,960	17,203	2.8%
		Volitional	354,684	10,837	3.1%
		All	971,644	28,040	2.9%
2013	2015	Forced	244,070	8,297	3.4%
		Volitional	338,020	15,763	4.7%
		All	582,090	24,060	4.1%
2014	2016	Forced	357,737	15,412	4.3%
		Volitional	351,370	16,547	4.7%
		All	709,107	31,959	4.5%
Average		***Forced***	***391,491***	***8,853***	***2.3%***
		Volitional	***554,703***	***15,837***	***2.9%***
		All	***946,194***	***24,690***	***2.6%***

3.3.2 Wenatchee-Basin In-Pond Survival

Based on PIT tag information, Wenatchee Basin in-pond survival in 2016 ranged between 67.8% and 97.6% (Table 11). Overall in-pond survival was slightly higher than the 15-year basin average, although individual in-pond survivals at the LFL's and Beaver pond were below-average (Table 12). Elevated in-pond mortality in LFL-2 (LCR-Tanner Cr. Origin) was due to the presence of coldwater disease (*Flavobacterium psychrophilum*; T. Welsh-Becker, personal communication, December 12, 2017). Butcher Creek and Nez Perce-origin release groups did not receive PIT tags and therefore could not have in-pond survival estimated via this methodology.

Table 11. PIT estimates of in-pond survival and tag detection efficiency, release year 2016

	Leavenworth NFH LFL 1	Leavenworth NFH LFL 2	Leavenworth NFH SFLs	Rohlfing's Pond	Beaver Pond	Coulter Pond
Total PITs	5,870	5,985	5,954	5,966	5,970	5,973
Unique Outlet Detections	5,488	3,942	5,146	5,647	5,001	5,504
Unique Downstream Detections	1,416	841	1,327	1,263	638	1,014
Downstream and Outlet Detections	1,371	817	1,201	1,225	630	986
Detection Efficiency	96.8%	97.1%	90.5%	96.9%	98.7%	97.2%
PITs released	5,668	4,058	5,686	5,822	5,065	5,660
In-Pond Survival	**96.6%**	**67.8%**	**95.5%**	**97.6%**	**84.8%**	**94.8%**

Table 12. Percent in-pond survival by rearing location and annual basin total, release years 2002-2016

Brood Year	Release Year	In-Pond Survival						
		Leavenworth NFH LFLs	Leavenworth NFH SFLs	Beaver Pond	Butcher Pond	Coulter Pond	Rohlfing's Pond	Basin Total
2000	2002	-	-	-	92.5%	-	-	92.5%
2001	2003	-	-	-	89.2%	-	-	89.2%
2002	2004	-	-	-	88.0%	-	94.1%	91.1%
2003	2005	-	-	-	75.2%	-	89.7%	82.5%
2004	2006	-	-	90.5%	-	83.6%	-	87.1%
2005	2007	-	-	87.7%	-	83.2%	-	85.5%
2006	2008	-	-	-	87.7%	-	98.6%	93.2%
2007	2009	-	-	-	76.6%	-	91.9%	84.3%
2008	2010	-	-	-	88.5%	-	94.6%	91.6%
2009	2011	-	-	89.6%	80.5%	-	91.4%	87.2%
2010	2012	94.6%	81.0%	87.3%	85.7%	82.2%	92.5%	87.2%
2011	2013	88.5%	97.1%	91.5%	-	92.0%	97.2%	93.3%
2012	2014	95.9%	96.4%	91.9%	-	93.6%	-	94.5%
2013	2015	91.8%	92.9%	94.9%	73.4%	-	95.4%	89.7%
2014	2016	82.2%	95.5%	84.8%	-	94.8%	97.6%	91.0%
Average		**90.6%**	**92.6%**	**89.8%**	**83.7%**	**88.2%**	**94.3%**	**89.9%**

3.3.3 Wenatchee-Basin Predation Assessment

We estimated that 26,342 coho were lost during acclimation due to predation and other causes (Table 13). A significant proportion (90%) of the total mortality was attributed to the estimated impacts of predation. Leavenworth NFH raceways saw the highest occurrences of both known and estimated mortalities. While it is normal to have a higher number of enumerated mortalities in the hatchery-setting, it is unusual for Leavenworth NFH to have a higher estimated rate of predation than the remote ponds (Table 14).

Table 13. Known and estimated morality at Wenatchee-basin acclimation sites, release year 2016

Release Location	Known Mortality[1]	Estimated Mortality (Predation Model)	Total Loss
Beaver Creek	2	927	929
Butcher Creek	130	2,522	2,652
Coulter Creek	24	1,577	1,601
Leavenworth NFH LFL's	981	7,850	8,831
Leavenworth NFH SFL's	1,203	9,120	10,323
Rohlfing's Pond	410	1,596	2,006
Total	**2,750**	**23,592**	**26,342**

[1]Dead coho removed from ponds/raceways

Table 14. Wenatchee-basin known and estimated mortalities during acclimation, release years 2000-2016

Brood Year	Release Year	Rearing Type	Known Mortality[1]	Estimated Mortality (Predation Model)	Total Loss
1998	2000	Hatchery	5,569	5,569	11,138
		Remote Pond	66	66	132
		All	5,635	5,635	11,270
1999	2001	Hatchery	8,057	8,057	16,114
		Remote Pond	50	50	100
		All	8,107	8,107	16,214
2000	2002	Hatchery	735	4,274	5,009
		Remote Pond	576	5,256	5,832
		All	1,311	9,530	10,841
2001	2003	Hatchery	1,956	8,422	10,378
		Remote Pond	593	15,639	16,232
		All	2,549	24,061	26,610
2002	2004	Hatchery	640	6,696	7,336
		Remote Pond	370	3,630	4,000
		All	1,010	10,326	11,336
2003	2005	Hatchery	–	–	–
		Remote Pond	–	–	–
		All	–	–	–
2004	2006	Hatchery	–	–	–
		Remote Pond	–	–	–
		All	–	–	–
2005	2007	Hatchery	13,100	7,400	20,500
		Remote Pond	2,250	18,801	21,051

		All	15,350	26,201	41,551
2006	2008	Hatchery	3,850	4,140	7,990
		Remote Pond	1,400	19,145	20,545
		All	5,250	23,285	28,535
2007	2009	Hatchery	3,005	871	3,876
		Remote Pond	100	23,132	23,232
		All	3,105	24,003	27,108
2008	2010	Hatchery	2,081	4,854	6,935
		Remote Pond	1,219	13,928	15,147
		All	3,300	18,782	22,082
2009	2011	Hatchery	10,406	4,854	15,260
		Remote Pond	1,023	24,523	25,546
		All	11,429	29,377	40,806
2010	2012	Hatchery	30,092	6,960	37,052
		Remote Pond	1,245	19,933	21,178
		All	31,337	26,893	58,230
2011	2013	Hatchery	16,788	3,288	20,076
		Remote Pond	129	5,337	5,466
		All	16,917	8,625	25,542
2012	2014	Hatchery	1,001	2,832	3,833
		Remote Pond	961	9,479	10,440
		All	1,962	12,311	14,273
2013	2015	Hatchery	1,856	5,557	7,413
		Remote Pond	137	10,387	10,524
		All	1,993	15,944	17,937
2014	2016	Hatchery	2,184	16,970	19,154
		Remote Pond	566	6,622	7,188
		All	2,750	23,592	26,342
Average		**Hatchery**	**6,755**	**6,050**	**12,804**
		Remote Pond	**712**	**11,729**	**12,441**
		All	**7,467**	**17,778**	**25,245**

[1]Dead coho removed from rearing location

3.3.4 Wenatchee-Basin Pre-Release Condition

Wenatchee-basin smolts released in 2016 averaged 17.1 fish per pound (FPP; Table 15). Though the MCCRP no longer uses a specific FPP as a target release weight, approximately 17 FPP is maintained as a suitable size for release. Coho release in 2016 were slightly larger than the 17-year mean size at release (Table 16).

Table 15. Wenatchee-basin pre-release condition by acclimation site, release year 2016

Release Location	Fork Length (mm)		Weight (g)		Fish Per Pound
	Mean	CV	Mean	CV	
Beaver Creek	133.6	5.8	27.5	17.2	16.5
Coulter Creek	135.3	5.5	28.1	15.6	16.2
Rohlfing's Pond	137.0	5.6	28.3	16.6	16.0
Butcher Creek	136.7	5.6	27.1	16.6	16.8
Leavenworth NFH LFL 1	135.8	6.6	28.1	18.6	16.1
Leavenworth NFH LFL 2 (Tanner Cr.)	132.0	7.4	25.8	23.3	17.6
Leavenworth NFH SFL's	120.9	6.3	24.6	17.6	20.7
Average	**133.0**	**6.1**	**27.1**	**17.9**	**17.1**

Table 16. Pre-release condition, release years 2000-2016

Brood Year	Release Year	Fork Length (mm)		Weight (g)		Fish Per Pound
		Mean	CV	Mean	CV	
1998	2000	-	-	-	-	19.2
1999	2001	126	-	21.1	-	19.5
2000	2002	130	6.9	27.7	21.9	16.4
2001	2003	134	8.1	27.3	23.1	16.6
2002	2004	136	7.1	29.4	20.6	15.4
2003	2005	132	8.2	26.2	24.9	17.3
2004	2006	130	9.7	25.9	22.8	17.5
2005	2007	130	8.9	25.2	27.3	18.0
2006	2008	128	7.5	24.5	23.4	18.5
2007	2009	131	7.1	27.4	22.5	16.5
2008	2010	132	6.7	26.2	20.5	17.3
2009	2011	125	7.4	22.2	23.5	20.5
2010	2012	126	7.5	23.2	23.6	19.5
2011	2013	133	6.1	26.3	18.2	17.2
2012	2014	127	7.4	23.3	20.3	19.5
2013	2015	130	7.6	25.0	21.9	18.1
2014	2016	132	7.4	26.4	19.8	17.2
Average		**130**	**7.6**	**25.7**	**22.3**	**17.7**

3.4 WENATCHEE BASIN NATURAL JUVENILE PRODUCTION

Emigrant estimates from the Wenatchee basin included 131 ± 514 BY2014 emigrants from Nason Creek, and 12,499 ± 3,629 BY2014 emigrants past the WDFW-run lower-Wenatchee trap. Few estimated emigrants from Nason Creek despite a large adult escapement may be due in-part to aggressive broodstock retention at Tumwater Dam, largely preventing adults from entering the upper-basin.

Table 17. Naturally-produced coho emigrant estimates from the Nason Creek and Wenatchee River smolt traps, brood years 2000-2014

Brood Year	Migratory Year	Nason Creek		Wenatchee River	
		Emigrant Estimate	95% CI	Emigrant Estimate	95% CI
2000	2002	–	–	17,054[3]	–
2001	2003	–	–	36,678[3]	–
2002	2004	–	–	5,826[3]	–
2003	2005	–	–	41,208[3]	–
2004	2006	260[1]	155	14,106[3]	–
2005	2007	937[1]	347	48,708[3]	–
2006	2008	7[1]	10	16,753[3]	–
2007	2009	14[1]	104	20,335[3]	–
2008	2010	50[1]	57	20,741[3]	–
2009	2011	471[1]	478	–	–
2010	2012	27[1]	231	–	–
2011	2013	1,017[1]	612	26,022[4]	4,833
2012	2014	46[2]	237	14,317[4]	2,379
2013	2015	91[2]	714	11,248[4]	2,958
2014	2016	131[2]	514	12,499[4]	3,629[5]

[1] Campground location
[2] Bolser location
[3] Monitor location
[4] Cashmere location

3.5 WENATCHEE BASIN SPAWNING/CARCASS SURVEYS

Spawning ground surveys were performed in the Wenatchee basin from October 2 to December 7. Surveys were performed on all established survey reached below Tumwater dam throughout the survey period. Surveys in the upper-Wenatchee basin were not performed due to a lack of female passage above Tumwater Dam; a result of both a poor adult return and aggressive collections for broodstock purposes. In total, only two adult coho were passed above Tumwater Dam. Though sexes of these two fish were not determined, given the male to female sex ratio (M:F) of 4.3:1, it is likely that they were both male.

3.5.1 Wenatchee-Basin Redd Count and Distribution

The annual count of 179 redds fell below the 17-year annual mean of 666 redds (Tables 17 & 18). Of redds documented in 2016, approximately 60% were found in Icicle Creek and 35% in the Mainstem Wenatchee River. Heavy use of these two major spawning aggregates is typical, although proportional use of the mainstem Wenatchee River was slightly higher than average. Due to the very limited passage at Tumwater Dam, we suspect that there was no successful coho spawning overlapping with major spring Chinook or bull trout spawning aggregates e.g., Nason Creek and Chiwawa River.

Table 18. Summary of Wenatchee River coho redd counts, distribution and carcass recovery in 2016

Stream	Redd Count				Live Fish				Recovered Carcasses				Sample Rate[2]
	Oct	Nov	Dec	Tot.	Oct	Nov	Dec	Tot.	Oct	Nov	Dec	Tot.	FINAL
Beaver Cr.[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Chiwaukum Cr.[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Chiwawa R.[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Chumstick Cr.	0	3	0	3	1	8	0	9	0	5	0	5	**77.5%**
Icicle Cr.	28	78	1	107	99	165	5	269	0	22	0	22	**9.6%**
Mission/Brender Cr.	1	3	–	4	0	5	–	5	0	0	–	0	**0.0%**
Nason Cr.	0	–	–	0	0	–	–	0	0	–	–	0	–
Peshastin Cr.	0	2	0	2	0	2	0	2	0	4	0	4	**93.0%**
Roaring Cr.	–	0	–	0	–	0	–	0	–	0	–	0	–
Wenatchee R. R1 - R5	14	49	0	63	37	58	0	95	0	4	0	4	**3.0%**
Wenatchee R. R6 & R7[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	**43**	**135**	**1**	**179**	**137**	**238**	**5**	**380**	**0**	**35**	**0**	**35**	**9.1%**

[1]Not sampled due to a known lack of female passage at Tumwater Dam

[2] Sample rate was based on Fish Per Redd (fpr) derived from calculated sex ratios from the run-at-large (1.15M: 1.0F)

Table 19. Wenatchee-basin coho redd distribution by tributary, return years 2000-2016

Brood Year	Return Year	Coho Redds										Basin Total
		Beaver Creek	Chiwaukum Creek	Chiwawa River	Chumstick Creek	Icicle Creek	Mission/ Brender Creek	Nason Creek	Peshastin Creek	Roaring Creek	Wenatchee River	
1998	2000	–	–	–	–	74	–	3	–	–	–	77
1999	2001	–	–	–	–	151	–	3	–	–	–	154
2000	2002	–	–	–	–	21	–	1	–	–	6	28
2001	2003	0	0	0	–	507	5	6	4	–	0	522
2002	2004	0	0	0	–	504	21	35	35	–	119	714
2003	2005	0	1	0	–	609	17	64	25	–	221	937
2004	2006	0	0	0	0	88	6	4	6	–	6	110
2005	2007	0	0	0	–	1,267	47	10	88	–	259	1,671
2006	2008	0	0	0	–	197	52	3	19	–	75	346
2007	2009	1	0	0	0	818	72	14	214	–	482	1,601
2008	2010	0	–	3	0	100	20	8	15	–	70	216
2009	2011	0	–	0	13	1,664	85	89	57	–	813	2,721
2010	2012	0	0	0	0	224	12	21	16	0	86	359
2011	2013	0	0	0	0	73	1	0	1	0	33	108
2012	2014	0	0	0	52	913	43	16	58	0	413	1,495
2013	2015	0	0	0	0	55	6	0	3	0	16	80
2014	2016	0	0	0	3	107	4	0	2	0	63	179
Average		**0**	**0**	**0**	**8**	**434**	**28**	**16**	**39**	**0**	**177**	**666**

3.5.2 Wenatchee-Basin Carcass Origin and Distribution

Thirty-five carcasses were recovered in the Wenatchee-basin (Table 19). This in-year total was below the 17-year mean of 247 carcasses recovered (Table 20). The majority (62.9%) of all carcasses were recovered in Icicle Creek. This is typical, with Icicle Creek on-average contributing over-half of the total Wenatchee-basin carcasses.

The majority (85.7%) of the carcasses were identified as hatchery-origin via scale and CWT analysis. Identification of hatchery-origin fish to specific release groups/locations was largely unfeasible due to a lack of CWTs in most the fish sampled; PBT analysis had proven difficult on the often degraded DNA samples taken off of carcasses.

Table 20. Summary of carcass distribution and origin throughout the Wenatchee River and its tributaries, return year 2016

Juvenile Coho Release Location/Origin through Scale and CWT analysis	Adult Recovery Location										
	Lower Wenatchee					Upper Wenatchee					
	Mission	Peshastin	Chumstick	Icicle	Wenatchee 1-4	Chiwaukum	Chiwawa	Beaver	Nason	Wenatchee 5-7	TOTAL
Leavenworth NFH LFL Tanner Creek	0	0	1	3	1	0	0	0	0	0	5
Unknown Hatchery Origin	0	4	3	15	3	0	0	0	0	0	25
Natural Origin	0	0	1	0	0	0	0	0	0	0	1
Indeterminate Rearing/Origin	0	0	0	4	0	0	0	0	0	0	4
TOTAL	**0**	**4**	**5**	**22**	**4**	**0**	**0**	**0**	**0**	**0**	**35**

Table 21. Wenatchee-basin coho carcass distribution by tributary, return years 2000-2016

Brood Year	Return Year	Coho Carcasses										Basin Total	Sample Rate[1]
		Beaver Creek	Chiwaukum Creek	Chiwawa River	Chumstick Creek	Icicle Creek	Mission/ Brender Creek	Nason Creek	Peshastin Creek	Roaring Creek	Wenatchee River		
1998	2000	–	–	–	–	41	–	0	–	–	–	41	25.4%
1999	2001	–	–	–	–	21	–	1	–	–	–	22	6.8%
2000	2002	–	–	–	–	9	–	0	–	–	0	9	15.3%
2001	2003	0	0	0	–	0	0	5	8	–	0	13	1.2%
2002	2004	0	0	0	–	0	0	7	0	–	0	7	0.5%
2003	2005	0	0	0	–	43	2	3	6	–	22	76	3.9%
2004	2006	0	0	0	0	31	38	1	3	–	4	77	33.3%
2005	2007	0	0	0	–	329	30	0	1	–	89	449	12.8%
2006	2008	0	0	0	–	22	12	0	8	–	17	59	8.1%
2007	2009	0	0	0	0	569	23	3	55	–	393	1,043	31.0%
2008	2010	0	–	0	0	51	4	0	8	–	15	78	15.7%
2009	2011	0	–	0	3	694	19	7	7	–	557	1,287	22.5%
2010	2012	0	0	0	0	76	4	0	6	0	69	155	20.6%
2011	2013	0	0	0	0	19	0	0	0	0	14	33	12.7%

2012	2014	0	0	0	80	387	32	4	7	0	291	801	23.3%
2013	2015	0	0	0	0	7	1	0	4	0	6	18	9.8%
2014	2016	0	0	0	5	22	0	0	4	0	4	35	9.1%
Average		0	0	0	10	137	12	2	8	0	99	247	14.8%

[1] Sample rate was based on Fish Per Redd (fpr) derived from calculated sex ratios from the run-at-large.

3.6 WENATCHEE-BASIN LIFE HISTORY MONITORING

3.6.1 Wenatchee-Basin Smolt-Smolt Survival

Smolt-to-smolt survival for individual release locations ranged between 30.5% and 51.3% (Table 21). The basin-wide smolt-to-smolt survival rate in 2016 was below the 17-year average and median. Out-migrant survival rates for individual ponds were all below their corresponding running average and median values, with the exception the Leavenworth NFH SFLs, which was slightly higher.

Table 22. Wenatchee-basin smolt-smolt survivals by release location, release years 2000-2016

Brood Year	Release Year	Upper-Basin						Leavenworth NFH			Basin Total
		Beaver Pond	Butcher Pond	Coulter Pond	Nason Wetland	Rohlfing Pond	2 Rivers	LFLs	SFLs	Dam 5	
1998	2000	-	-	-	-	-	-	-	-	63.0%	63.0%
1999	2001	-	-	-	-	-	-	-	-	21.6%	21.6%
2000	2002		39.3%							82.5%	60.9%
2001	2003	-	37.2%	-	-	-	20.4%	-		62.8%	40.1%
2002	2004	-	32.5%	-	-	36.2%	-	-	56.3%	60.8%	46.5%
2003	2005	-	16.4%	-	-	17.5%	-	48.2%	42.1%	-	31.1%
2004	2006	48.8%	-	44.8%	15.9%	-	-	43.7%	45.5%	-	38.3%
2005	2007	58.8%	-	54.5%	-	45.0%	-	86.5%	56.3%	-	60.2%
2006	2008	-	71.2%	-	-	46.3%	-	52.0%	56.5%	-	56.5%
2007	2009	-	48.3%	-	-	46.6%	-	43.8%	50.5%	-	47.3%
2008	2010	-	58.6%	-	-	69.0%	-	77.0%	51.8%	-	64.1%
2009	2011	39.8%	32.1%	-	-	40.5%	-	35.2%	44.2%	-	38.4%
2010	2012	29.3%	32.4%	54.3%	-	42.5%	-	42.4%	27.5%	-	38.1%
2011	2013	48.6%	-	36.2%	-	48.8%	-	55.8%	65.4%	-	51.0%
2012	2014	42.2%	-	41.5%	-	-	-	41.6%	46.7%	-	43.0%
2013	2015	50.7%	33.0%	-	-	40.0%	-	37.4%	23.6%	-	36.9%
2014	2016	31.7%	-	38.1%	-	30.5%	-	49.6%	51.3%	-	40.2%

Average	**43.7%**	**40.1%**	**44.9%**	**15.9%**	**42.1%**	**20.4%**	**51.1%**	**47.7%**	**58.1%**	**40.4%**
Median	**45.4%**	**35.1%**	**43.2%**	**15.9%**	**42.5%**	**20.4%**	**46.0%**	**50.9%**	**62.8%**	**43.0%**

3.6.2 Wenatchee-Basin Escapement

Estimated escapements to the Wenatchee-basin derived from the four estimation methods ranged from 1,085 to 2,071 coho in 2016 (Table 22). Seen as the most reliable estimate of total escapement in 2016, Method-3's estimate of 1,574 returning coho was below the running 15-year average and median values (Table 23).

Table 23. Estimated coho run size to the Wenatchee River, return year 2016

Method	Est. Run Size
1) Dryden Dam counts expanded for non-trapping days plus redds located below Dryden Dam[1]	1,126 (1,088 adults & 38 jacks)
2) Redd counts plus broodstock collected[1]	1,085 (1,063 adults & 21 jacks)
3)Tumwater Dam counts, redds below Tumwater Dam, and broodstock collected[1]	1,574 (1,548 adults & 26 jacks)
4) Mainstem Dam Counts[2]	2,071 (1,968 adults & 15 jacks)

[1] Each redd count was expanded by 2.15 fish per redd based on the sex ratio of coho observed at Dryden Dam, 1.15M:1F.
[2] Mainstem dam counts represent the difference in adult passage observed between Rock Island Dam and Rocky Reach Dam.

Table 24. Wenatchee-basin estimated coho escapement, return years 2000-2016

Return Year	Adults	Jacks	Total Escapement
2000	ND	ND	1,113
2001	ND	ND	1,773
2002	255	88	343
2003	4,025	43	4,068
2004	3,519	75	3,594
2005	3,574	36	3,610
2006	1,772	327	2,099
2007	4,861	7	4,868
2008	1,539	95	1,634
2009	4,922	45	4,967
2010	1,463	259	1,722
2011	7,351	4	7,355
2012	2,717	10	2,727
2013	995	71	1,066
2014	8,721	56	8,777

2015	1,408	0	1,408
2016	1,548	26	1,574
Average	**3,245**	**76**	**3,100**
Median	**2,717**	**45**	**2,099**

3.6.3 Wenatchee-Basin Smolt-Adult Survival

Smolt-to-adult ratios (SAR) for returning BY2013 fish ranged from 0.00006 to 0.0046, with a basin-wide mean of 0.0026 (Table 24). The BY2013 hatchery-origin SAR fell below the running programmatic mean of 0.0032 (Table 25). The natural origin SAR estimate was also well-below the running mean value.

Table 25. Wenatchee River brood year 2013 hatchery-origin SARs by release site, brood origin, and rearing facility

Release Site	Minimum Acclimation Duration (d)	Brood Origin	Rearing Facility	*n* (Adult Returns)	Total Released	SAR
Beaver Pond	30	MCR-Wenatchee	Cascade	522	101,106	0.0052
Butcher Pond	43	MCR-Wenatchee	Cascade	150	96,137	0.0016
Coulter Pond	49	MCR-Wenatchee	Cascade	133	51,388	0.0026
Leavenworth NFH LFL 1	68	MCR-Wenatchee	Cascade	389	84,750	0.0046
Leavenworth NFH LFL 2	68	LCR- Tanner	Cascade	115	96,206	0.0012
Leavenworth NFH SFL 23-25	62	MCR-Wenatchee	Willard	159	63,114	0.0025
Rohlfing's Pond	37	MCR-Wenatchee	Willard	58	94,545	0.0006
Total				**1,530**	**598,176**	**0.0026**

Table 26. Wenatchee-basin SAR survivals, return years 2000-2016

Brood Year	Return Year	Origin	SAR
1997	2000	Hatchery	0.0022
		Natural	–
1998	2001	Hatchery	0.0018
		Natural	–
1999	2002	Hatchery	0.0003
		Natural	–
2000	2003	Hatchery	0.0041
		Natural	0.0038
2001	2004	Hatchery	0.0037

		Natural	0.0043
2002	2005	Hatchery	0.0034
		Natural	0.0090
2003	2006	Hatchery	0.0018
		Natural	0.0015
2004	2007	Hatchery	0.0044
		Natural	0.0159
2005	2008	Hatchery	0.0014
		Natural	0.0015
2006	2009	Hatchery	0.0046
		Natural	0.0135
2007	2010	Hatchery	0.0016
		Natural	0.0036
2008	2011	Hatchery	0.0072
		Natural	0.0079
2009	2012	Hatchery	0.0030
		Natural	0.0020
2010	2013	Hatchery	0.0012
		Natural	0.0008
2011	2014	Hatchery	0.0093
		Natural	0.0091
2012	2015	Hatchery	0.0014
		Natural	0.0026
2013	2016	Hatchery	0.0026
		Natural	0.0004
Average		**Hatchery**	**0.0032**
		Natural	**0.0054**

3.6.4 Wenatchee-Basin Adult-Adult Replacement

BY2013 hatchery replacement rate (HRR) and natural replacement rate (NRR) were both below 14-year mean and median values for the Wenatchee-basin (Table 26).

Table 27. Wenatchee-basin hatchery and natural-origin Adult-to-Adult replacement rates, brood year 2000-2013.

Brood Year	Broodstock Spawned	Spawning Escapement[1]	HOR	NOR	HRR	NRR
2000	824	163	3,254	75	3.95	0.46
2001	1,051	339	4,616	226	4.39	0.67
2002	208	62	1,029	78	4.95	1.27
2003	1,419	1,148	3,465	117	2.44	0.10
2004	1,331	1,571	13,994	579	10.51	0.37
2005	1,334	2,061	3,231	158	2.42	0.08
2006	1,198	242	15,472	738	12.91	3.05
2007	984	3,676	3,997	189	4.06	0.05
2008	898	761	23,300	533	25.95	0.70
2009	1,002	3,522	5,540	297	5.53	0.08
2010	940	475	1,972	19	2.10	0.04
2011	828	5,986	33,415	1,086	40.36	0.18
2012	870	790	2,452	65	2.82	0.08
2013	876	238	2,071	5	2.36	0.02
Average	**983**	**1,502**	**8,415**	**298**	**8.91**	**0.51**
Median	**962**	**776**	**3,731**	**174**	**4.23**	**0.14**

[1]Calculated as number of redds by run-at-large FPR

SECTION 4: METHOW-BASIN MONITORING AND EVALUATION

4.1 METHOW-BASIN BROODSTOCK COLLECTION AND SAMPLING

In 2016, the Methow program collected total of 198 coho; 197 of which were successfully spawned (Tables 27&28). Pre-spawn mortality was 0.4%; below the program's running 16-year mean. Broodstock were only retained from Wells Dam and Winthrop NFH, with the latter being the primary collection point (Table 29). Broodstock collections in the Methow-basin were well-below the target goal of 948 adults (Wolfe 2016). This was the result of both a poor return, and heavy retention by the Wenatchee-basin program at Priest Rapids dam as a risk –aversion measure in light of the low adult escapement.

Table 28. Methow-basin coho salmon and incidentals handled during trapping, 2016

Location	Coho (*broodstock*)[1]	Bull Trout	Steelhead	Spring Chinook
Methow Fish Hatchery weir	11 (*0*)	0	0	0
Wells Dam West/East Ladders	102 (*75*)	0	14	0
Winthrop NFH adult holding pond/collection weir	133 (*123*)	0	0	0

[1] Parenthesized number denotes fish retained at the collection location

Table 29. Summary of Methow coho broodstock collection and retention, return years 2001-2016

Return year	Handled	Collected	Pre-spawn Mortality/ Non-Viable	Released	Total Spawned
2001	205	205	13	0	192
2002	52	52	8	0	44
2003	208	208	40	54	114
2004	118	118	12	0	106
2005	354	354	17	55	282
2006	342	331	19	21	291
2007	959	959	38	371	550
2008	517	507	50	0	457
2009	594	559	110	56	393
2010	721	721	21	181	519
2011	565	565	13	86	466
2012	821	779	43	151	585

2013	300	277	13	36	228
2014	791	621	67	121	433
2015	729	727	59	142	526
2016	246	198	1	0	197
Average	**470**	**452**	**33**	**83**	**336**

Table 30. Percent annual Methow broodstock collections by point of capture, 2002-2016

Return Year	Winthrop NFH	Methow Hatchery	Wells Dam
2001	100.0%	0.0%	0.0%
2002	82.7%	0.0%	17.3%
2003	79.3%	0.0%	20.7%
2004	89.0%	0.0%	11.0%
2005	36.7%	0.0%	63.3%
2006	67.4%	0.0%	32.6%
2007	61.5%	0.0%	38.5%
2008	38.5%	0.0%	61.5%
2009	41.3%	0.0%	58.7%
2010	64.8%	0.0%	35.2%
2011	66.7%	10.3%	23.0%
2012	87.9%	0.3%	11.8%
2013	31.4%	5.4%	63.2%
2014	4.5%	0.0%	95.5%
2015	24.3%	4.3%	71.4%
2016	62.1%	0.0%	37.9%
Average	**52.4%**	**1.3%**	**40.1%**

4.1.1 Methow-Basin Broodstock Age/Origin

Coho spawned in the Methow-basin included BY2012 and BY2013 adults as well as BY2014 jacks. The majority (97.4%) of fish spawned were BY2013 ocean-reared adults. BY2014 jacks comprised 1.5% of the total broodstock, and 3.0% of all males spawned. BY2012 adult coho also comprised a small portion (1.0%) of the brood (Table 30).

Coho originating from Methow-basin juvenile releases comprised 84.0% of the total brood (Table 30). Fish that could only be identified as hatchery-origin via scale analysis only (CWTs lost or not available) are suspected of being largely of Methow-origin. Eventual PBT analysis of these fish will confirm Methow, or out of basin origin.

Table 31. Rearing and origin of coho spawned at Winthrop National Fish Hatchery, 2016

Juvenile Release Location		BY2012 Adults	BY2013 Adults	BY2014 Jacks	Percentage of Brood by Release Site
Methow River Basin	*Winthrop NFH On-station*	1	150	3	77.8%
	Winthrop NFH Back Channel	0	0	0	0.0%
	Lower Twisp Ponds	0	7	0	3.5%
	Wolf Creek Pond	0	2	0	1.0%
	Gold Creek Ponds	0	4	0	2.0%
Out-of-Basin Hatchery Origin		0	0	0	0.0%
Unknown Hatchery Origin		0	27	0	13.6%
Unknown Origin		0	0	0	0.0%
Natural Origin		1	3	0	2.0%
Total		**2**	**193**	**3**	**100.0%**

4.1.2 Methow-Basin Broodstock Length Data

Natural-origin BY2013 ocean-reared adults had a greater mean FL than their hatchery-reared counterparts; a trend commonly observed in the past 13 years of broodstock sampling (Table 31). BY2014 hatchery-origin jacks were on average larger than previously spawned age 1.0 males. The single age 1.2 BY2012 fish measured was the first of its life history to be sampled so a precedent mean FL could not be compared to.

Table 32. Mean fork length and age of Methow coho broodstock, 2003-2016

Return Year	Origin	Fork Length (cm)								
		Age 1.0			Age 1.1			Age 1.2		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
2003	Natural	–	–	–	–	–	–	–	–	–
	Hatchery	–	–	–	63	192	6.6	–	–	–
2004	Natural	–	–	–	–	–	–	–	–	–
	Hatchery	–	–	–	65	106	8.0	–	–	–
2005	Natural	–	–	–	–	–	–	–	–	–
	Hatchery	–	–	–	68	282	6.8	–	–	–
2006	Natural	–	–	–	–	–	–	–	–	–
	Hatchery	39	7	3.8	67	284	7.3	–	–	–
2007	Natural	–	–	–	–	–	–	–	–	–
	Hatchery	–	–	–	63	547	5.9	–	–	–
2008	Natural	–	–	–	76	1	–	–	–	–
	Hatchery	38	4	2.6	70	452	6.8	–	–	–

2009	Natural	–	–	–	68	5	6.9	–	–	–
	Hatchery	–	–	–	64	388	6.0	–	–	–
2010	Natural	–	–	–	73	2	1.4	–	–	–
	Hatchery	39	6	4.8	67	511	5.3	–	–	–
2011	Natural	–	–	–	–	–	–	–	–	–
	Hatchery	–	–	–	65	466	4.6	–	–	–
2012	Natural	–	–	–	–	–	–	–	–	–
	Hatchery	–	–	–	61	585	4.8	–	–	–
2013	Natural	–	–	–	59	5	4.2	–	–	–
	Hatchery	–	–	–	63	223	4.8	–	–	–
2014	Natural	–	–	–	65	5	4.2	–	–	–
	Hatchery	–	–	–	63	428	5.3	–	–	–
2015	Natural	–	–	–	60	5	6.0	–	–	–
	Hatchery	–	–	–	58	521	4.7	–	–	–
2016	Natural	–	–	–	67	3	8.1	–	–	–
	Hatchery	52	3	5.7	63	189	5.2	56	1	-
Average	***Natural***	**-**	**-**	**-**	**66.8**	**4**	**5.1**	**-**	**-**	**-**
	Hatchery	**41.9**	**5.0**	**4.2**	**64.4**	**370**	**5.9**	**56.0**	**1.0**	**-**

4.2 METHOW-BASIN SPAWNING & INCUBATION

Five spawns were performed between October 17, and November 14 yielding a total of 237,909 green eggs (Table 32). Egg collections were well-below the target green egg take of 1,321,178 eggs (Wolfe 2016). Target egg collections were based on the Broodstock Development Phase II (BDPII) goal of 1,000,000 smolts released in the spring of 2018 (YNFRM 2017). The inability to meet egg collection goals was due to the aforementioned poor adult return and collection of Methow-origin fish at Priest Rapids dam for spawning at Leavenworth NFH.

Annual average fecundity was slightly higher than both the 16-year average and median values (Table 33). The percent eye-up rate for eggs collected by the Methow program was also higher than running average and median values.

Table 33. Spawn dates, number of eggs collected, and eye-up rate for coho spawned and reared at Winthrop NFH, 2016.

Spawn Date	Females Spawned	Total Eggs Taken	Mean Fecundity	Viable eggs	Mean Viable Eggs /Female	% Viable Eggs
10/17/2017	2	6,277	3,139	4,852	2,426	77.3
10/24/2017	17.5	51,052	2,917	43,754	2,500	85.7
10/31/2017	27	81,329	3,012	71,226	2,638	87.6

11/7/2017	41	113,716	2,774	101,030	2,464	88.8
11/14/2017	8.5	21,628	2,544	17,047	2,006	78.8
Total	**96**	**274,002**	**2,877**	**237,909**	**2,407**	**84**

Table 34. Total Methow-basin eggs taken and viability, 2000-2016

Return Year	Females Spawned	Green Eggs	Mean Fecundity	Eyed Eggs	% Eye-up
2001	93	241,680	2,599	190,622	78.9%
2002	11	21,701	1,973	17,806	82.1%
2003	48	106,734	2,224	83,582	78.3%
2004	37	94,763	2,561	58,727	62.0%
2005	140	364,880	2,606	308,697	84.6%
2006	141	422,265	2,995	363,647	86.7%
2007	268	654,457	2,442	592,731	90.6%
2008	238	751,032	3,156	636,469	84.7%
2009	197	539,961	2,741	453,848	84.1%
2010	252	786,198	3,126	652,921	83.0%
2011	231	662,830	2,869	601,802	90.8%
2012	286	700,580	2,450	609,574	87.0%
2013	112	335,403	3,008	277,230	82.7%
2014	211	584,579	2,777	440,173	75.3%
2015	250	529,094	2,116	417,970	79.0%
2016	96	274,002	2,854	237,909	86.8%
Average	**163**	**441,885**	**2,656**	**371,482**	**82.3%**
Median	**169**	**475,680**	**2,674**	**390,809**	**83.6%**

4.3 METHOW-BASIN ACCLIMATION

Acclimation in the Wenatchee Basin occurred at both Winthrop NFH and three remote ponds. Throughout acclimation and release, performance metrics were recorded via several means including daily observation, predation assessment, growth sampling, and tracking with PIT tags.

4.3.1 Methow-Basin Release Location and Marking

In total, 388,790 BY2015 coho smolts were released into the Methow-basin (Table 34). Approximately 62.7% of all coho were released from Winthrop NFH, while 37.3% were released from remote acclimation ponds. Marking of all Methow-basin included both CWTs and PBT. PIT tags were included in all release groups except for Twisp Ponds. Overall tag rate was higher than the running 17-year average, but below average for volitionally-released fish (Table 35).

Table 35. Summary of Methow-basin Coho Releases, 2016

Location	Release Date	Release Number	Mark	No. PIT Tags
Wolf Creek Acclimation Pond	4/24/2016	44,288	CWT, PBT	5,756
Lower Twisp River Acclimation Pond	4/24/2016	64,950	CWT, PBT	-
Gold Creek Acclimation Ponds	4/24/2016	35,809	CWT, PBT	5,561
Winthrop NFH C12 – C16	4/21/2016	243,743	CWT, PBT	5,712
Methow Total	–	**388,790**	–	**17,029**

Table 36. Methow-basin coho released and PIT tag rate by release type, release years 2000-2016

Brood Year	Release Year	Release Type	Total	No. PIT Tags	% PIT Tags
1998	2000	Forced	-	-	-
		Volitional	199,763	8,937	4.5%
		All	199,763	8,937	4.5%
1999	2001	Forced	-	-	-
		Volitional	260,157	8,937	3.4%
		All	260,157	8,937	3.4%
2000	2002	Forced	-	-	-
		Volitional	186,053	0	0.0%
		All	186,053	0	0.0%
2001	2003	Forced	-	-	-
		Volitional	242,355	0	0.0%
		All	242,355	0	0.0%
2002	2004	Forced	-	-	-
		Volitional	308,019	8,944	2.9%
		All	308,019	8,944	2.9%
2003	2005	Forced	-	-	-
		Volitional	283,695	0	0.0%
		All	283,695	0	0.0%
2004	2006	Forced	149,804	0	0.0%
		Volitional	310,091	0	0.0%
		All	460,795	0	0.0%
2005	2007	Forced	140,157	0	0.0%
		Volitional	337,531	0	0.0%
		All	477,688	0	0.0%
2006	2008	Forced	442,636	0	0.0%
		Volitional	76,949	7,504	9.8%

		All	519,585	7,504	1.4%
2007	2009	Forced	44,420	0	0.0%
		Volitional	424,937	11,371	2.7%
		All	469,357	11,371	2.4%
2008	2010	Forced	126,262	0	0.0%
		Volitional	400,275	11,958	3.0%
		All	526,537	11,958	2.3%
2009	2011	Forced	48,399	0	0.0%
		Volitional	377,748	20,955	5.5%
		All	426,147	20,955	4.9%
2010	2012	Forced	121,582	0	0.0%
		Volitional	408,400	17,103	4.2%
		All	529,982	17,103	3.2%
2011	2013	Forced	98,917	0	0.0%
		Volitional	456,397	23,146	5.1%
		All	555,314	23,146	4.2%
2012	2014	Forced	-	-	-
		Volitional	512,992	22,640	4.4%
		All	512,992	22,640	4.4%
2013	2015	Forced	-	-	-
		Volitional	475,269	23,177	4.9%
		All	475,269	23,177	4.9%
2014	2016	Forced	-	-	-
		Volitional	388,790	17,029	4.4%
		All	388,790	17,029	4.4%
Average		***Forced***	***146,522***	***0***	***0.0%***
		Volitional	***336,829***	***15,142***	***4.6%***
		All	***410,146***	***15,142***	***3.6%***

4.3.2 Methow-Basin In-Pond Survival

Based on PIT tag information, Methow-basin in-pond survival ranged between 93.4% and 96.7% (Table 36). Overall in-pond survival was equal to the 15-year basin average (Table 37).

Table 37. PIT estimates of Methow-basin in-pond survival and tag detection efficiency, 2016

	Gold Creek Ponds	**Wolf Creek Ponds**	**Winthrop NFH C12 - C16**
Total PITs Released	5,949	5,989	5,961
Unique Outlet Detections	5,466	5,664	5,394
Unique Downstream Detections	3,278	3,181	3,124

Downstream and Outlet Detections	5,523	5,715	5,283
Detection Efficiency	98.3%	98.4%	94.4%
PITs released	5,561	5,756	5,712
In-Pond Survival	**93.4%**	**96.7%**	**95.9%**

Table 38. Percent in-pond survival by Methow-basin rearing location and annual basin total, 2004-2016

Brood Year	Release Year	Remote Pond			Winthrop NFH		Basin Total
		Gold Creek	Wolf Creek	Lower Twisp Ponds	Back-Channel	On-Station	
2002	2004	-	-	-	100.0%	100.0%	100.0%
2003	2005	-	-	-	-	99.4%	99.4%
2004	2006	-	-	-	-	97.2%	97.2%
2005	2007	-	-	-	99.1%	99.6%	99.1%
2006	2008	-	-	-	74.7%	97.0%	85.9%
2007	2009	-	-	96.3%	92.8%	98.7%	95.9%
2008	2010	-	-	96.0%	92.5%	99.1%	94.3%
2009	2011	-	-	99.6%	91.6%	99.2%	95.6%
2010	2012	-	-	92.7%	96.8%	99.9%	96.5%
2011	2013	97.9%	97.5%	94.6%	96.0%	98.4%	96.5%
2012	2014	98.7%	90.6%	88.9%	95.9%	98.7%	93.5%
2013	2015	96.5%	91.2%	93.3%	-	94.4%	93.9%
2014	2016	93.4%	96.7%	-	-	95.9%	95.1%
Average		**96.6%**	**94.0%**	**94.5%**	**93.3%**	**97.5%**	**95.1%**

4.3.3 Methow-Basin Predation Assessment

We estimated that 5,467 coho were lost during acclimation due to predation and other causes (Table 38). A significant proportion (92.8%) of the total mortality was attributed to predation. Total estimated loss was higher than the 10-year average, and driven mainly by high estimated predation in the remote ponds (Table 39). Known loss was well below the running average.

Table 39. Known and estimated morality at Methow-basin acclimation sites, release year 2016

Release Location	Known Mortality	Estimated Mortality (Predator Consumption Model)	Total Loss
Gold Creek Ponds	20	260	280
Lower Twisp Ponds	128	2,647	2,775
Winthrop NFH C12 and C16[1]	158	-	158

Wolf Creek Ponds	88	2,166	2,254
Total	**394**	**5,073**	**5,467**

[1] Predators not monitored at Winthrop NFH, no estimate made

Table 40. Methow-basin known and estimated mortalities during acclimation, release years 2008-2016

Brood Year	Release Year	Rearing Type	Known Mortality[1]	Estimated Mortality (Predator Consumption Model)	Total Loss
2006	2008	Hatchery	8,042	0	8,042
		Remote Pond	36	6,805	6,841
		All	8,078	6,805	14,883
2007	2009	Hatchery	2,175	347	2,522
		Remote Pond	58	2,183	2,241
		All	2,233	2,530	4,763
2008	2010	Hatchery	2,764	0	2,764
		Remote Pond	145	5,187	5,332
		All	2,909	5,187	8,096
2009	2011	Hatchery	1,559	0	1,559
		Remote Pond	171	2,920	3,091
		All	1,730	2,920	4,650
2010	2012	Hatchery	0	0	0
		Remote Pond	50	1,809	1,859
		All	50	1,809	1,859
2011	2013	Hatchery	339	0	339
		Remote Pond	36	3,729	3,765
		All	375	3,729	4,104
2012	2014	Hatchery	2,021	0	2,021
		Remote Pond	2,678	8,633	11,311
		All	4,699	8,633	13,332
2013	2015	Hatchery	6,394	0	6,394
		Remote Pond	51	5,663	5,714
		All	6,455	5,663	12,118
2014	2016	Hatchery	158	0	158
		Remote Pond	236	5,073	5,309
		All	394	5,073	5,467
Average		**Hatchery**	**2,606**	**39**	**2,644**
		Remote Pond	**385**	**4,667**	**5,051**
		All	**1,495**	**2,353**	**3,848**

[1] Dead coho recovered from rearing ponds

4.3.4 Methow-Basin Pre-Release Condition

Methow-basin smolts released in 2016 ranged in size between 17.6 and 19.3 FPP, with a run-at-large mean of 18.4 FPP (Tables 40 & 41). Though the MCCRP no longer uses a specific FPP as a target release weight, approximately 17 FPP is generally used as a suitable size for release. Coho release in 2016 were smaller than the 17-year mean size at release.

Table 41. Methow-basin pre-release condition by acclimation site, release year 2016

Release Location	Fork Length (mm)		Weight (g)		Fish Per Pound
	Mean	CV	Mean	CV	
Wolf Creek	132	6.5	25.8	17.6	17.6
Gold Creek	133	5.2	23.5	15.7	19.3
Lower Twisp Ponds	139	6.3	28.0	18.5	16.2
Winthrop NFH	130	6.6	23.9	19.0	18.9
Average[1]	**134**	**6.1**	**25.3**	**17.7**	**18.0**

[1] Average of individual ponds, not run-at-large

Table 42. Methow-basin pre-release condition, release years 2002-2016

Brood Year	Release Year	Fork Length (mm)[1]		Weight (g)[1]		Fish Per Pound[1]
		Mean	CV	Mean	CV	
1998	2000	-	-	-	-	17.0
1999	2001	-	-	-	-	17.0
2000	2002	-	-	-	-	18.4
2001	2003	-	-	-	-	18.6
2002	2004	-	-	-	-	17.3
2003	2005	-	-	-	-	16.4
2004	2006	-	-	-	-	18.1
2005	2007	-	-	-	-	17.0
2006	2008	135	9.2	28.3	25.3	16.0
2007	2009	135	7.9	26.7	22.6	17.0
2008	2010	134	7.1	31.0	20.1	14.6
2009	2011	134	6.4	29.9	22.2	15.2
2010	2012	133	6.1	28.4	18.6	16.0
2011	2013	136	5.2	28.0	15.8	16.2
2012	2014	134	5.8	26.9	18.7	16.9
2013	2015	138	6.0	28.5	17.6	15.9
2014	2016	132	6.7	24.6	19.4	18.4
Average In-Basin		**135**	**6.7**	**28.0**	**20.0**	**16.8**

[1] Run-at-large metrics

4.4 METHOW-BASIN NATURAL JUVENILE PRODUCTION

WDFW operated the Methow River smolt trap between February 19 and December 5, 2016 (Snow et al. 2017). During that time, 135 BY2014 natural-origin coho smolts were captured. WDFW estimated that 11,529 ± 2,836 naturally-produced coho smolt emigrated past the trap by the spring of 2016 (Table 42). This is the largest emigration estimate of naturally-produced coho made by the trap in the past 12 years of operation. Previous (2005 to 2015 migratory year) estimates ranged between 194 and 3,147 emigrants.

Table 43. Naturally-produced coho emigrant estimates from the Methow Smolt Trap, brood years 2003-2014

Brood Year	Migratory Year	Emigrant Estimate[1]	95% CI
2003	2005	990	161
2004	2006	194	31
2005	2007	1,999	1,378
2006	2008	412	779
2007	2009	1,144	2,476
2008	2010	1,009	1,266
2009	2011	2,330	1,239
2010	2012	1,618	864
2011	2013	3,147	829
2012	2014	2,373	795
2013	2015	1,012	489
2014	2016	11,529	2,836

[1] Estimates provided by WDFW

4.5 METHOW-BASIN SPAWNING/CARCASS SURVEYS

Spawning ground surveys were performed in the Methow-basin from October 3 to December 12. All established reaches in the Methow-basin were surveyed with no lapses in coverage.

4.5.1 Methow-Basin Redd Count and Distribution

A total of 51 redds were document in the Methow-basin (Table 42). The majority of redds were concentrated in the 1890'2 Side channel (41.2%) and Spring Creek (39.2%). Peak spawning occurred in October, with no documented activity in December. Annual redd count was below the 12-year average, and the second lowest on record for the program (Table 43).

Table 44. Summary of Methow-basin coho redd counts, distribution and carcass recovery, 2016

Stream	Redd Count				Live Fish				Recovered Carcasses				Sample Rate[a]
	Oct	Nov	Dec	Total	Oct	Nov	Dec	Total	Oct	Nov	Dec	Total	
1890's Side Channel	18	3	0	21	10	1	0	11	3	1	0	4	12.8%
Beaver Cr.	0	0	-	0	0	0	-	0	0	0	-	0	0.0%
Chewuch R.	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Gold Cr.	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Hancock Springs Cr.	-	0	0	0	-	0	0	0	-	0	0	0	0.0%
Libby Cr.	0	1	-	1	0	0	-	0	0	0	-	0	0.0%
Methow R.	0	1	0	1	0	1	0	1	0	2	0	2	134.2%
Methow Hatchery Outfall	0	2	0	2	0	8	1	9	0	0	0	0	0.0%
Twisp R.	0	5	0	5	0	0	0	0	0	0	0	0	0.0%
Winthrop NFH /Spring Cr.	16	4	-	20	2	3	-	5	0	0	-	0	0.0%
Wolf Cr.	-	1	0	1	-	2	2	4	-	0	0	0	0.0%
Total	**34**	**17**	**0**	**51**	**12**	**15**	**3**	**30**	**3**	**3**	**0**	**6**	**7.9%**

[1] Sample rate was based on 2.5 Fish Per Redd (fpr) derived from calculated sex ratios from the run-at-large (1.5M: 1.0F)

Table 45. Methow-basin coho redd distribution by tributary, return years 2001-2016

Brood Year	Return Year	Coho Redds - In Basin												Basin Total
		Methow 1-4	Methow 5-8	Methow 9-11	Twisp River	Chewuch River	WNFH Spring Creek	MFH Outfall	Beaver Creek	Libby Creek	Gold Creek	1890's Side Channel	Wolf Creek	
1999	2001	65	0	0	0	0	0	0	0	0	0	0	0	65
2000	2002	41	0	0	0	0	0	0	0	0	0	0	0	41
2001	2003	13	0	0	0	0	7	0	5	0	3	0	0	28
2002	2004	13	0	0	0	0	8	9	1	0	0	0	0	31
2003	2005	17	1	0	0	0	48	5	0	0	0	0	0	71
2004	2006	22	6	0	2	0	29	15	1	1	0	0	0	76
2005	2007	134	33	9	0	0	73	49	8	0	0	0	0	306
2006	2008	81	29	3	1	4	25	15	0	1	0	0	0	159
2007	2009	98	44	9	0	0	77	35	2	1	3	0	0	269
2008	2010	47	18	1	0	0	29	22	0	0	2	0	0	119

2009	2011	72	98	13	11	0	77	39	0	0	2	0	0	312
2010	2012	26	56	7	33	0	54	22	0	0	2	0	0	200
2011	2013	5	13	0	11	0	19	2	0	0	0	0	0	50
2012	2014	19	243	31	92	22	226	53	0	2	11	19	0	718
2013	2015	8	19	5	12	4	13	2	0	1	0	44	0	108
2014	2016	0	1	0	5	0	20	2	0	1	0	21	1	51
Average		**41**	**35**	**5**	**10**	**2**	**44**	**17**	**1**	**0**	**1**	**5**	**0**	**163**

4.5.2 Methow-Basin Carcass Origin and Distribution

Six coho carcasses were recovered in 2016, with the majority found in the 1890's Side Channel (Table 44). The middle section of the Methow River (reaches 5-11) was the only other reach in which carcasses were recovered. Carcass recovery in 2016 was below the 12-year average (Table 45). Recovery rate was the second lowest on record.

Table 46. Summary of carcass distribution and origin throughout the Methow River and its tributaries, return year 2016

Juvenile Coho Release Location/Origin through CWT analysis	Adult Recovery Location											
	Methow 1-4	Methow 5-8	Methow 9-11	Twisp River	Chewuch River	Spring Creek	Methow Hatchery Outfall	Gold Creek	1890's Side Channel	Wolf Creek	Libby Creek	TOTAL
Winthrop NFH	0	2	0	0	0	0	0	0	3	0	0	5
No CWT	0	0	0	0	0	0	0	0	1	0	0	1
TOTAL	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**6**

Table 47. Methow-basin coho carcass distribution by tributary, return years 2000-2016

Brood Year	Return Year	Coho Carcasses In-Basin											Basin Total	Sample Rate[1]
		Methow 1-4	Methow 5-8	Methow 9-11	Twisp River	Chewuch River	Spring Creek	Methow Hatchery Outfall	Gold Creek	1890's Side Channel	Libby Creek	Wolf Creek		
1999	2001	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2000	2002	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2001	2003	3	0	0	0	0	0	0	0	0	0	0	3	4.9%

2002	2004	0	0	0	0	0	0	1	0	0	0	0	1	1.5%
2003	2005	4	4	0	1	0	5	2	0	0	0	0	16	12.3%
2004	2006	3	1	0	0	0	5	3	0	0	0	0	12	7.2%
2005	2007	52	11	5	0	0	13	9	0	0	0	0	90	22.8%
2006	2008	20	5	2	0	1	14	1	0	0	0	0	43	16.7%
2007	2009	82	58	1	0	0	60	9	0	0	1	0	211	32.8%
2008	2010	10	16	0	0	0	16	3	2	0	0	0	47	18.8%
2009	2011	50	209	5	1	0	100	4	0	0	0	0	369	51.4%
2010	2012	10	38	1	8	0	16	0	0	0	0	0	73	13.5%
2011	2013	2	11	2	6	0	9	0	0	0	0	0	30	23.1%
2012	2014	6	167	12	39	5	142	25	4	22	0	0	422	29.0%
2013	2015	9	5	0	1	0	3	0	0	6	0	0	24	11.2%
2014	2016	0	2	0	0	0	0	0	0	4	0	0	6	7.9%
Average		**21**	**44**	**2**	**5**	**1**	**32**	**5**	**1**	**3**	**0**	**0**	**112**	**20.6%**

[1] Sample rate was based on Fish Per Redd (fpr) derived from calculated sex ratios from the run-at-large.

4.6 METHOW-BASIN LIFE HISTORY MONITORING

4.6.1 Methow-Basin Smolt-Smolt Survival

Smolt-to-smolt survival for individual release locations ranged between 49.7% and 50.6% (Table 46). The basin-wide smolt-to-smolt survival rate in 2016 was above the 9-year average, and equal to the 9-year median value.

Table 48. Methow-basin smolt-McNary survivals by release location, release years 2000-2016

Brood Year	Release Year	Remote Pond			Winthrop NFH		Basin Mean
		Gold Creek	Wolf Creek	Lower Twisp Ponds	On-Station	Back-Channel	
1998	2000	-	-	-	33.3%	-	33.3%
1999	2001	-	-	-	9.9%	-	9.9%
2000[1]	2002[1]	-	-	-	-	-	-
2001[1]	2003[1]	-	-	-	-	-	-
2002	2004	-	-	-	27.8%	-	27.8%
2003[1]	2005[1]	-	-	-	-	-	-
2004[1]	2006[1]	-	-	-	-	-	-
2005[1]	2007[1]	-	-	-	-	-	-
2006	2008	-	-	-	-	28.3%	28.3%
2007	2009	-	-	-	40.5%	49.1%	44.8%
2008	2010	-	-	-	73.2%	65.5%	69.4%
2009	2011	-	-	43.4%	35.6%	41.6%	40.2%

2010	2012	-	-	47.7%	45.0%	33.4%	42.0%
2011	2013	47.4%	-	51.4%	63.0%	57.0%	54.7%
2012	2014	55.4%	-	63.6%	51.8%	51.7%	55.6%
2013	2015	52.2%	-	41.1%	78.5%	-	57.3%
2014	2016	50.1%	50.6%	-	49.7%	-	50.1%
Average		**51.3%**	**50.6%**	**49.4%**	**46.2%**	**46.7%**	**42.8%**
Median		**51.2%**	**50.6%**	**47.7%**	**45.0%**	**49.1%**	**43.4%**

[1] No PIT tags released

4.6.2 Methow-Basin Escapement

Escapement estimation method 1 is preferred for the Methow Basin in that it considers in-basin coho activity rather than simple passage in the mainstem Colombia River. The estimate of 194 returning coho to the Methow Basin was the second smallest estimated return in the past 16 years (Tables 48 & 49). Estimated escapements to the Methow River have ranged between 92 and 1,970 coho since return-year 2001.

Table 49. Estimated coho run size to the Methow River, return year 2016

Method	Est. Run Size
1) Redd counts plus broodstock collected	194
2) Wells Dam Counts plus Wells Dam broodstock collected	536

Table 50. Methow-basin estimated coho escapement, return years 2000-2016

Return Year	Adults	Jacks	Total Escapement
2001	604	5	609
2002	69	23	92
2003	268	0	268
2004	214	0	214
2005	334	2	336
2006	467	18	481
2007	1,583	18	1,601
2008	867	0	867
2009	1,669	11	1,680
2010	781	2	783
2011	1,283	7	1,290
2012	610	1	611
2013	279	2	281
2014	1,968	2	1,970
2015	664	11	675

2016	188	6	194
Average	**741**	**7**	**747**
Median	**607**	**4**	**610**

4.6.3 Methow-Basin Smolt-Adult Survival

Smolt-to-adult ratios (SAR) for returning hatchery-origin BY2013 fish ranged from 0.0001 to 0.0007, with a basin-wide mean of 0.0004 (Table 50). The BY2013 hatchery-origin SAR fell below the running programmatic mean of 0.0018 (Table 51). There were no natural-origin BY2013 adults represented in the run, so the SAR is assumed to be 0.0000.

Table 51. Methow-basin brood year 2013 hatchery-origin SARs by release site, brood origin, and rearing facility

Release Site	Minimum Acclimation Duration (d)	Brood Origin	Rearing Facility	*n* (Adult Returns)	Total Released	SAR
Gold Creek	47	Met/Wen	Cascade	11	31,760	0.0004
Wolf Creek	45	Met/Wen	Cascade	6	37,996	0.0001
Winthrop BC (C10 &16)	68	Met/Wen	Cascade	53	81,405	0.0007
Lower Twisp Ponds	27	Met/Wen	Cascade	17	61,307	0.0003
Winthrop NFH c12-16	52	Met/Wen	Winthrop NFH	59	116,918	0.0005
Winthrop NFH c12-17	52	Met	Winthrop NFH	48	116,451	0.0004
Total				**194**	**445,837**	**0.0004**

Table 52. Methow-basin SAR survivals, return years 2001-2016

Brood Year	Return Year	Origin	SAR
1998	2001	Hatchery	0.0030
		Natural	ND
1999	2002	Hatchery	0.0003
		Natural	ND
2000	2003	Hatchery	0.0014
		Natural	ND
2001	2004	Hatchery	0.0009
		Natural	ND
2002	2005	Hatchery	0.0011
		Natural	ND
2003	2006	Hatchery	0.0017

		Natural	0.0000
2004	2007	Hatchery	0.0037
		Natural	0.0000
2005	2008	Hatchery	0.0018
		Natural	0.0017
2006	2009	Hatchery	0.0032
		Natural	0.0790
2007	2010	Hatchery	0.0018
		Natural	0.0100
2008	2011	Hatchery	0.0025
		Natural	0.0151
2009	2012	Hatchery	0.0015
		Natural	0.0000
2010	2013	Hatchery	0.0006
		Natural	0.0058
2011	2014	Hatchery	0.0032
		Natural	0.0051
2012	2015	Hatchery	0.0014
		Natural	0.0038
2013	2016	Hatchery	0.0004
		Natural	0.0000
Average		**Hatchery**	**0.0018**
		Natural	**0.0110**

4.6.4 Methow-Basin Adult-Adult Replacement

Methow-basin HRR rates have ranged between 1.79 and 20.71 between BY2003 and BY2013 (Table 51). BY2013 hatchery-origin coho had a replacement rate below the running average and median values. NRR could not be calculated for BY2013 due to a lack of representation in the adult escapement.

Table 53. Methow-basin hatchery and natural-origin Adult-to-Adult replacement rates, brood year 2003-2013.

Brood Year	Broodstock Spawned	Spawning Escapement[1]	HOR	NOR	HRR	NRR
2003	114	–	347	0	3.04	–
2004	106	–	1,533	0	14.46	–
2005	282	156	504	6	1.79	0.04
2006	291	167	1,647	33	5.66	0.20
2007	550	673	1,191	18	2.17	0.03
2008	457	350	5,814	69	12.72	0.20

2009	393	592	2,118	0	5.39	0.00
2010	519	262	731	24	1.41	0.09
2011	466	686	9,651	79	20.71	0.12
2012	585	440	1,644	22	2.81	0.05
2013	228	110	536	0	2.35	0.00
Average	**363**	**382**	**2,338**	**23**	**6.59**	**0.08**
Median	**393**	**350**	**1,533**	**18**	**3.04**	**0.05**

[1] Calculated as number of redds by run-at-large FPR

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ATTACHMENT A: 2016 MCCRP ESA Compliance Report

MID-COLUMBIA COHO REINTRODUCTION PROJECT
BPA PROJECT #1996-040-00
2016 ANNUAL COMPLIANCE REPORT TO NMFS and USFWS

Yakama Nation
Fisheries Resource Management
Mid-Columbia Field Offices
7051 Hwy. 97
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INTRODUCTION

The Yakama Nation (YN) Mid-Columbia Coho Reintroduction Project (MCCRP) is in the process of restoring self-sustaining populations of coho salmon (*Oncorhynchus kisutch*) into the Wenatchee and Methow River sub-basins (YNFRM 2010). Activities associated with the return of coho to these areas present the likelihood of direct and/or indirect contact with Endangered Species Act (ESA)-listed fish species including Upper-Columbia spring Chinook (*Oncorhynchus tshawytscha*), summer steelhead (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*). Consultation for these associated take levels has occurred through Biological Assessments (BAs) with both the National Marine Fisheries Service (NMFS) and the Unites States Fish and Wildlife Service (USFWS), resulting in Biological Opinions (BOs). These permitting documents were based solely on, or in part to an approved Hatchery Genetic Management Plan (HGMP). Specific spring Chinook and steelhead take guidelines and limits have been articulated in the NMFS Section 7 BO (NMFS-WCR-2015-3778), while bull trout take is outlined in USFWS Section 7 BO (USFWS- 01EWFW00-2013-F-0272-R001). Both of these BOs set the confines in which MCCRP must operate given potential interaction with listed species.

The following document outlines MCCRP programmatic activities for the year 2016 with a focus on adherence to the terms and conditions set forth in the aforementioned NMFS and USFWS BOs. All relevant take will be noted and quantified for each aspect of the program. In the event that any take level is exceeded, subsequent documentation, determination of cause, and regulatory review will be shown. Activities permitted by the BOs but not performed in 2016, e.g., electrofishing, will not be addressed herein.

MID-COLUMBIA COHO REINTRODUCTION PROJECT

Wenatchee River Basin Smolt Releases

In the Wenatchee River basin, coho juveniles were acclimated at five release locations; Leavenworth National Fish Hatchery (LNFH), Beaver Creek , Butcher Creek, Coulter Creek , and Rohlfing's pond (Table 1). Seine or barrier net placement at all remote acclimation sites segregated hatchery coho from potential wild fish interactions. Seine configuration at Rohlfing's pond allowed juvenile coho to be contained while maintaining wild fish passage through the pond inlet and upstream channel. Juvenile coho at Beaver Creek were confined with both a seine net and a barrier grate at the pond outlet. Passage around the coho-rearing area was provided via the roughen channel project; completed in the summer of 2015. Coulter Creek was segregated from the rest of the surrounding wetland complex with a barrier net blocking the two outlet channels. Access to adjacent wetlands by wild fish was provided via Coulter Creek proper, or nearby minor channels/inundated areas. None of the ESA species of concern (bull trout, spring Chinook, or summer steelhead) were encountered throughout acclimation or release at these sites.

Table 1. Summary of coho (BY2014) releases from the Wenatchee River Basin, 2016.

Location	Ponding Date	Release Date	Acclimation time (d)	Release Number	Size @ release (FPP)	No. PIT Tags
Beaver Creek	31-Mar	27-Apr	27	75,307	16.5	5,065
Butcher Creek	16-Mar	26-Apr	41	128,419	16.8	0
Coulter Creek	16-Mar	26-Apr	41	40,816	16.2	5,660
Rohlfing's Pond	29-Feb	26-Apr	57	106,828	16	5,822
LNFH LFL 1	11-Feb	25-Apr	74	107,397	16.1	5,668
LNFH LFL 2	11-Feb	25-Apr	74	73,720	17.6	4,058
LNFH SFL's	11-Feb	19-Apr	68	176,620	18.5	5,686
Total Released				**709,107**		**31,959**

A total of 709,107 hatchery produced coho juveniles were released from the Wenatchee River basin in the spring of 2016. LNFH coho were force-released on April 19 and April 25. Volitional releases of upper-basin acclimation sites began on April 26 and April 27. Excluding Butcher pond, all releases were monitored by PIT tag detection system to determine in-pond loss and migratory timing. The NMFS BO established a maximum mean travel time from LNFH to the lower-Wenatchee PIT tag array (LWE) of 15 days (NMFS-WCR-2015-3778 Section 2.8.1.2 Factor 3). Due to a complete lack of hatchery coho detections at LWE in 2016, surrogate mean travel times from LNFH to Rock Island Dam (RIA) and McNary Dam (MCN) were calculated to demonstrate run-at-large speed of outmigration (Table 2). Despite location approximately 23 river kilometers (rkm) downstream from the mouth of the Wenatchee River, mean travel time from LNFH to RIA was still below the 15 day limit. Travel times from remote sites (not held to 15-day limit)

were additionally included in table 2 to demonstrate rate of outmigration from upper-basin locations.

Table 2. Mean travel times for Wenatchee Basin hatchery coho from point of release to detection at the Rock Island Dam (RIA) and McNary Dam (MCN)

Location	To Rock Island			To McNary		
	Mean Travel Time (d)[a]	*n*	SE	Mean Travel Time (d)[a]	*n*	SE
Rohlfing's Pond	7.83	3	1.94	19.39	435	0.21
Leavenworth NFH	3.25	12	0.85	21.1	1,667	0.16
Coulter Pond	4.80	3	1.83	16.17	492	0.20
Beaver Creek Pond	N/A	0	N/A	15.69	361	0.23

[a]- *Harmonic Mean*

Predation by out-migrating hatchery coho on spring Chinook fry in Nason Creek was calculated using gastric evaluation and consumption models developed by He and Wurtsbaugh (1993). In accordance with methodology specified in the NMFS BO, we used the incidence of predation determined by the preceding Murdoch et al. (2005) estimate of coho predation in Nason Creek. All other variables were unique to the 2016 outmigration. We estimated that during the 2016 release of coho into Nason Creek, 2,556 spring Chinook fry were consumed representing 0.97% of the total Nason Creek population (Table 3). This was below the 2% limit established in the NMFS BO (NMFS-WCR-2015-3778 Section 2.8.1.2 Factor 3). An elevated proportion of the spring Chinook fry population consumed in 2016 was due mainly to a low spawner escapement in 2015 of only 85 redds; the lowest redd count in the past 13 years (Hillman et al. 2015).

Table 3. Estimated number of spring Chinook consumed by hatchery coho smolts, 2014-2016

Migratory Year	Sample Size	Mean Residence Time (d)	Evacuation Rate (h)	Incidence of Predation	Estimated Fry Consumed	% Spring Chinook Population Consumed
2014	74	2.46	38.9	0.0028	1,440	0.24%
2015	1,878	3.49	31.2	0.0028	2,436	0.79%
2016	79	4.16	40.4	0.0028	2,556	0.97%

Methow River Basin Smolt Releases

In the Methow River basin, coho were acclimated at four locations; Winthrop National Fish Hatchery (WNFH), Gold Creek Pond, Lower Twisp Ponds, and Wolf Creek Pond (Table 4). Juvenile grates were placed at the head of the inlet stream and at the terminus of the Lower Twisp Ponds outlet channel. Grates were used in lieu of a sein net after snorkel surveys confirmed a lack of wild fish presence within the intended rearing area. Access to the rest of the Lower Twisp Pond wetland complex was not prohibited by the juvenile grates. Seine nets

were used at Wolf Creek and Gold Creek ponds to isolate hatchery-origin fish from potential natural-origin cohabitants. Net configuration was such that wild fish were allowed unimpeded passage upstream and downstream of the site. Throughout the acclimation and release period, no ESA-listed species were encountered within the barrier nets.

Table 4. Summary of coho (BY2014) releases from the Methow River Basin, 2016.

Location	Ponding Date	Release Date	Acclimation time (d)	Release Number	Size @ release (FPP)	No. PIT Tags
Gold Creek	22-Mar	24-Apr	33	35,848	19.3	5,561
Lower Twisp Ponds	25-Mar	24-Apr	30	64,950	16.2	0
Wolf Creek	23-Mar	24-Apr	32	44,000	17.6	5,756
WNFH C12 - C16	15-Jun	21-Apr	311	243,658	19.1	5,712
Total Released				**388,456**		**17,029**

Approximately 388,456 hatchery-origin coho juveniles emigrated from the Methow Basin in spring of 2016. WNFH volitional releases were initiated on April 21. Volitional releases at the remote acclimation sites began on April 24. NMFS permitting established a 15 day maximum mean travel time from WNFH to the lower Methow PIT tag array (NMFS-WCR-2015-3778 Section 2.8.1.2 Factor 3; LMR). Mean travel time between WNFH and (LMR) could not be calculated due to a lack of detections in 2016 (Table 5). However, mean travel time from WNFH to the Rock Reach Dam juvenile bypass (RCJ) was well-below the permitted limit. We will continue to report travel times to RCJ in light of persistent low efficiency and resulting low sample size at the LMR array.

Table 5. Mean travel times for Methow Basin hatchery coho from point of release to detection at the Lower Methow River Array (LMR) and Rocky Reach Dam (RCJ)

Location	To Lower-Methow Array			To Rocky Reach Dam		
	Mean Travel Time (d)[a]	*n*	SE	Mean Travel Time (d)[a]	*n*	SE
Wolf Creek Acclimation Pond	0.91	7	0.18	10.19	2,698	0.12
Gold Creek Acclimation Ponds	1.08	3	0.30	9.00	2,530	0.34
Winthrop NFH C12 - C16	–	–	–	8.77	2,673	0.12

[a]- *Harmonic Mean*

Wenatchee River Basin Broodstock Collections

Wenatchee program broodstock were collected from Dryden Dam, Entiat National Fish Hatchery (ENFH), Priest Rapids Dam, and Tumwater Dam (Table 6). ENFH is not identified as a trapping location in either BOs. These adults were through incidental collections on-station during summer Chinook collections for the USFWS program. The timing of all collection efforts adhered with the regime stated in the NMFS BO (NMFS-WCR-2015-3778

Section 2.8.4. T&C 4e, 4f, 4g, and 4i). Supplemental collections were performed at Grant County Public Utility District's (GCPUD) Priest Rapids Dam fish bypass.

Table 6. Coho salmon and incidentals handled during Wenatchee-basin broodstock trapping, 2016.

Location	Coho (*broodstock*)	Bull Trout	Steelhead	Spring Chinook
Dryden Dam	436 (*417*)	0	0	0
Entiat NFH	2 (*2*)	0	0	0
Priest Rapids Dam	568 (*544*)	0	0	0
Tumwater Dam	282 (*278*)	0	0	0

Coho broodstock collections for the Wenatchee-basin program were almost entirely concurrent with WDFW broodstock collection/stock assessment efforts at each site. Per the terms of the NMFS BO, incidental take of ESA-listed species during this overlapping permit coverage was counted toward WDFW-held permits (NMFS-WCR-2015-3778 Section 2.8.4 T&C 4e, 4f, and 4i). Collection activities outside of overlapping permit coverage were limited to October 29 through November 10 at Dryden Dam. During this period, one summer Chinook was handled and released by YNF personnel. Broodstock from Entiat NFH were transferred from USFWS personnel to YNF; bycatch during summer Chinook broodstock collection at the hatchery intake. No additional take was incurred during this transfer.

Methow River Basin Broodstock Collections

Broodstock collections occurred at Wells Dam east and west fish ladders, Winthrop National Fish Hatchery (WNFH), and Methow Fish Hatchery (MFH; Table 7). Wells Dam east and west fish ladders were used as primary collection facilities to ensure representative run-of-the-river (hatchery and natural origin fish) were obtained. All Collections at Wells Dam facilities adhered to the following variable schedule (NMFS-WCR-2015-3778 Section 2.8.4. T&C 4d):

1) **Sept 1 – Sept 26: 3days/week and 16 hrs/day**
2) **Sept 27 – Oct 9: 5 days/week and 9 hrs/day**
3) **Oct 10 – Dec 7: 7 days/week and 16 hrs/day**

Supplemental collections at WNFH and MFH relied on volitional swim-ins to their adult collection weirs and occurred continuously throughout the trapping period. Collections at these sites did not occur outside of the permitted timeframe (Sept 1 – Dec 7; NMFS-WCR-2015-3778 Section 2.8.4. T&C 4g and 4h).

Table 7. Coho salmon and incidentals handled during Methow-basin broodstock trapping, 2016.

Location	Coho (*broodstock*)	Bull Trout	Steelhead	Spring Chinook
Methow Fish Hatchery weir	133 (*112*)	0	0	0
Wells Dam West/East Ladders	11 (*11*)	0	258	0
WNFH adult holding pond/collection weir	102 (*75*)	0	0	0

The handling of ESA-listed species in the Methow-basin only occurred at Wells Dam (Table 6). Total steelhead take was 5.3% of the total run during collection; below the maximum allowable take of 6% (NMFS-WCR-2015-3778 Section 2.8.4. T&C 4d). During collections in which YN was sole operator, steelhead encountered were diverted back into the fish ladder with no physical handling. There were no steelhead mortalities incurred; spring Chinook and bull trout were absent entirely from broodstock collection efforts.

Nason Creek Rotary Smolt Trap

In 2016, Grant County Public Utility District (GCPUD) and the MCCRP cost-shared the operational expenses of the Nason Creek rotary trap. Project objectives were to provide juvenile production estimates for ESA-listed spring Chinook, ESA-listed summer steelhead, and coho salmon while monitoring temporal variability of these species as they emigrate from Nason Creek. Trap operation was permitted through NMFS and USFWS under their respective BOs as part of the MCCRP project. The Nason Creek trap (1.5m) was installed on February 25 (began operations on March 1) and removed for the season on December 5 (concluded operations on November 30). The trap was successfully operated for a total of 197 days throughout the trapping season (Table 8). For the majority of the time, trap operations were continuous; 24 hours per day and 7 days per week. During spring run-off, active trapping limited to hours of darkness only to minimize potential damage to the trap and inherent risks associated with high discharge and debris load.

Table 8. Summary of Nason Creek smolt trap operation, 2016.

Date of Trap Operations	Trap Status	Description	Days
March 1 to June 30	Operating	Continuous data collection	120
	Interrupted	Interrupted by debris	2
	Pulled	Intentionally pulled due to high flow, low flow, or heavy debris load	0
July 1 to November 30	Operating	Continuous data collection	77
	Interrupted	Interrupted by debris or low flows	14
	Pulled	Intentionally pulled due to high flow, low flow, or heavy debris load	62

All wild summer steelhead, hatchery summer steelhead, wild spring Chinook, and hatchery spring Chinook take limits (< 20% of outmigration handled and < 2.0% mortality) were not

exceeded in 2016 (NMFS-WCR-2015-3778 Section 2.8.1.2 Factor 5; Table 9). The single bull trout captured at the smolt trap was measure and released without any further handling.

Table 9. Number of fish captured and mortality incurred at the Nason Creek smolt trap, 2016.

Species	ESA Species	Total Captured	Mean Fork Length (mm)	Total Mortality	% Mortality
Wild Spring Chinook Yearling	X	61	96	0	0.00%
Wild Spring Chinook Fry	X	300	38	4	1.33%
Wild Spring Chinook Subyearling	X	491	85	2	0.41%
Total Wild Spring Chinook	***X***	***852***	***219***	***6***	***0.70%***
Hatchery Spring Chinook	***X***	***124***	***119***	***0***	***0.00%***
Wild Summer Steelhead Smolt	X	9	120	0	0.00%
Wild Summer Steelhead Fry	X	335	40	1	0.30%
Wild Summer Steelhead Parr	X	663	78	0	0.00%
Total Wild Summer Steelhead	***X***	***1,007***	***238***	***1***	***0.10%***
Hatchery Summer Steelhead	***X***	***98***	***175***	***0***	***0.00%***
Bull Trout	***X***	***1***	***199***	***0***	***0.00%***
Natural-Origin Coho Yearling		6	100	0	0.00%
Hatchery Coho		343	134	2	0.58%
Cutthroat Trout		1	140	0	0.00%
Fathead Minnow		4	52	0	0.00%
Longnose Dace		230	52	0	0.00%
Northern Pikeminnow		18	91	0	0.00%
Redside Shiner		99	41	4	4.04%
Sculpin		84	64	0	0.00%
Sucker		319	58	1	0.31%
Whitefish		81	58	2	2.47%

All spring Chinook, steelhead, and coho measuring ≥60 mm FL were PIT tagged using sterilized needles. During the 2016 trapping season, YN PIT tagged 495 wild spring Chinook, 531 steelhead (various sizes and age classes), and 6 naturally-produced coho. All fish handled were first anesthetized with a solution of tricaine methanesulfonate (MS-222). Tagging was forgone on specimens showing any signs of injury or potential poor health.

Mark-recapture trials were conducted with PIT tagged fish over a range of stream discharges in order to determine species-specific flow-efficiency relationships (Table 10). Given significant correlation between flow and trap efficiency, regression analyses were then conducted for each species/stage to produce emigrant estimates. If no significant flow-efficiency relationship existed, pooled (mean) trap efficiencies were alternatively used to produce emigrant estimates.

Table 10. Trap efficiency mark/recapture trial summary for Nason Creek, 2016.

Origin/Species/Stage	Total Marked	Total Recaptured	Trap Efficiency Rate	Number of Trials*
Wild Chinook Yearlings	61	4	6.56%	8
Spring Chinook Subyearlings	292	34	11.64%	12
Wild Steelhead Parr	227	3	1.32%	33

**Invalid trials not included*

Wenatchee River Spawning Ground Surveys

Coho spawning ground surveys in the Wenatchee River and its tributaries began on October 2 and were discontinued on December 7. Mainstem Wenatchee River surveys were conducted by raft at 7-14 day intervals depending on reach location and concentration of spawning aggregates. Tributary surveys were performed both on foot and raft depending on flow conditions at weekly intervals. Surveys were forgone during periods of high flow and/or conditions posing unsafe conditions for personnel. In total, 179 redds and 35 carcasses were identified in the Wenatchee-basin (Table 11). Carcass recovery rate for the year was 9.1%.

Table 11. Summary of coho spawning ground surveys in the Wenatchee River Basin, 2016.

Stream	Redd Count				Live Fish				Recovered Carcasses				Sample Rate[a]
	Oct	Nov	Dec	Tot.	Oct	Nov	Dec	Tot.	Oct	Nov	Dec	Tot.	FINAL
Beaver Cr.[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Chiwaukum Cr.[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Chiwawa R.[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Chumstick Cr.	0	3	0	3	1	8	0	9	0	5	0	5	**77.5%**
Icicle Cr.	28	78	1	107	99	165	5	269	0	22	0	22	**9.6%**
Mission/Brender Cr.	1	3	–	4	0	5	–	5	0	0	–	0	**0.0%**
Nason Cr.	0	–	–	0	0	–	–	0	0	–	–	0	–
Peshastin Cr.	0	2	0	2	0	2	0	2	0	4	0	4	**93.0%**
Roaring Cr.	–	0	–	0	–	0	–	0	–	0	–	0	–
Wenatchee R. R1 - R5	14	49	0	63	37	58	0	95	0	4	0	4	**3.0%**
Wenatchee R. R6 & R7[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	**43**	**135**	**1**	**179**	**137**	**238**	**5**	**380**	**0**	**35**	**0**	**35**	**9.1%**

[a] *- Sample rate was based on Fish Per Redd (fpr) derived from calculated sex ratios from the run-at-large (1.15M: 1.0F)*

Spatial distribution of coho redds was similar to past years with the highest concentrations occurring on Icicle Creek and the middle Wenatchee River near the town of Leavenworth. Elevated redd densities in these reaches were likely a function of two factors: 1) proximity to a primary release site at LNFH, and 2) extent of spawning migration due to a potential

energetic threshold within returning adult (unpublished data, MCCRP 2012). No redd superimposition was detected in the upper Wenatchee basin for both ESA listed spring Chinook and bull trout. Although coho spawning densities theoretically overlap with those of spring Chinook, superimposition by coho on completed spring Chinook redds has previously only been noted in Icicle Creek (a non ESA-listed population) and likely due to overpopulation and excessive coho densities directly related to current broodstock development phase. Preferences for substrate size and stream location (margins vs. thalweg) also differ between coho and spring Chinook and these differences may serve to alleviate serious competition. A high broodstock collection rate (99.6%) at Tumwater Dam in 2016 limited upstream passage of only 2 adult coho into the major spring Chinook and bull trout aggregates. Given the low passage and a skewed male to female sex ratio (4.3:1) at Tumwater Dam, the likelihood of undocumented spawning and superimposition in the upper basin was very low.

Methow Basin Spawning Ground Surveys

Methow River basin spawning ground surveys were initiated on October 3 and discontinued on December 12. Mainstem Methow River surveys were conducted by raft from Weeman Bridge to the confluence with the Columbia River every seven to ten days. Tributary survey reaches included the Twisp River, Chewuch River, Winthrop NFH and Methow Fish Hatchery (FH) outfalls, the 1890's Side Channel, Hancock Springs, and lower reaches of Beaver, Gold, and Libby creeks. The frequency of tributary surveys was based on previously-noted spawning activity, with reaches containing prevalent spawning aggregates surveyed weekly, and those without visited less often. During periods of high flow or poor conditions, surveys were forgone. The 2016 total redd count was 51 with an overall carcass recovery rate of 7.9% (Table 12).

Table 12. Survey location, number of redds, and carcass recoveries in the Methow River Basin, 2016.

Stream	Redd Count				Live Fish Count				Recovered Carcasses				Sample Rate[a]
	Oct	Nov	Dec	Tot.	Oct	Nov	Dec	Tot.	Oct	Nov	Dec	Tot.	FINAL
Methow R	0	1	0	1	0	1	0	1	0	2	0	2	**134.2%**
Twisp R.	0	5	0	5	0	0	0	0	0	0	0	0	**0.0%**
Chewuch R.	0	0	0	0	0	0	0	0	0	0	0	0	**0.0%**
Libby Cr.	0	1	-	1	0	0	-	0	0	0	-	0	**0.0%**
Gold Cr.	0	0	0	0	0	0	0	0	0	0	0	0	**0.0%**
Beaver Cr.	0	0	-	0	0	0	-	0	0	0	-	0	**0.0%**
Wolf Cr.	-	1	0	1	-	2	2	4	-	0	0	0	**0.0%**
WNFH /Spring Cr.	16	4	-	20	2	3	-	5	0	0	-	0	**0.0%**
MFH outfall	0	2	0	2	0	8	1	9	0	0	0	0	**0.0%**
1890's Side Chan.	18	3	0	21	10	1	0	11	3	1	0	4	**12.8%**
Hancock Springs	-	0	0	0	-	0	0	0	-	0	0	0	**0.0%**
Total	**34**	**17**	**0**	**51**	**12**	**15**	**3**	**30**	**3**	**3**	**0**	**6**	**7.9%**

[a] - *Sample rate was based on Fish Per Redd (fpr) derived from calculated sex ratios from the run-at-large (1.5M: 1.0F)*

Spatial distribution of coho redds in the mainstem Methow and Twisp rivers was similar to previous years, with the highest concentrations occurring in close proximity to hatchery release locations (i.e., Winthrop NFH and Lower Twisp Ponds). Coho spawning densities were highest in the 1890's side channel and similar to 2014 and 2015. Recruitment to this tributary may be attributed to behavioral thermoregulation from ground water influence, which provides stable-temperature habitats and redd site selection from increased spawning habitat availability.

Coho spawning distribution did not overlap with ESA spring Chinook within lower reaches of the Twisp River in 2016. Winthrop NFH and Methow FH hatchery outfalls were expected to contain a high level of superimposition, considering the unnatural, high spawning densities observed within these confined outfall channels. There is also an expected low productivity from this spawning aggregate, primarily composed of excess, hatchery origin adults, since spawning habitat was limited as compared to other, more natural spawning environments. Spawning activity and/or migratory adults were not observed within any other high-risk areas designated for ESA bull trout. No bull trout redds were identified and/or superimposed by coho in these areas. Additionally, there were no coho adults detected by in-stream remote PIT tag detection systems within these areas in the Methow Basin.

Site Development and Construction

The Gold Creek acclimation ponds were dredged in September 2016 via tracked excavator. In-water work began on September 19, and concluded on September 23. Total area dredged was less than 0.03 acres, with approximately 260 cubic yards of sediment removed. All dredging activates followed the guidelines and protocols set forth in consultation from USFWS, NMFS, United States Army Corps of Engineers (USCAE), and WDFW (Attachments A-D). Pre-implementation fish documentation and removal efforts occurred between September 15 and 19. Summer steelhead juveniles were the only species noted during pre-construction snorkels. Fish were pushed out/relocated from the ponds using a combination of "snerding" and dip-netting techniques. Only the uppermost pond was dredged due to concerns regarding turbidity confinement in the lower three sections. During dewatering, inflow and outflow to the upper pond were cut off, separating the project area completely from the lower ponds. Turbidity measurements were taken above (background), and below the project area at one-hour intervals (Attachment E). Both USFWS and NMFS BOs established a turbidity limit of 5 nephelometric turbidity units (NTUs) above background levels (NMFS-WCR-2015-3778 T&C 2, NMFS-WCR-2015-3778 Section 1.3.3.3.1) There was only one instance (September 21) in which water emanating from the project area exceeded 5 NTUs, and did not persist for more than one hour. Under observation, water was slowly re-introduced into the project area to ensure that suspended sediments were kept to a minimum. All spoils removed, including sediment-laden water was removed from the site and deposited in the same area used during the 2012 excavation. The spoils area was confined by both a trench and a sediment barrier.

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