MONITORING AND EVALUATION OF THE WELLS HATCHERY AND METHOW HATCHERY PROGRAMS

2016 ANNUAL REPORT

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Prepared by:

The Washington State Dept. of Fish and Wildlife

Charlie Snow
Charles Frady
David Grundy
Benjamin Goodman
and
Alf Haukenes

Prepared for:
Douglas PUD, Grant PUD, Chelan PUD, and the Wells and Rocky Reach HCP Hatchery Committees, and the Priest Rapids Hatchery Subcommittee

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Table of Contents

Section 1: Introduction

The Public Utility District No. 1 of Douglas County (Douglas PUD) funds hatchery programs to compensate for inundation of spawning habitat (Wells Hatchery steelhead and summer Chinook Salmon inundation programs) and lost harvest opportunities related to the construction of the Wells Hydroelectric Project and for mortality associated with operation and passage at the Project (Methow Hatchery spring Chinook Salmon and Wells Hatchery steelhead No Net Impact [NNI] programs) as part of the Anadromous Fish Agreement and Habitat Conservation Plan (HCP) for the Wells Hydroelectric Project (Wells HCP 2002). Douglas PUD also operates programs on behalf of, in collaboration with, and funded by, Grant County PUD (Methow Hatchery Spring Chinook Salmon and Wells Hatchery steelhead) to meet mitigation obligations specified in Grant PUD's Priest Rapids Salmon and Steelhead Settlement Agreement (SSSA) and associated Biological Opinion for the Priest Rapids Project. Douglas PUD also operates on behalf of, and funded by, Chelan County PUD to meet mitigation obligations associated with operation and passage at Rocky Reach Hydroelectric Project (Methow Hatchery Spring Chinook salmon NNI program) as part of the Anadromous Fish Agreement and HCP for the Rocky Reach Hydroelectric Project (Rocky Reach HCP 2002). The Hatchery Committees developed specific goals for these hatchery programs, which are described in Monitoring and Evaluation Plans (M&E Plan) for PUD Hatchery Programs (Wells HCP HC 2005; Hillman et al. 2013). More specifically, these programs are intended to:

1. Support the recovery of ESA-listed species by increasing the abundance of the natural adult population, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity (Methow spring Chinook Salmon, Methow summer steelhead, Okanogan summer steelhead).

2. Increase the abundance of the natural adult population of unlisted HCP plan species, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity. In addition, provide harvest opportunities in years when spawning escapement is sufficient to support harvest (Methow summer/fall Chinook Salmon).

3. Provide salmon for harvest and increase harvest opportunities, while segregating returning adults from natural tributary spawning populations (Wells summer/fall Chinook Salmon).

These programs occur at either Wells Hatchery, located on the west bank of the Columbia River adjacent to Wells Dam (Columbia River km 830), or Methow Hatchery, located on the Methow River (Methow River km 83) upstream of the town of Winthrop, Washington. Hatchery programs at these facilities have been categorized within the M&E Plan under three categories; conservation, safety-net, or harvest-augmentation programs. Conservation programs (Methow Composite [Methow and Chewuch], and Twisp river spring Chinook Salmon; Twisp and

Okanogan River steelhead) are integrated hatchery programs intended to increase natural production of targeted fish populations. A fundamental assumption of this strategy is that hatchery programs will increase the number of fish returning to the spawning grounds, which will therefore increase the number of wild fish produced assuming that hatchery fish are reproductively similar to naturally produced fish. Safety-net programs (Methow and Columbia River steelhead) are an extension of conservation programs, intended to provide a demographic and genetic reserve of hatchery adults in years of low returns. In years of high adult abundance, safety-net programs would function like harvest-augmentation programs (e.g., Wells summer Chinook Salmon); increasing harvest opportunities while limiting interactions with natural origin conspecifics. Harvest-augmentation programs are intended to provide opportunities for harvest while having minimal interaction with natural populations.

The M&E Plan adopted by the Wells HCP Hatchery Committee (Hillman et al. 2013) consists of 12 objectives designed to monitor whether the intended management objectives of conservation, safety-net, and harvest augmentation hatchery programs are being met. These objectives are:

Objective 1: Determine if conservation programs have increased the number of naturally spawning and naturally produced adults of the target population and if the program has reduced the natural replacement rate (NRR) of the supplemented population.

Objective 2: Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.

Objective 3: Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate, HHR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate, NRR) and the target hatchery survival rate.

Objective 4: Determine if the proportion of hatchery-origin spawners (pHOS or PNI) is meeting the management target.

Objective 5: Determine if the run timing, spawn timing, and spawning distribution of the hatchery component is similar to the natural component of the target population or is meeting program-specific objectives.

Objective 6: Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation among stocks.

Objective 7: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program.

Objective 8: Determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

Objective 9: Determine if hatchery fish were released at the programmed size and number.

Objective 10: Determine if appropriate harvest rates have been applied to conservation, safety-net, and segregated harvest augmentation programs to meet the HCP/SSSA goal of providing harvest opportunities while also contributing to population management and minimizing risk to natural populations.

Objective 11: Determine if the incidence of disease has increased in the natural and hatchery populations.

Objective 12: Determine if the release of hatchery fish affects non-target taxa of concern (NTTOC) within acceptable limits.

Each objective has a suite of associated statistical hypotheses tested by analyzing variables derived or measured from the target populations through the implementation of annual work plans approved by the Wells HCP Hatchery Committee. Most of these analyses will be conducted at 5-year intervals specified within the M&E Plan (Hillman et al. 2013). This report is the eleventh annual report, summarizing data collected during 2016 required to address the program-specific objectives of the M&E Plan and is consistent with the implementation plan approved by the Wells HCP Hatchery Committee (MRT 2015). Data collection in 2016 was conducted by Washington State Department of Fish and Wildlife (WDFW) personnel through a contract between WDFW and Douglas PUD with the exception of those spring Chinook (sections M6-M8, WN1) and steelhead (WN1) spawning ground surveys conducted by U.S. Fish and Wildlife Service personnel.

Section 2: Summary of Methods

Data collection and fish sampling conducted in 2016 followed the general methods described within the M&E Plans (Wells HCP HC 2005; Hillman et al. 2013) or within recent annual reports (e.g., Snow et al., 2012). In some instances, methods and protocols are developed and approved annually through the Wells HCP Hatchery Committee (i.e., broodstock collection protocols) and are included as appendices within this report. In the following section we briefly summarize the methods used for completing specific tasks or objectives within the M&E Plan.

2.1: Broodstock Collection and Sampling

Broodstock collection methods, locations, and numeric targets for 2016 were described in full in annual broodstock collection protocols (Tonseth 2016). Spring Chinook Salmon and steelhead collection at Wells Hatchery attempted to collect broodstock in a manner representing the run-at-large of the target species passing Wells Dam. Collection of broodstock at the Twisp River weir (steelhead), and the Methow (spring Chinook Salmon and steelhead) and Wells (summer Chinook Salmon and summer steelhead) hatchery outlet channels is conducted such that extraction of natural origin fish does not exceed 33% of natural origin returns. Biological sampling of adult fish was conducted during broodstock collection and spawning activities to estimate the migration timing, age-structure, sex ratio, and the estimated total return and extraction rate of hatchery and naturally produced spring Chinook Salmon and steelhead passing Wells Dam. Samples collected include fork and post-eye to hypural plate (POH) lengths (mm), sex, scales, origin, hatchery marks, fecundity, and enzyme-linked immunosorbent assay (ELISA) sampling to assess the relative incidence of bacterial kidney disease in spawned spring Chinook Salmon females. This sampling provided the information necessary to assess age-at-maturity, length-at-maturity, and fecundity-at-age. In addition, all fish were scanned for passive integrated transponder (PIT) tags and coded-wire tags (CWT's). Recorded PIT codes were uploaded to the PTAGIS database (www.ptagis.org), and CWT's were recovered from all lethally spawned fish and reported to the Regional Mark Processing Center website whose collective databases serve as the primary repository for CWT data; known as the Regional Mark Information System (RMIS).

Digital video records of fish passage at Wells Dam between 22 May and 2 July for both fish ladders were reviewed to exclude summer Chinook Salmon from the spring Chinook Salmon count and vice versa, based on physical characteristics of the fish. In general, we reviewed the three busiest hours of passage per ladder per day during this time, and expanded the proportion of spring and summer Chinook Salmon during those hours to estimate total passage of each species for the day. The number of fish that were double counted (i.e., re-ascensions) or fell back (i.e., fell below the dam without re-ascending) were estimated based on PIT-tag detections at in-stream interrogation sites and mainstem Columbia and Snake River dams. Proportions of fish detected at locations downstream of Wells Dam and records of fish migrating through Wells Dam multiple times were expanded to remove fall-backs and multiple-counts from the run-at-large estimate at Wells Dam. No estimates of predation, pre-spawn mortality, or illegal removal (i.e., poaching) were made.

2.2: Within-hatchery Monitoring

After spawning, progeny were monitored from incubation to release to assess life-stage specific survival rates. The survival of juveniles in the hatchery is a monitoring indicator (an indicator meant to inform or augment primary indicators) in the M&E Plan used in cases when release goals were not met. This indicator is useful for explaining why the number of fish released did not meet goals despite adequate broodstock collection. The number of juvenile fish released was calculated based on a census of the population during fish tagging or marking, minus mortality that occurred between marking and release. However, the number of steelhead released from

Wells Hatchery was calculated as the sum of all fish trucked to a release location. The number of fish within each truckload was determined by applying the mean number of fish per pound (FPP) at truck-loading by the weight of fish loaded as estimated through examination of a gravimetric tube attached to each truck. A sample of 200 fish were collected just prior to release from each stock to estimate pre-release mean fork length, weight, FPP, condition factor (K), and coefficient of variation (CV) of length. Pre-release sampling results were compared to target release values described in Murdoch et al. (2012; Table 2.1). Observed survival rates, size-at-release, and number at release were compared with life-stage specific target survival rates within the M&E plan (Table 2.2).

Table 2.1. Draft Target release values for Wells and Methow hatchery program steelhead and salmon in 2016 (pending finalization in M&E Plan by the HCP HCs).

Release location, species	Release number	Fork length		Weight	
		Mean (mm)	CV	Mean (g)	FPP
Twisp River steelhead	48,000	191	<10	75.6	6
Methow River steelhead	100,000	191	<10	75.6	6
Okanogan River steelhead	90,000	191	<10	75.6	6
Columbia River steelhead	160,000	191	<10	75.6	6
Wells age-1 summer Chinook	320,000	168	<7	45.4	10
Wells age-0 summer Chinook	484,000	NA	<7	9.1	50
Methow River spring Chinook	133,249	137	<10	30.2	15
Twisp River spring Chinook	30,000	135	<10	30.2	15
Chewuch River spring Chinook	60,516	136	<10	30.3	15

Table 2.2. Life-stage survival rate standards for spring Chinook, summer Chinook, and steelhead reared at the Wells and Methow hatcheries.

Life stage	Survival standard (%)
Collection-to-spawning-female	90
Collection-to-spawning-male	85
Unfertilized egg-to-eyed	92
Eyed egg-to-ponding	98
30 d after ponding	97
100 d after ponding	93
Ponding-to-release	90
Transport-to-release	95
Unfertilized egg-to-release	81

All fish at the Wells and Methow hatcheries receive either an internal tag (CWT), external mark (e.g., adipose fin-clip), or a combination of both (e.g., fin-clip and CWT) prior to release. In addition, representative groups of fish from some populations received a PIT tag prior to release to estimate migration timing, emigration survival, and smolt-to-adult survival (SAR). Mark retention was estimated prior to release by collecting a random sample of fish and scanning for marks and tags visually (ad-clipped fish) or with electronic detection equipment (CWT'd fish). Hatchery mark retention and release information is provided to the RMIS database annually so that subsequent recaptures of marked fish can be expanded to account for un-marked fish.

2.3: Natural Origin Juvenile Productivity

Sampling of juvenile fish was conducted using rotary smolt traps in the Twisp and Methow rivers, and through hook-and-line angling and electrofishing in the Twisp subbasin. Smolt trapping was conducted to estimate the number of emigrating salmonids from the Twisp River (Twisp River trap at rkm 2) or the Methow River basin (Methow River trap at rkm 30). Trapping occurred between late-February and early December at both trap sites. A detailed description of smolt trapping methods can be found in Snow et al. (2012) and in Attachment A. In general, all species captured at each trap site were identified and enumerated by origin (hatchery or natural) on a daily basis. Biological data collected from salmonid species included fork length (mm), weight (g), hatchery mark, PIT tag code (if present), state of smoltification (steelhead), and scale samples were collected from natural-origin steelhead, Bull Trout, and Cutthroat Trout. To estimate capture efficiency for each smolt trap and trapping position, some captured fish were marked (PIT tag and/or fin-clip) and released upstream of each trap site to determine recapture rates. These mark/recapture trials were conducted over a wide range of discharges so that a linear regression model relating discharge and capture efficiency could be developed for each separate trapping position at each site.

Total emigration estimates for steelhead, spring and summer Chinook Salmon, and Coho Salmon were calculated as the sum of the daily capture of each species at each site, expanded by the site-specific capture efficiency estimated through the application of the discharge/trap efficiency linear regression model. Because these species may emigrate from their natal tributaries over multiple years, emigration estimates of different ages of fish from the same brood were summed to estimate total emigration for specific broods of fish.

Juvenile spring Chinook Salmon and steelhead were captured by hook-and-line angling or through backpack electroshocking in the Twisp subbasin to estimate over-winter (parr to smolt) and smolt to adult survival and to estimate stray rates of natural-origin adult spawners. Captured fish were held briefly in 19L buckets, then anesthetized in a solution of MS-222 prior to bio-sampling. Fork length (mm) and weight (g) were measured for each fish and those with a fork length greater than 54 mm were PIT tagged prior to release. In general, scale samples were collected from all steelhead with a fork length greater than 89 mm. Each release site was geo-referenced with a hand-held global positioning system (GPS) unit so that approximate river kilometer for each release site could be determined and included within the tagging file uploaded to the PIT tag information system (PTAGIS) website. Parr to smolt survival was calculated from PIT tag detections using the Cormack-Jolly-Seber (CJS) survival estimates obtained from the Data Access Real Time website (DART) maintained by the University of Washington's School of Aquatic and Fishery Sciences. Smolt to adult and stray rate information was calculated from adult PIT tag detections at mainstem Columbia River dams and in-stream PIT tag detection arrays. Additionally, PIT tagged juvenile Chinook were used to estimate Chinook emigration from the Twisp River during periods when the smolt trap was not operating (e.g., winter) by expanding PIT tag detections at the Twisp River PIT tag array by the expected array efficiency as determined by mark/recapture sampling and the expected PIT tag rate determined from smolt trap sampling.

2.4: Spawning Ground Surveys

Spawning ground surveys were used to evaluate spawn timing and spatial distribution of spring Chinook Salmon and steelhead. The Methow River basin was divided into four geographic subbasins: upper Methow River (upstream of Winthrop), lower Methow River (downstream of Winthrop), Chewuch River, and Twisp River. Each subbasin was further divided into survey sections based on stream length and unique natural or anthropogenic features (Tables 2.3-2.6). Spring Chinook Salmon redd surveys were conducted weekly between about 1 August and 30 September throughout their spawning area in the Methow Basin. Steelhead surveys occurred weekly between about 15 March and 31 May throughout the Twisp River subbasin, and were considered total redd counts. Steelhead surveys in the lower Methow subbasin were conducted during the same period, but primarily within selected index areas. River sections outside the selected index areas were surveyed once when spawning was near completion. The application of the surveyor efficiency model previously developed was not applied to redd counts in 2016 therefore redd totals in lower Methow River reaches should be considered minimum values (Attachment D). In general, each redd was individually marked with biodegradable flagging tape and the survey date, redd number, and general stream channel location were recorded on each flag. Steelhead escapement estimates in the Chewuch and upper Methow subbasins, and in the lower Methow River tributaries were produced by expanding PIT tag detections at in-stream PIT tag arrays (Attachment D).

Table 2.3. Upper Methow River subbasin survey sections (steelhead index areas in bold).

Stream	Section	Code	Section length (rkm)		
			Begin	End	Total
Upper Methow	Ballard CG. - Lost River Confluence	M15	121.2	117.2	4.0
	Lost River Confluence - Gate Creek	M14	117.2	112.4	4.8
	Gate Creek - Early Winters Creek	M13	112.4	108.2	4.2

	Early Winters Creek - Mazama Bridge	M12	108.2	105.0	3.2
	Mazama Bridge - Suspension Bridge	**M11**	**105.0**	**101.0**	**4.0**
	Suspension Bridge - Weeman Bridge	**M10**	**101.0**	**95.8**	**5.2**
	Weeman Bridge - Along Hwy 20	M9	95.8	86.8	9.0
	Along Highway 20 - Wolf Creek	M8	86.8	84.6	2.2
	Wolf Creek - Foghorn Dam	M7	84.6	82.8	1.8
	Foghorn Dam - Winthrop Bridge	M6	82.8	80.1	2.7
Lost River	Sunset Creek - Eureka Creek	L3	11.2	6.6	4.6
	Eureka Creek - Lost River Bridge	L2	6.6	0.8	5.8
	Lost River Bridge - Confluence	L1	0.8	0.0	0.8
Early Winters Cr.	Klipchuck CG. - Early Winters Bridge	EW5	7.2	5.8	1.4
	Early Winters Bridge - Hwy 20 Bridge	EW4	5.8	3.7	2.1
	Highway 20 Bridge – Diversion dam	EW3	3.7	0.8	2.9
	Diversion dam - Hwy 20 Bridge	EW2	0.8	0.5	0.3
	Hwy 20 Bridge - Confluence	EW1	0.5	0.0	0.5
Suspension Creek	100m above fork - Confluence	Susp1	0.3	0.0	0.3
Little Susp. Creek	50m above fork - Confluence	Lsusp1	0.1	0.0	0.1
Hancock Cr.	Springs - Wolf Creek Road	HA2	1.1	0.2	0.9
	Wolf Creek Road - Confluence	HA1	0.2	0.0	0.2
Wolf Creek	Upper diversion – Rd. 5505 access	W3	7.0	2.4	4.6
	Rd. 5505 access – Footbridge	W2	2.4	0.5	1.9
	Footbridge – Confluence	W1	0.5	0.0	0.5
Gate Creek	Culvert - Confluence	GA1	0.3	0.0	0.3
MH Outfall[1]	Hatchery to Methow River	MH1	0.4	0.0	0.4
WNFH Outfall[2]	Hatchery to Methow River	WN1	0.4	0.0	0.4

[1]Methow State Fish Hatchery outfall.

[2]Winthrop National Fish Hatchery outfall.

Table 2.4. Lower Methow River subbasin survey sections (steelhead index areas in bold).

Stream	Section	Code	Section length (rkm)		
			Begin	End	Total
Lower Methow	Winthrop Bridge - MVID Dam	M5	80.1	72.1	8.0
	MVID - Twisp Confluence	M4	72.1	64.9	7.2
	Twisp Confluence - Carlton Bridge	M3	64.9	43.8	21.1
	Carlton Bridge - Upper Burma Bridge	**M2**	**43.8**	**20.1**	**23.7**
	Upper Burma Bridge - Pateros	M1	20.1	0.0	20.1
Beaver Creek	Lester Hill Road - Balky Hill Road	BV3	15.2	10.2	5.0
	Balky Hill Road - Hwy 20	BV2	10.2	3.4	6.8
	Hwy 20 - Confluence	BV1	3.4	0.0	3.4

Table 2.5. Twisp River subbasin survey sections.

Stream	Section	Code	Section length (rkm)		
			Begin	End	Total
Twisp River	Road's End CG. - South Creek Bridge	T10	46.4	41.8	4.6
	South Cr. Bridge - Poplar Flats CG.	T9	41.8	38.6	3.2
	Poplar Flats CG. - Mystery Bridge	T8	38.6	35.4	3.2
	Mystery Bridge - War Creek Bridge	T7	35.4	28.5	6.9
	War Creek Bridge - Buttermilk Bridge	T6	28.5	21.1	7.4
	Buttermilk Br. - Little Bridge Cr.	T5	21.1	15.2	5.9
	Little Bridge Creek - Twisp weir	T4	15.2	11.4	3.8
	Twisp weir - Upper Poorman Bridge	T3	11.4	7.8	3.6
	Up. Poorman Br. - Low. Poorman Br.	T2	7.8	2.9	4.9
	Lower Poorman Bridge - Confluence	T1	2.9	0.0	2.9
Little Bridge Creek	Road’s End - Vetch Creek	LBC4	9.1	7.8	1.3
	Vetch Creek - Upper Culvert	LBC3	7.8	4.8	3.0
	Upper Culvert - Lower Culvert	LBC2	4.8	2.4	2.4
	Lower Culvert - Confluence	LBC1	2.4	0.0	2.4
Buttermilk Creek	(Fork - Cattle Guard)	BM2	4.1	2.0	2.1
	(Cattle Guard - Confluence)	BM1	2.0	0.0	2.0
Eagle Creek	(FR 4430 Culvert - Confluence)	EA1	0.5	0.0	0.5
War Creek	(FR 4430 Bridge - Confluence)	WR1	1.0	0.0	1.0
South Creek	(Falls - Confluence)	SO1	0.6	0.0	0.6
MSRF pond outfall[1]	Acclimation pond to confluence	MSRF1	0.2	0.0	0.2

[1]Methow Salmon Recovery Foundation pond outfall.

Table 2.6. Chewuch River subbasin survey reaches (steelhead index reaches in bold).

Stream	Section	Code	Section length (rkm)		
			Begin	End	Total
Chewuch River	Chewuch Falls - 30 Mile Bridge	C13	54.4	50.2	4.2
	30 Mile Bridge - Road Side Camp	C12	50.2	45.6	4.6
	Road Side Camp - Andrews Creek	C11	45.6	41.3	4.3
	Andrews Creek - Lake Creek	C10	41.3	37.3	4.0
	Lake Creek - Buck Creek	C9	37.3	35.0	2.3
	Buck Creek - Camp 4 CG.	**C8**	**35.0**	**32.6**	**2.4**
	Camp 4 CG. - Chewuch CG.	C7	32.6	27.5	5.1
	Chewuch CG. - Falls Creek CG.	C6	27.5	21.8	5.7
	Falls Creek CG. - Eightmile Creek	C5	21.8	18.1	3.7
	Eightmile Creek - Boulder Creek	**C4**	**18.1**	**14.4**	**3.7**
	Boulder Creek - Chewuch Bridge	C3	14.4	12.6	1.8
	Chewuch Bridge - WDFW Land	C2	12.6	5.1	7.5
	WDFW Land - Confluence	C1	5.1	0.0	5.1

Cub Creek	W. Chewuch Road - Confluence	CU1	1.0	0.0	1.0
Eightmile Creek	300m above diversion - Bridge	EM2	1.1	0.6	0.5
	Bridge - Confluence	EM1	0.6	0.0	0.6

Carcasses recovered during spring Chinook Salmon spawning ground surveys were sampled to determine origin, sex, fork length, POH length, egg retention (females), and scale samples were collected from each carcass when possible. Carcasses were scanned for PIT tags using hand-held devices and detected tags were recorded. A GPS location was collected where each carcass was discovered. Tissue samples were collected from hatchery- and natural-origin fish for genetic analyses. All carcasses were scanned for CWTs using hand-held electronic detection wands (because many spring Chinook Salmon released from Methow Basin hatcheries in recent years have been tagged with a CWT but have not been externally marked, thus requiring the use of electronic detectors) and when present the tag was collected for analysis. Coded-wire tag data are uploaded to- and retrieved from the RMIS database to calculate harvest rates, adult survival, age-at-return, and straying of CWT'd hatchery fish. Coded-wire tag data availability in the RMIS database is often two or more years behind the collection event, thus monitoring indicators that rely on these data must be continually updated (Table 2.7).

The hatchery replacement rate (HRR) and natural replacement rate (NRR) are two primary indicators that rely on CWT data. For each brood of CWT'd hatchery fish released, the sum of estimated CWT returns available in the RMIS database is divided by the number of adult broodstock used to produce the brood releases to calculate HRR. For NRR, the number of adult returns is estimated as described in the Harvest Monitoring section 2.5 below, then divided by the estimated naturally spawning (hatchery and wild fish) population for the cohort.
Data collected from redd and carcass surveys, stock assessment at Wells Dam, and CWT data retrieved from the RMIS database are used to assess spawn timing and distribution, SAR, HRR, NRR, harvest exploitation rates, straying, length- and age-at-maturity, and the proportion of hatchery origin spawners (pHOS) and the proportionate natural influence (PNI) within the spawning subbasins. Because too few carcasses are recovered during steelhead surveys to estimate spawn timing, distribution, and straying of specific hatchery stocks, evaluation of these indicators occurs at specific locations where adult steelhead are sampled (e.g., Twisp weir) or through analysis of PIT tag data collected at multiple in-stream antenna arrays throughout the Methow Basin. Adult steelhead PIT tag detections at each spawning tributary antenna/array were evaluated to assess the date of tributary entry and tributary residence during the spawning period. Fish that entered tributaries on a date consistent with a spawning migration (March-May) and were not subsequently detected anywhere in the Methow Basin downstream of the specific antenna/array, were considered to have spawned above that antenna/array. Hatchery fish that met these criteria within a tributary other than their tributary of release were considered strays.

Table 2.7. Broodstock requirements and smolt release, smolt-to-adult survival (SAR), and hatchery replacement rate (HRR) goals for PUD hatchery program steelhead and Chinook Salmon. SAR, adult equivalent, and smolt per adult values were derived from the HRR target and smolt release goals.

Program	Broodstock	Smolts released	SAR	Adult equivalents	# Smolts/ adult	HRR
Wells age-1 summer Chinook	178	320,000	0.003	943	339	5.3
Wells age-0 summer Chinook	284	484,000	0.001	625	774	2.2
Twisp spring Chinook	18	30,000	0.003	81	370	4.5
Methow Comp. spring Chinook	104	193,765	0.002	468	414	4.5
DCPUD safety-net steelhead	170	260,000	0.01	3,332	78	19.6
Twisp WxW steelhead	28	48,000	0.01	549	87	19.6
GCPUD-Okanogan steelhead	42	80,000	0.01	823	97	19.6

The M&E Plan evaluates straying of hatchery fish by assessing the overall stray rate of each release group (donor population) and by evaluating the proportion of stray hatchery fish within the spawning escapement of other (recipient) populations within each spawning year (Hillman et al., 2013). To further evaluate stray rates, adult returns of hatchery origin fish were categorized depending on their release and recovery location (Table 2.8).

Table 2.8. Categories and definitions used to evaluate homing and straying of hatchery fish.

Category	Definition
Donor population	Hatchery population being evaluated; grouped by species, brood, and release location.
Recipient population	Spawning population of species being evaluated; may be at the tributary (e.g., Methow, Twisp, Chewuch), or basin scale (e.g., Entiat, Wenatchee).
In-basin homing	Fish homed to its release stream (population).
In-basin stray	Fish strayed to another population within its release basin.
Out-of-basin stray	Fish strayed to a population in a different release basin.

Fish retained for broodstock at Wells Dam or those for which the CWT code could not be used to identify release subbasin (e.g., 1998 and 2000 Methow and Chewuch spring Chinook Salmon releases) were excluded from stray rates calculations.

2.5: Harvest Monitoring

The harvest of fish stocks covered under the M&E Plan is monitored through the use of the RMIS database (spring and summer Chinook Salmon), or through local creel sampling efforts (steelhead). Depending on fishery type, harvest of natural origin fish can be intentional (i.e., non-selective fishery) or unintentional (e.g., post-release mortality in selective fisheries). Because non-selective fisheries may retain spring Chinook Salmon regardless of mark type, the exploitation rate of specific hatchery stocks (e.g., Methow River) should be the same as for naturally produced fish from the same population. Harvest of natural origin fish, and hatchery fish that were not adipose-fin clipped (i.e., Methow Hatchery spring Chinook Salmon), was estimated using the exploitation rates of surrogate hatchery stocks where the run-timing and exposure to fisheries was assumed to be similar to that of natural origin fish.

Coded-wire tag data queried from the RMIS database was expanded by the sample rate of the data collection event, and the tag-code specific mark rate for the population estimated during in-hatchery monitoring. The expanded data was sorted by fishery code and site name, and grouped into four categories to evaluate M&E Plan indicators including HRR, NRR, SAR, and straying:

1. Broodstock
2. Spawning ground
3. Ocean fishery
4. Freshwater fishery

Within the broodstock and spawning ground categories, subcategories were employed to designate target areas (i.e., stream or hatchery of release), and non-target areas (i.e., stray locations). Within the ocean and freshwater categories, subcategories were developed to designate commercial, sport, or tribal harvests. Wells summer Chinook Salmon are propagated for harvest augmentation and all spawning ground recoveries of these fish were considered to be in non-target areas.

Since ESA listing in 1997, steelhead returns have had to meet specific requirements for abundance and genetic composition before a local fishery could be considered. Because hatchery steelhead were not coded-wire tagged, no stock-specific fishery harvest estimate could be generated from the RMIS database. Instead, creel census was used to estimate harvest and indirect mortality (i.e., hooking mortality) associated with local fisheries. Creel census was conducted consistent with roving creel census methodologies described by Malvestuto et al. (1978). An estimated hooking mortality rate of 5% was used to estimate mortality of wild and hatchery fish released by sport anglers (WDFW 2016). Angler interviews produced a catch-per-unit-effort (CPU) statistic where one unit of effort was equal to one angler fishing for one hour. The total number of steelhead captured was determined by multiplying the total angler effort by the overall CPU for each fishery location.

Section 3: Methow Hatchery Spring Chinook

This section focuses on the Methow Hatchery spring Chinook program which includes broodstock collected at Wells Dam, the Twisp River weir, and the Methow and Winthrop hatcheries. These collections produced juvenile Twisp and Methow Composite stock spring Chinook released into the Twisp, Methow, and Chewuch subbasins.

3.1: Broodstock Collection and Sampling

Trapping of the 2016 brood Methow Hatchery spring Chinook occurred concurrently with run-at-large evaluation at Wells Dam between 2 May and 23 June, 2016. During this time, a total of 61 wild origin fish were retained for broodstock, representing 9.3% of the estimated wild fish escapement above Wells Dam during the trapping period (N = 659). Trapping and collection of hatchery origin spring Chinook was also conducted at the Methow Hatchery outfall trap. Most fish trapped at that location were transferred to Winthrop National Fish Hatchery for broodstock or surplus purposes, but some hatchery fish were retained for broodstock or were euthanized to reduce pHOS (Table 3.1). Spring Chinook trapping occurred at the Twisp River weir between 27 May and 18 July, 2016. During this time, a total of 11 wild and 4 hatchery origin fish were retained for broodstock (Table 3.1), and 15 additional hatchery origin age-3 males (i.e., jacks) were euthanized to reduce pHOS at the Twisp weir. Historically, most spring Chinook collected have been used for spawning (Table 3.1). Fish collected for broodstock but not utilized (e.g., excess males, non-viable females) were considered surplus.

Table 3.1. Collection of spring Chinook and the prespawn mortality (PSM), surplus mortality (Mort), and spawning (Spawn) by fish origin (hatchery or wild). Fish for which the origin or disposition (PSM, Spawn, etc.) are unknown (U) are included in the hatchery total for each brood.

Brood year	Wild Chinook					Hatchery Chinook					Total spawned
	Total	PSM	Mort	Spawn	U	Total	PSM	Mort	Spawn	U	
Methow Composite spring Chinook											
1992	21	0	2	19	0	5	0	0	5	0	24
1993	114	0	4	109	1	100	6	2	87	5	196
1994	10	0	0	10	0	4	0	0	4	0	14
1995	0	0	0	0	0	14	2	0	12	0	12
1996	98	0	0	96	2	146	6	70	70	0	166
1997	13	0	0	13	0	334	0	76	258	0	271
1998	94	0	0	94	0	87	2	9	68	8	162
1999	33	0	0	33	0	149	13	19	53	64	86
2000	2	0	1	1	0	254	21	88	139	6	140
2001	27	0	0	27	0	314	9	129	170	6	197
2002	0	0	0	0	0	426	19	46	361	0	361
2003	2	0	0	2	0	221	7	38	175	1	177
2004	1	0	0	1	0	279	4	1	274	0	275
2005	2	0	0	2	0	264	2	7	255	0	257
2006	9	1	0	8	0	321	13	8	300	0	308
2007	19	0	0	19	0	169	2	31	136	0	155
2008	43	0	0	43	0	296	4	83	209	0	252
2009	97	1	5	91	0	180	0	22	158	0	249
2010	139	1	16	122	0	146	6	20	120	0	242
2011	100	2	2	96	0	280	7	79	194	0	290
2012	48	1	5	42	0	104	1	3	100	0	142
2013	40	0	1	39	0	52	0	6	46	0	85
2014	95	1	1	93	0	1	0	0	1	0	94
2015	77	0	0	77	0	53	1	33	19	0	96
2016	80	5	0	75	0	53	1	42	10	0	85
Mean	47	0	1	44	0	170	5	32	129	4	174
Twisp spring Chinook											
1992	24	0	2	22	0	1	0	1	0	0	22
1993	30	0	0	30	0	15	3	0	12	0	42
1994	5	0	0	5	0	0	0	0	0	0	5
1995	0	0	0	0	0	0	0	0	0	0	0
1996	23	0	0	23	0	28	2	6	20	0	43
1997	0	0	0	0	0	15	0	0	15	0	15
1998	1	0	0	1	0	10	0	0	10	0	11
1999	16	0	0	16	0	24	1	0	22	1	38
2000	6	0	0	6	0	63	2	0	61	0	67
2001	18	2	0	16	0	18	1	1	16	0	32

Table 3.1. Continued.

Brood year	Wild Chinook					Hatchery Chinook					Total spawned
	Total	PSM	Mort	Spawn	U	Total	PSM	Mort	Spawn	U	
					Twisp spring Chinook						
2002	0	0	0	0	0	15	3	1	11	0	11
2003	18	1	0	17	0	18	2	0	16	0	33
2004	47	5	0	42	0	25	0	0	25	0	67
2005	7	0	0	7	0	17	0	6	11	0	18
2006	0	0	0	0	0	28	1	0	27	0	27
2007	4	0	0	4	0	36	0	2	34	0	38
2008	12	1	2	9	0	31	0	2	29	0	38
2009	24	0	1	23	0	17	0	0	17	0	40
2010	32	3	0	29	0	26	1	7	18	0	47
2011	16	2	6	8	0	6	0	4	2	0	10
2012	13	1	0	12	0	20	0	6	14	0	26
2013	7	0	0	7	0	12	0	2	10	0	17
2014	25	0	0	25	0	1	0	0	1	0	26
2015	19	0	0	19	0	0	0	0	0	0	19
2016	6	0	0	6	0	4	0	0	4	0	11
Mean	14	1	0	13	0	17	1	1	15	0	28

Length and Age at Maturity

Most spring Chinook spawned at Methow Hatchery are age-4 hatchery origin fish. Because of this, sample sizes within ages and sexes are generally too small to make valid comparisons within years (Table 3.2). These analyses will be conducted across years in *Statistical Reports* scheduled at 5-year intervals (e.g., Murdoch et al. 2012).

Table 3.2. Mean fork length (cm) by brood, origin, sex, and age at return of spring Chinook retained for broodstock at Methow Hatchery.

Brood	Origin	Sex	Age-3			Age-4			Age-5		
			Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Methow / Methow Composite spring Chinook						
1998	H	F	-	-	-	76	8	4	85	23	9
1998	W	F	-	-	-	76	27	4	89	42	6
1999	H	F	-	-	-	78	27	3	-	-	-
1999	W	F	-	-	-	78	13	5	87	4	7
2000	H	F	-	-		75	74	3	-	-	-
2000	W	F	-	-	-	-	-	-	-	-	-
2001	H	F	-	-	-	77	67	4	-	-	-
2001	W	F	-	-	-	-	-	-	-	-	-
2002	H	F	-	-	-	76	145	4	87	6	8

Table 3.2. Continued.

Brood	Origin	Sex	Age-3			Age-4			Age-5		
			Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Methow / Methow Composite spring Chinook											
2002	W	F	-	-	-	-	-	-	-	-	-
2003	H	F	-	-	-	75	17	3	-	-	-
2003	W	F	-	-	-	-	-	-	-	-	-
2004	H	F	-	-	-	73	144	4	76	1	-
2004	W	F	-	-	-	75	1	-	-	-	-
2005	H	F	-	-	-	74	98	4	81	1	-
2005	W	F	-	-	-	71	2	3	-	-	-
2006	H	F	-	-	-	74	121	4	83	7	5
2006	W	F	-	-	-	77	4	2	92	1	-
2007	H	F	-	-	-	74	43	5	88	21	4
2007	W	F	-	-	-	-	-	-	90	9	2
2008	H	F	66	1	-	77	180	4	88	7	6
2008	W	F	-	-	-	76	16	4	90	4	6
2009	H	F	66	1	-	77	98	4	86	2	6
2009	W	F	-	-	-	78	38	3	91	10	4
2010	H	F	-	-	-	77	67	4	-	-	-
2010	W	F	-	-	-	78	69	4	93	2	1
2011	H	F	-	-	-	76	128	4	89	16	3
2011	W	F	-	-	-	79	28	5	90	17	6
2012	H	F	-	-	-	74	54	3	90	2	6
2012	W	F	-	-	-	77	16	4	88	11	2
2013	H	F	-	-	-	74	26	3	-	-	-
2013	W	F	-	-	-	75	15	4	89	6	3
2014	H	F	-	-	-	80	1	-	-	-	-
2014	W	F	-	-	-	78	46	4	90	2	6
Mean	H	F	66	1	-	76	76	4	85	9	6
Mean	W	F	-	-	-	77	23	4	90	10	4
1998	H	M	55	10	4	77	3	3	95	23	5
1998	W	M	52	2	7	75	12	6	93	11	9
1999	H	M	51	67	5	78	44	4	88	1	-
1999	W	M	-	-	-	76	14	5	100	2	10
2000	H	M	51	40	4	73	59	7	-	-	-
2000	W	M	-	-	-	-	-	-	-	-	-
2001	H	M	60	1	-	81	10	5	-	-	-
2001	W	M	-	-	-	-	-	-	-	-	-
2002	H	M	48	7	6	79	88	6	100	1	-
2002	W	M	-	-	-	-	-	-	-	-	-

Table 3.2. Continued.

Brood	Origin	Sex	Age-3			Age-4			Age-5		
			Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Methow / Methow Composite spring Chinook											
2003	H	M	49	36	4	-	-	-	97	9	3
2003	W	M	51	1	-	-	-	-	-	-	-
2004	H	M	48	85	3	72	52	7	-	-	-
2004	W	M	-	-	-	-	-	-	-	-	-
2005	H	M	52	28	4	72	74	7	-	-	-
2005	W	M	-	-	-	-	-	-	-	-	-
2006	H	M	45	3	4	76	110	5	91	2	8
2006	W	M	50	1	-	76	3	1	95	1	-
2007	H	M	52	16	4	70	40	7	93	14	5
2007	W	M	48	1	-	72	6	7	96	3	4
2008	H	M	57	32	5	75	75	6	96	1	-
2008	W	M	50	2	4	74	21	8	102	1	-
2009	H	M	61	34	5	78	44	5	95	1	-
2009	W	M	53	16	4	77	28	6	94	3	11
2010	H	M	50	12	7	78	63	7	-	-	-
2010	W	M	49	3	6	76	63	7	-	-	-
2011	H	M	50	13	4	75	116	6	92	7	8
2011	W	M	51	6	6	73	42	6	97	7	5
2012	H	M	-	-	-	73	48	6	-	-	-
2012	W	M	-	-	-	73	13	7	97	8	5
2013	H	M	63	2	1	74	23	5	67	1	-
2013	W	M	-	-	-	77	18	6	-	-	-
2014	H	M	-	-	-	-	-	-	-	-	-
2014	W	M	65	1	-	76	44	7	-	-	-
Mean	H	M	54	11	5	75	40	6	93	4	6
Mean	W	M	54	11	5	75	43	6	93	5	6
Twisp Spring Chinook											
1998	H	F	-	-	-	77	2	2	77	4	16
1998	W	F	-	-	-	-	-	-	-	-	-
1999	H	F	-	-	-	-	-	-	-	-	-
1999	W	F	-	-	-	79	13	3	89	3	2
2000	H	F	-	-	-	75	38	4	-	-	-
2000	W	F	-	-	-	-	-	-	91	3	1
2001	H	F	-	-	-	77	7	2	93	2	10
2001	W	F	-	-	-	80	7	1	88	1	-
2002	H	F	-	-	-	75	5	3	-	-	-
2002	W	F	-	-	-	-	-	-	-	-	-

Table 3.2. Continued.

Brood	Origin	Sex	Age-3			Age-4			Age-5		
			Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
						Twisp spring Chinook					
2003	H	F	-	-	-	71	3	8	-	-	-
2003	W	F	-	-	-	-	-	-	93	5	1
2004	H	F	-	-	-	73	16	4	-	-	-
2004	W	F	-	-	-	76	20	6	-	-	-
2005	H	F	-	-	-	-	-	-	-	-	-
2005	W	F	-	-	-	81	4	8	89	2	4
2006	H	F	-	-	-	72	15	4	85	1	-
2006	W	F	-	-	-	-	-	-	-	-	-
2007	H	F	-	-	-	74	16	5	-	-	-
2007	W	F	-	-	-	73	1	-	93	2	3
2008	H	F	-	-	-	76	16	5	90	1	-
2008	W	F	-	-	-	75	9	4	-	-	-
2009	H	F	-	-	-	77	8	5	90	3	2
2009	W	F	-	-	-	76	6	9	-	-	-
2010	H	F	-	-	-	76	16	3	-	-	-
2010	W	F	-	-	-	78	11	3	93	1	-
2011	H	F	-	-	-	73	2	6	-	-	-
2011	W	F	-	-	-	77	4	5	91	3	3
2012	H	F	-	-	-	74	9	3	-	-	-
2012	W	F	-	-	-	74	6	5	93	1	-
2013	H	F	-	-	-	73	6	2	-	-	-
2013	W	F	-	-	-	76	2	1	92	2	1
2014	H	F	-	-	-	76	1	-	-	-	-
2014	W	F	-	-	-	76	10	2	74	1	-
Mean	H	F	-	-	-	75	8	4	90	2	2
Mean	W	F	-	-	-	75	8	4	90	2	2
1998	H	M	-	-	-	80	3	1	87	1	-
1998	W	M	-	-	-	-	-	-	98	1	-
1999	H	M	50	24	4	-	-	-	-	-	-
1999	W	M	-	-	-	-	-	-	-	-	-
2000	H	M	52	1	1	72	23	11	-	-	-
2000	W	M	45	1	-	-	-	-	98	2	1
2001	H	M	63	2	3	79	4	6	-	-	-
2001	W	M	53	2	2	75	22	5	-	-	-
2002	H	M	46	4	5	-	-	-	-	-	-
2002	W	M	-	-	-	-	-	-	-	-	-
2003	H	M	51	3	3	-	-		-	-	-

Table 3.2. Continued.

Brood	Origin	Sex	Age-3			Age-4			Age-5		
			Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
						Twisp spring Chinook					
2003	W	M	50	4	3	67	1	-	-	-	-
2004	H	M	49	1	-	72	6	9	-	-	-
2004	W	M	46	3	2	72	21	7	-	-	-
2005	H	M	50	10	2	-	-	-	-	-	-
2005	W	M	-	-	-	82	1	-	-	-	-
2006	H	M	50	2	2	66	10	10	-	-	-
2006	W	M	-	-	-	-	-	-	-	-	-
2007	H	M	48	7	4	70	10	5	-	-	-
2007	W	M	48	1	-	-	-	-	-	-	-
2008	H	M	53	4	2	73	9	5	-	-	-
2008	W	M	-	-	-	73	3	5	-	-	-
2009	H	M	50	3	7	72	2	2	-	-	-
2009	W	M	52	11	3	71	6	5	96	1	-
2010	H	M	50	8	3	66	2	3	-	-	-
2010	W	M	43	1	-	71	19	6	-	-	-
2011	H	M	52	2	2	67	1	-	-	-	-
2011	W	M	46	4	7	63	5	8	-	-	-
2012	H	M	47	1	-	73	10	7	-	-	-
2012	W	M	-	-	-	74	6	5	-	-	-
2013	H	M	-	-	-	70	6	3	-	-	-
2013	W	M	-	-	-	75	3	6	-	-	-
2014	H	M	-	-	-	-	-	-	-	-	-
2014	W	M	-	-	-	73	14	5	-	-	-
Mean	H	M	49	4	4	71	7	5	96	1	-
Mean	W	M	49	4	4	71	7	5	96	1	-

Sex Ratio and Fecundity

The overall mean sex ratio of the Methow Composite and Twisp stock fish retained for broodstock (excludes released fish) favored females (Table 3.3). For the 2014 brood, the sex ratio favored female fish in the Methow Composite program, and male fish in the Twisp program. Of the female fish retained, fecundity of the 2014 brood was generally higher for hatchery origin fish than for natural origin fish within each program, but sample sizes for hatchery females was very low. Overall fecundities of the 2014 brood were above the value used in broodstock protocol calculations for hatchery fish (3,556) but below the value used for wild

(3,751) Methow Composite females. Similarly, fecundity of Twisp hatchery origin females was above the value used in broodstock protocol (3,504), but below the value used for wild origin females (3,699).

Table 3.3. Sex ratio (Male/Female) and mean fecundity by return year and origin of spring Chinook retained for broodstock at Methow Hatchery.

Return year	Hatchery Chinook				Wild Chinook				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
					Methow Composite spring Chinook					
1998	31	36	4,469	0.86:1	25	68	4,606	0.37:1	0.54:1	4,505
1999	34	51	4,121	0.67:1	16	17	4,530	0.94:1	0.74:1	4,279
2000	76	87	3,759	0.87:1	0	0	-	-	0.87:1	3,759
2001	11	44	3,854	0.25:1	0	0	-	-	0.25:1	3,854
2002	32	46	3,809	0.70:1	0	0	-	-	0.70:1	3,809
2003	15	15	3,887	1.00:1	0	0	-	-	1.00:1	3,887
2004	20	33	3,347	0.61:1	0	0	-	-	0.61:1	3,347
2005	37	52	3,455	0.71:1	0	0	-	-	0.71:1	3,455
2006	65	76	3,318	0.86:1	5	2	3,598	2.50:1	0.90:1	3,338
2007	103	64	3,845	1.61:1	10	9	5,048	1.11:1	1.54:1	3,995
2008	108	188	3,726	0.57:1	24	20	3,568	1.20:1	0.63:1	3,711
2009	79	101	3,875	0.78:1	48	49	4,217	0.98:1	0.85:1	3,987
2010	75	67	3,927	1.12:1	66	71	3,846	0.93:1	1.02:1	3,876
2011	136	144	3,773	0.94:1	55	45	4,384	1.22:1	1.01:1	3,920
2012	48	56	3,362	0.86:1	21	27	4,316	0.78:1	0.83:1	3,668
2013	26	26	3,521	1.00:1	18	22	3,657	0.82:1	0.91:1	3,585
2014	0	1	4,329	-	47	49	4,123	0.96:1	0.94:1	4,125
Mean	53	64	3,787	0.83:1	20	22	4,172	0.90:1	0.84:1	3,829
					Twisp spring Chinook					
1998	3	4	4,116	0.75:1	0	0	-	-	0.75:1	3,122
1999	23	0	-	-	0	16	4,595	0:01	1.44:1	4,595
2000	24	39	3,820	0.62:1	2	3	5,292	0.67:1	0.62:1	3,927
2001	7	10	3,691	0.70:1	10	8	4,689	1.25:1	0.94:1	4,160
2002	9	5	4,224	1.80:1	0	0	-	-	1.80:1	4,224
2003	6	12	3,239	0.50:1	13	5	5,867	2.6:1	1.12:1	4,012
2004	7	17	3,579	0.41:1	26	21	3,811	1.24:1	0.87:1	3,704
2005	17	0	-	-	1	6	4,393	0.17:1	3.00:1	4,393

Table 3.3. Continued.

Return year	Hatchery Chinook				Wild Chinook				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
					Twisp spring Chinook					
2006	12	16	3,301	0.75:1	0	0	-	-	0.75:1	3,301
2007	20	16	3,422	1.25:1	1	3	4,529	0.33:1	1.11:1	3,597
2008	13	18	3,590	0.72:1	3	9	3,204	0.33:1	0.59:1	3,471
2009	6	11	4,050	0.55:1	18	6	4,402	3:01	1.41:1	4,174
2010	10	16	3,877	0.63:1	20	12	3,952	1.67:1	1.07:1	3,907
2011	4	2	3,382	2.00:1	9	7	3,466	1.29:1	1.44:1	3,442
2012	11	9	3,224	1.22:1	6	7	3,977	0.86:1	1.06:1	3,525
2013	6	6	3,251	1.00:1	3	4	4,153	0.75:1	0.90:1	3,652
2014	0	1	3,858	-	14	11	3,591	1.27:1	1.17:1	3,614
Mean	10	11	3,642	0.91:1	7	7	4,280	1.00:1	0.94:1	3,813

ELISA Monitoring

Adult female Chinook spawned at Methow Hatchery are screened for the presence of Bacterial Kidney Disease (BKD) using an ELISA assay. Results of this test are grouped into four general categories based on the optical density (OD) of each sample. Overall, at least 72% of OD values from sampled Methow Composite and Twisp program females have been in the "Below-low" category. For most broods of Twisp and Methow Composite stock fish, management actions specified in broodstock collection protocols (Tonseth 2014) have increased the proportion of progeny with lower ELISA OD values retained at Methow Hatchery. For the 2014 brood, all Twisp females were in the below-low category, and all Methow Composite females were in the below-low category except for the single hatchery female spawned (Table 3.4).

Table 3.4. Enzyme-linked immunosorbent assay (ELISA) test results (% of sampled fish) by return year and ELISA category for female spring Chinook spawned at Methow Hatchery. Values are listed for all fish spawned (before), and for all fish retained for yearling-release (after) following ELISA management (i.e., culling), removal of non-viable fish, and release of unfed fry.

Return year	Origin	Below-low (<0.099)		Low (0.099 - 0.199)		Medium (0.200 - 0.449)		High (< 0.450)		Total number	
		Before	After	Before	After	Before	After	Before	After	Before	After
					Chewuch River spring Chinook						
1992	H	33.3	33.3	66.7	66.7	0.0	0.0	0.0	0.0	3	3
1992	W	0.0	0.0	88.9	88.9	0.0	0.0	11.1	11.1	9	9
1993	H	33.4	33.4	33.3	33.3	0.0	0.0	33.3	33.3	3	3

Table 3.4. Continued.

Return year	Origin	Below-low (<0.099)		Low (0.099 - 0.199)		Medium (0.200 - 0.449)		High (< 0.450)		Total number	
		Before	After	Before	After	Before	After	Before	After	Before	After
Chewuch River spring Chinook											
1993	W	30.4	30.9	33.9	34.5	7.1	7.3	28.6	27.3	56	55
1994	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1994	W	33.3	33.3	50.0	50.0	0.0	0.0	16.7	16.7	6	6
1996	H	66.7	66.7	14.3	14.3	4.7	4.7	14.3	14.3	21	21
1996	W	81.8	81.8	18.2	18.2	0.0	0.0	0.0	0.0	11	11
1997	H	35.9	36.0	28.2	27.8	28.2	30.6	7.7	5.6	39	36
1997	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Mean	H	42.4	42.4	35.6	35.5	8.2	8.8	13.8	13.3	17	16
Mean	W	36.4	36.5	47.7	47.9	1.8	1.8	14.1	13.8	21	20
Methow Composite spring Chinook											
1993	H	40.0	40.0	45.7	45.7	2.9	2.9	11.4	11.4	35	35
1993	W	35.8	35.8	50.0	50.0	7.1	7.1	7.1	7.1	14	14
1994	H	44.5	100.0	44.5	0.0	0.0	0.0	11.0	0.0	9	1
1994	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1995	H	14.3	14.3	42.8	42.8	14.3	14.3	28.6	28.6	7	7
1995	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1996	H	84.2	84.2	15.8	15.8	0.0	0.0	0.0	0.0	19	19
1996	W	83.8	83.4	8.1	8.3	0.0	0.0	8.1	8.3	37	36
1997	H	29.6	29.4	50.9	53.0	11.2	15.1	8.3	2.5	169	119
1997	W	20.0	22.2	60.0	66.7	10.0	11.1	10.0	0.0	10	9
1998	H	76.3	78.4	0.0	0.0	10.5	10.8	13.2	10.8	38	37
1998	W	69.1	69.1	11.8	11.8	0.0	0.0	19.1	19.1	68	68
1999	H	64.6	59.3	29.0	33.3	3.2	3.7	3.2	3.7	31	27
1999	W	88.2	88.2	0.0	0.0	0.0	0.0	11.8	11.8	17	17
2000	H	80.6	78.3	16.1	18.9	1.1	1.4	2.2	1.4	93	74
2000	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2001	H	60.8	75.3	10.0	11.8	4.2	2.3	25.0	10.6	120	85
2001	W	90.0	90.0	10.0	10.0	0.0	0.0	0.0	0.0	10	10
2002	H	57.5	72.2	32.3	24.6	1.6	0.0	8.6	3.2	257	126
2002	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2003	H	39.4	34.0	32.9	34.0	6.6	6.4	21.1	25.6	76	47
2003	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2004	H	45.2	66.7	13.7	20.2	11.0	13.1	30.1	0.0	146	99
2004	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	1	1
2005	H	89.7	89.7	6.3	6.3	0.0	0.0	4.0	4.0	126	126
2005	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	2	2
2006	H	81.6	87.9	18.4	12.1	0.0	0.0	0.0	0.0	158	140
2006	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	3	3

Table 3.4. Continued.

Return year	Origin	Below-low (<0.099)		Low (0.099 - 0.199)		Medium (0.200 - 0.449)		High (< 0.450)		Total number	
		Before	After	Before	After	Before	After	Before	After	Before	After
Methow Composite spring Chinook											
2007	H	92.1	92.1	4.7	4.7	1.6	1.6	1.6	1.6	64	64
2007	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	9	9
2008	H	90.1	98.3	8.8	1.7	1.1	0.0	0.0	0.0	182	117
2008	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	19	19
2009	H	78.2	94.0	17.8	6.0	2.0	0.0	2.0	0.0	101	83
2009	W	98.0	98.0	2.0	2.0	0.0	0.0	0.0	0.0	49	49
2010	H	69.1	86.8	26.5	13.2	4.4	0.0	0.0	0.0	68	53
2010	W	94.4	95.6	5.6	4.4	0.0	0.0	0.0	0.0	71	68
2011	H	26.6	48.1	51.0	51.9	21.0	0.0	1.4	0.0	143	79
2011	W	97.8	97.8	2.2	2.2	0.0	0.0	0.0	0.0	45	45
2012	H	92.7	92.7	7.3	7.3	0.0	0.0	0.0	0.0	55	55
2012	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	27	26
2013	H	76.0	76.0	24.0	24.0	0.0	0.0	0.0	0.0	25	25
2013	W	95.5	95.5	4.5	4.5	0.0	0.0	0.0	0.0	22	22
2014	H	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	1	1
2014	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	47	47
Mean	H	57.6	62.0	27.1	25.1	4.3	4.4	11.1	8.5	59	43
Mean	W	83.0	87.2	13.3	11.8	1.9	0.7	1.8	0.3	62	52
Twisp spring Chinook											
1992	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1992	W	0.0	0.0	77.8	77.8	11.1	11.1	11.1	11.1	9	9
1993	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1993	W	4.3	4.3	52.2	52.2	26.1	26.1	17.4	17.4	23	23
1994	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1994	W	25.0	25.0	50.0	50.0	0.0	0.0	25.0	25.0	4	4
1996	H	61.5	61.5	23.1	23.1	0.0	0.0	15.4	15.4	13	13
1996	W	77.8	77.8	11.1	11.1	11.1	11.1	0.0	0.0	9	9
1997	H	36.4	36.4	36.4	36.4	18.2	18.2	9.0	9.0	11	11
1997	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1998	H	50.0	50.0	33.3	33.3	0.0	0.0	16.7	16.7	6	6
1998	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1999	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1999	W	81.2	80.0	6.3	6.7	0.0	0.0	12.5	13.3	16	15
2000	H	81.6	81.6	18.4	18.4	0.0	0.0	0.0	0.0	38	38
2000	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	3	3
2001	H	85.7	100.0	0.0	0.0	0.0	0.0	14.3	0.0	7	6
2001	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	8	8
2002	H	80.0	80.0	20.0	20.0	0.0	0.0	0.0	0.0	5	5

Table 3.4. Continued.

Return year	Origin	Below-low (<0.099)		Low (0.099 - 0.199)		Medium (0.200 - 0.449)		High (< 0.450)		Total number	
		Before	After	Before	After	Before	After	Before	After	Before	After
						Twisp spring Chinook					
2002	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2003	H	50.0	50.0	33.4	33.4	8.3	8.3	8.3	8.3	12	12
2003	W	60.0	60.0	20.0	20.0	0.0	0.0	20.0	20.0	5	5
2004	H	47.1	47.1	23.5	23.5	23.5	23.5	5.9	5.9	17	17
2004	W	80.0	80.0	20.0	20.0	0.0	0.0	0.0	0.0	20	20
2005	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2005	W	83.3	83.3	16.7	16.7	0.0	0.0	0.0	0.0	6	6
2006	H	80.0	80.0	13.3	13.3	0.0	0.0	6.7	6.7	15	15
2006	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2007	H	92.9	92.9	0.0	0.0	7.1	7.1	0.0	0.0	14	14
2007	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	3	3
2008	H	94.1	94.1	5.9	5.9	0.0	0.0	0.0	0.0	17	17
2008	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	8	6
2009	H	54.5	54.5	45.5	45.5	0.0	0.0	0.0	0.0	11	11
2009	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	6	6
2010	H	42.9	50.0	50.0	50.0	7.1	0.0	0.0	0.0	14	12
2010	W	90.9	90.9	9.1	9.1	0.0	0.0	0.0	0.0	11	11
2011	H	0.0	0.0	50.0	0.0	50.0	0.0	0.0	0.0	2	0
2011	W	80.0	100.0	0.0	0.0	20.0	0.0	0.0	0.0	5	4
2012	H	75.0	75.0	25.0	25.0	0.0	0.0	0.0	0.0	8	8
2012	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	6	6
2013	H	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	5	5
2013	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	4	4
2014	H	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	1	1
2014	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	11	11
Mean	H	59.6	60.4	25.5	25.5	5.0	5.0	10.0	9.1	11	11
Mean	W	81.0	82.4	13.0	10.5	5.4	1.5	0.6	0.6	9	9

3.2: Within-hatchery Monitoring

Juvenile Marking and Tagging

Juvenile Spring Chinook at Methow Hatchery are tagged with a CWT prior to release and broods prior to 2000 were also marked with an adipose fin-clip. The Methow Composite and Twisp programs have been marked with only a CWT for the 2000-2014 brood releases (Tables 3.5–3.6). Spring Chinook are acclimated on-station at Methow Hatchery (Methow-release Methow Composite stock) or transferred to the Twisp or Chewuch acclimation ponds prior to release

(Twisp releases of Twisp origin and Chewuch-release Methow Composite stocks). Additionally, in some years, fish have been released from Biddle's Pond (Wolf Creek; broods 2002, 2008, and 2009) and/or Mid-Valley Pond (Methow River; broods 2010, 2011, and 2012). Acclimation time averaged 28 days for the Chewuch River releases and 164 days for Methow Hatchery releases (Table 3.5). Twisp River releases have been acclimated for 28 days on average prior to release (Table 3.6).

For the 2014 brood, Twisp River releases achieved 121% of the release goal of 30,000 smolts specified in broodstock collection protocols (Tonseth 2014; Table 3.6). Releases into the Methow River achieved 118% of the release goal of 133,249 smolts specified for Methow Composite stock release in the broodstock collection protocols (Table 3.5). Brood year 2014 Chewuch River releases were conducted under a separate program operated by Chelan County PUD and achieved 119% of the release goal of 60,516 smolts specified in broodstock collection protocols.

Table 3.5. Pre-release tagging of spring Chinook by brood year released into the Methow and Chewuch rivers.

Brood	Release date	Days acclimated	CWT code (s)	Total released
			Chewuch River spring Chinook	
1992	18-Apr-94	3	634331, 634332, 634848, 634850, 635121, 635123, 635124, 635133, 635138, 635139, 635140	40,881
1993	17-Apr-95	18	634127, 635161 635350	284,165
1994	21-Apr-96	31	635132, 635415, 635416, 635863, 635903, 635905	11,854
1996	15-Apr-98	21	630233	91,672
1997	19-Apr-99	27	630614	132,759
1998	17-Apr-00	36	631024	435,670
2000	16-Apr-02	18	630776	266,392
2001	23-Apr-03	26	631384, 631440, 631494	261,284
2002	14-Apr-04	22	631976	254,238
2003	18-Apr-05	39	632566, 632569	127,614
2004	18-Apr-06	27	632899	204,906
2005	16-Apr-07	27	633294	232,811
2006	17-Apr-08	31	633884	154,381
2007	21-Apr-09	29	634294, 634471	126,055
2008	15-Apr-10	38	635099	260,344
2009	25-Apr-11	34	635076, 635078, 635491, 635492, 635494, 635495	149,863
2010	23-Apr-12	29	635197	88,788
2011	18-Apr-13	37	635664	93,372
2013	16-Apr-15	28	636707	60,860
2014	21-Apr-16	31	636761, 636757	71,768
			Methow River spring Chinook	
1993	15-Apr-95	227	635410, 635551	210,849

Table 3.5. Continued.

Brood	Release date	Days acclimated	CWT code (s)	Total released
			Methow River spring Chinook	
1994	22-Apr-96	29	635417	4,477
1995	15-Apr-97	350	636037, 636038, 636039, 636040, 636041, 636042, 636043	28,878
1996	15-Apr-98	300	630130, 630246, 630248, 636315	202,947
1997	15-Apr-99	300	630613	332,484
1999	17-Apr-01	171	630377, 630380	180,775
2001	21-Apr-03	82	630976, 631179, 631477	130,887
2002	14-Apr-04	42	631524, 631891	181,235
2003	18-Apr-05	169	632568	48,831
2004	18-Apr-06	169	631187, 632694 (subyearling release)	107,398
2005	16-Apr-07	153	633281, 633395	156,633
2006	16-Apr-08	168	633866	211,717
2007	21-Apr-09	152	634293, 634674	119,407
2008	15-Apr-10	137	634866	201,290
2009	18-Apr-11	139	635077, 635079, 635080, 635299, 635493, 635496, 635497, 635499	347,993
2010	23-Apr-12	146	635687, 636064, 636065, 636066, 636067, 636068	339,540
2011	15-Apr-13	135	636409, 636410, 636411, 636412, 636413, 636414, 636415	396,085
2012	15-Apr-14	139	636284	196,188
2013	15-Apr-15	136	636606, 636640, 636623	161,145
2014	18-Apr-16	139	636773, 636759, 636687	157,206

Table 3.6. Pre-release tagging of spring Chinook by brood year released into the Twisp River.

Brood	Release date	Days acclimated	CWT code (s)	Total released
1992	15-Apr-94	3	634849, 634851, 635122, 635125, 635134, 635135, 635136, 635137, 635141	35,853
1993	17-Apr-95	20	635329, 635609	116,749
1994	21-Apr-96	36	634515, 635418, 635419, 635420	19,835
1996	15-Apr-98	26	636114, 636316, 636317	76,687
1997	15-Apr-99	30	630434	26,714
1998	17-Apr-00	36	631041	15,470
1999	17-Apr-01	36	630378, 630379, 630381	67,408
2000	23-Apr-02	0	630182, 630994	75,704
2001	21-Apr-03	27	631068, 631478	57,471
2002	13-Apr-04	27	631076, 631077, 631582, 631694, 631695	58,074
2003	18-Apr-05	35	632499, 632564, 632567, 632565	136,998
2004	22-Apr-06	28	631508 (subyearling release), 632878, 632988	100,260
2005	16-Apr-07	34	633483	27,658
2006	21-Apr-08	41	633687, 634068	45,892

Table 3.6. Continued.

Brood	Release date	Days acclimated	CWT code (s)	Total released
2007	25-Apr-09	10	634673, 634675	54,096
2008	15-Apr-10	43	635085	78,656
2009	25-Apr-11	36	635498, 635506, 635509	67,031
2010	23-Apr-12	35	635584	81,380
2011	18-Apr-13	35	636179	18,190
2012	22-Apr-14	31	636464	48,924
2013	15-Apr-15	37	636613	31,333
2014	15-Apr-16	31	636688	36,316

Juvenile Size and Condition at Release

Size-at-release fork length and weight targets for DCPUD program fish are described in Murdoch et al. (2012). Releases into the Methow, Twisp, and Chewuch rivers attained 95%, 97%, and 98% respectively, of the target fork lengths prior to release (Table 3.7). Coefficient of variation (CV) in length for 2014 brood releases was slightly above the target value of nine for Twisp releases (9.9), but below nine for Methow (8.8) and Chewuch (7.5) releases.

Table 3.7. Pre-release mean fork length (mm), weight (g), coefficient of variation (CV), standard deviation (SD), and condition factor (K) of Methow Hatchery spring Chinook.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
Chewuch River spring Chinook								
1992	141.8	- -	- -	30.0	- -	- -	15.1	1.05
1993	134.5	- -	- -	27.7	- -	- -	16.4	1.14
1994	145.7	- -	- -	35.7	- -	- -	12.7	1.15
1996	129.8	- -	- -	22.7	- -	- -	20.0	1.04
1997	132.7	- -	- -	27.9	- -	- -	16.2	1.19
1998	127.9	8.7	6.8	24.6	5.0	20.3	18.4	1.18
2000	131.3	6.8	5.2	26.8	4.8	17.9	16.9	1.18
2001	133.8	6.7	5.0	30.2	- -	- -	15.0	1.26
2002	142.5	16.1	11.3	35.0	13.2	37.7	12.9	1.21
2003	131.0	11.7	8.9	27.6	7.9	28.6	16.4	1.23
2004	144.1	20.8	14.4	42.4	21.0	49.5	10.7	1.42
2005	126.0	15.3	12.1	24.7	10.2	41.3	18.0	1.23
2006	115.7	10.9	9.4	19.2	6.2	32.3	23.7	1.24
2007	145.5	29.0	19.9	43.3	28.8	66.5	10.4	1.41
2008	133.7	17.1	12.8	30.2	12.1	40.1	14.9	1.26
2009	135.4	19.6	14.5	30.8	14.3	46.4	14.7	1.24

Table 3.7. Continued.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
Chewuch River spring Chinook								
2010	126.2	12.6	10.0	25.2	8.6	34.1	18.0	1.25
2011	130.6	12.8	9.8	26.0	9.0	34.6	17.5	1.17
2013	133.2	7.8	5.8	28.0	5.5	19.7	16.2	1.18
2014	133.9	10.1	7.51	27.3	6.9	25.2	16.6	1.14
Target	136.0	- -	9.0	30.3	- -	- -	15.0	1.20
Methow River spring Chinook								
1993	134.8	- -	- -	28.5	- -	- -	15.9	1.16
1994	132.0	- -	- -	31.2	- -	- -	14.5	1.36
1995	134.9	- -	- -	32.2	- -	- -	14.1	1.31
1996	128.2	- -	- -	25.0	- -	- -	18.1	1.19
1997	126.5	- -	- -	24.7	- -	- -	18.3	1.22
1998	133.9	6.7	5.0	28.3	5.6	19.8	16.0	1.18
1999	151.0	14.3	9.5	40.9	13.1	32.0	11.0	1.19
2000	131.3	6.8	5.2	26.8	4.8	17.9	16.9	1.18
2001	132.8	- -	- -	28.4	- -	- -	16.0	1.21
2002	132.5	12.5	9.4	28.7	8.1	28.2	15.8	1.23
2003	135.0	10.9	8.1	28.4	6.5	22.9	16.0	1.15
2004	137.3	7.3	5.3	32.1	5.7	17.8	14.1	1.24
2005	130.8	13.9	10.6	27.4	9.3	33.9	17.0	1.22
2006	127.6	15.8	12.4	25.3	12.0	47.4	17.9	1.22
2007	130.8	14.0	10.7	27.0	9.3	34.4	16.8	1.21
2008	125.9	12.2	9.7	24.0	7.0	29.2	18.9	1.20
2009	124.2	16.0	12.9	22.9	7.1	31.0	19.8	1.20
2010	128.8	13.8	10.7	26.9	8.7	32.3	16.9	1.26
2011	142.8	16.1	11.3	33.6	13.8	41.1	14.4	1.15
2012	132.2	11.0	8.3	27.2	8.6	31.6	17.1	1.18
2013	141.1	12.5	8.9	33.6	9.5	28.4	13.5	1.19
2014	130.7	11.5	8.8	26.8	8.1	30.4	17.0	1.20
Target	137.0	- -	9.0	30.3	- -	- -	15.0	1.18
Twisp River spring Chinook								
1992	135.0	- -	- -	30.0	- -	- -	15.1	1.22
1993	132.9	- -	- -	29.8	- -	- -	15.2	1.27
1994	138.5	- -	- -	31.4	- -	- -	14.4	1.18
1996	137.2	- -	- -	30.7	- -	- -	14.8	1.19
1997	133.4	- -	- -	28.2	- -	- -	16.1	1.19
1998	138.0	10.6	7.7	30.3	7.6	25.1	15.0	1.15
1999	155.9	15.5	9.9	47.7	15.7	32.9	9.5	1.26
2000	133.4	6.8	5.1	27.2	- -	- -	16.7	1.15
2001	122.5	10.0	8.2	21.6	- -	- -	21.0	1.18
2002	135.9	9.6	7.1	30.3	7.2	23.8	15.0	1.21
2003	132.8	11.1	8.4	28.2	7.9	28.0	16.1	1.20
2004	130.2	14.6	11.2	27.9	12.0	43.0	16.2	1.26
2005	139.0	10.0	7.2	33.9	7.8	23.0	13.0	1.26
2006	134.0	11.1	8.3	29.6	8.3	28.0	15.3	1.23
2007	127.5	13.6	10.7	24.9	9.3	37.3	18.2	1.20
2008	128.7	11.8	9.2	26.8	7.8	29.1	16.8	1.26

Table 3.7. Continued.

Brood	Fork length (mm) Mean	SD	CV	Weight (g) Mean	SD	CV	FPP	K
Twisp River spring Chinook								
2009	144.6	16.0	11.1	37.2	12.0	32.3	12.2	1.23
2010	130.4	17.3	13.3	27.7	12.5	45.1	16.4	1.25
2011	135.6	8.7	6.4	31.1	6.8	21.9	14.6	1.25
2012	135.5	11.7	8.6	29.3	8.1	27.7	15.5	1.18
2013	137.6	7.5	5.5	31.2	5.5	17.7	14.5	1.20
2014	131.1	12.9	9.9	26.7	9.8	36.5	17.0	1.18
Target	135.0	- -	9.0	30.2	- -	- -	15.0	1.23

Survival Estimates

In-hatchery survival of Methow Composite and Twisp program fish from the 2014 brood exceeded target values (Wells HCP HC 2005; Table 3.8). Overall (all-year average) mean survival in most categories was also above target values (Table 3.8).

Table 3.8. Survival (%) of Methow Hatchery spring Chinook by brood and survival category.

Brood	Collection to spawning Female	Collection to spawning Male	Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
Methow Composite spring Chinook									
1999	96.0	96.3	97.4	100.0	99.5	99.5	99.2	N/A	92.5
2000	96.2	97.2	96.5	100.0	99.6	99.4	99.0	99.9	92.7
2001	98.9	97.3	96.1	100.0	99.3	99.1	97.0	99.8	90.8
2002	97.7	95.1	93.6	100.0	98.6	98.6	96.5	98.5	92.7
2003	96.3	97.2	90.0	100.0	98.8	98.3	93.0	99.8	77.9
2004	97.7	99.2	94.8	96.2	99.2	99.1	96.1	99.8	84.2
2005	99.0	99.1	96.1	100.0	99.6	99.5	90.4	99.6	87.7
2006	96.8	95.1	94.8	100.0	97.2	97.0	83.0	96.2	77.6
2007	98.6	98.8	92.9	96.0	98.8	98.2	94.5	99.1	84.2
2008	97.6	100.0	95.9	99.7	99.6	97.7	90.2	99.8	84.8
2009	100.0	99.2	95.9	100.0	99.5	99.4	96.8	99.9	92.5
2010	98.6	96.5	92.6	99.9	98.6	98.4	98.0	99.9	90.6
2011	100.0	96.3	93.5	93.6	100.0	99.9	99.5	99.4	87.0
2012	98.8	98.6	95.3	100.0	99.6	99.5	95.4	68.7	91.0
2013	100.0	100.0	95.4	99.6	98.9	98.8	98.2	99.8	93.3
2014	100.0	97.9	98.3	100.0	99.6	99.2	96.2	99.6	94.5
Mean	98.3	97.7	94.9	99.1	99.2	98.9	95.2	97.3	88.4

Table 3.8. Continued.

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
Methow Composite spring Chinook									
Target	90.0	85.0	92.0	98.0	97.0	93.0	90.0	95.0	81.0
Twisp spring Chinook									
1999	100.0	95.7	94.3	100.0	99.2	99.0	98.0	99.7	92.3
2000	96.4	92.9	97.1	100.0	99.6	99.5	47.3	23.9	46.0
2001	93.8	88.2	91.1	100.0	99.0	95.7	90.1	100.0	81.2
2002	100.0	66.7	97.9	100.0	99.3	99.1	98.5	99.9	96.4
2003	100.0	88.2	91.8	99.8	98.8	98.5	95.9	100.0	86.4
2004	97.4	87.9	95.5	97.8	99.1	98.8	78.7	99.5	73.3
2005	100.0	100.0	95.7	98.2	99.6	99.5	99.2	99.9	93.2
2006	85.7	100.0	95.9	100.0	99.6	99.3	94.2	99.7	90.4
2007	100.0	100.0	92.4	96.0	99.4	98.4	88.6	99.7	78.6
2008	96.3	100.0	90.1	99.5	99.9	99.5	96.3	99.9	86.5
2009	100.0	100.0	97.3	99.9	99.8	98.7	97.6	99.6	94.9
2010	96.3	90.0	88.0	99.9	98.9	98.6	98.0	99.9	86.2
2011	77.8	100.0	97.3	100.0	99.2	99.1	98.4	99.9	95.7
2012	93.8	100.0	91.8	100.0	99.5	99.1	98.1	99.9	90.1
2013	100.0	100.0	95.3	99.7	99.0	98.9	98.5	99.9	93.6
2014	100.0	100.0	91.7	100.0	99.5	99.4	99.0	99.9	90.9
Mean	96.1	94.4	94.0	99.4	99.3	98.8	92.3	95.1	86.0
Target	90.0	85.0	92.0	98.0	97.0	93.0	90.0	95.0	81.0

3.3 Natural Origin Juvenile Productivity

Smolt trapping was conducted in 2016 in the Methow and Twisp Rivers to estimate the productivity (smolts per redd) of spring Chinook spawning in the Methow and Twisp river basins. Because juvenile Chinook emigrate as age-0 fall parr and as age-1 spring smolts, productivity estimates are the result of combining trapping effort from two years to complete estimates for each brood. Spring Chinook fry that emigrate during the spring past the Twisp and Methow smolt traps are not included in spring Chinook production estimates at those sites, thus their contribution to overall juvenile production is unknown (Attachment A).

Emigrant and Smolt Estimates

Methow Trap

Trapping at the Methow River trap site (rkm 30) occurred between 19 February and 5 December 2016 using smolt traps with a 1.5 m or 2.4 m cone diameter. These traps were operated in two different trapping positions depending on the river discharge at the site. Trapping at the Methow site was interrupted on two occasions for a total of three days because of high flow and debris. Spring Chinook production estimates were based on daily capture of wild Chinook emigrants, expanded by the estimated trap efficiency derived from a trap efficiency/flow model developed for each trap configuration (Attachment A). Juvenile Chinook captured during the spring of each year as yearling emigrants were assumed to be spring Chinook. Juvenile Chinook captured in the fall of each year have recently been identified to species (spring vs. summer Chinook) using DNA analysis. With the results of this analysis, captured Chinook parr were classified as either spring or summer Chinook.

We captured 487 wild yearling spring Chinook emigrants between 19 February and 30 June at the Methow River trapping location, with peak capture on 1 April (N = 56). Overall mortality of wild Chinook captured totaled three of the 487 fish captured (0.62%). We PIT tagged 476 of the wild Chinook emigrants and released 471 after subtracting shed tags and mortalities. We also captured 3,339 hatchery Chinook at the Methow River trap, which included spring and summer races. Overall mortality of the hatchery Chinook captured totaled 74 fish (2.2%).

We captured 179 emigrant Chinook parr between 1 October and 5 December with peak capture occurring on 2 November (N = 51). We DNA sampled 174 of the Chinook captured and conducted genetic analysis on 100 of these samples. One sample failed to amplify, of the remainder, 96 (97.0%) were confirmed to be spring Chinook and 3 (3.0%) were summer Chinook. We inserted PIT tags into 174 of the Chinook parr captured and released 173 parr after subtracting a single mortality.

No mark/recapture trials were conducted with Chinook smolts for the low position in the spring at the Methow trap because high discharge enabled the trap to operate in the upper position for most of the spring trapping season. Previous mark/recapture trials in the low position from previous years resulted in a significant relationship ($P < 0.01$; $r^2 = 0.52$), and we used the regression parameters ($y = -2.57E-05x+0.161723324$) to determine estimates for the low trapping position in 2016. For the upper trapping position, we were able to conduct two mark/recapture trials with hatchery Chinook, and one trial with wild Chinook. Adding these groups to the previous years' model resulted in a significant relationship ($P< 0.01$, $r^2 = 0.75$; Table 4) and the regression parameters ($y = -2.52E-05x + 0.270693602$) were used for this position in 2016 to determine estimates. Using both these flow models, the estimated number of yearling spring Chinook emigrants was 35,330 (± 5,169, 95% CI). When combined with the estimate of parr that emigrated past the trap in 2015 (34,402 ± 180,061 95% CI), we estimated that 69,732 (± 180,135 95% CI) 2014 brood wild spring Chinook migrated from the Methow River basin between 1 October 2015 and 30 June 2016 (Figure 3.1; Table 3.9). We did not attempt to estimate the contribution of spring Chinook fry that passed the Methow trap during the spring to basin-wide juvenile production.

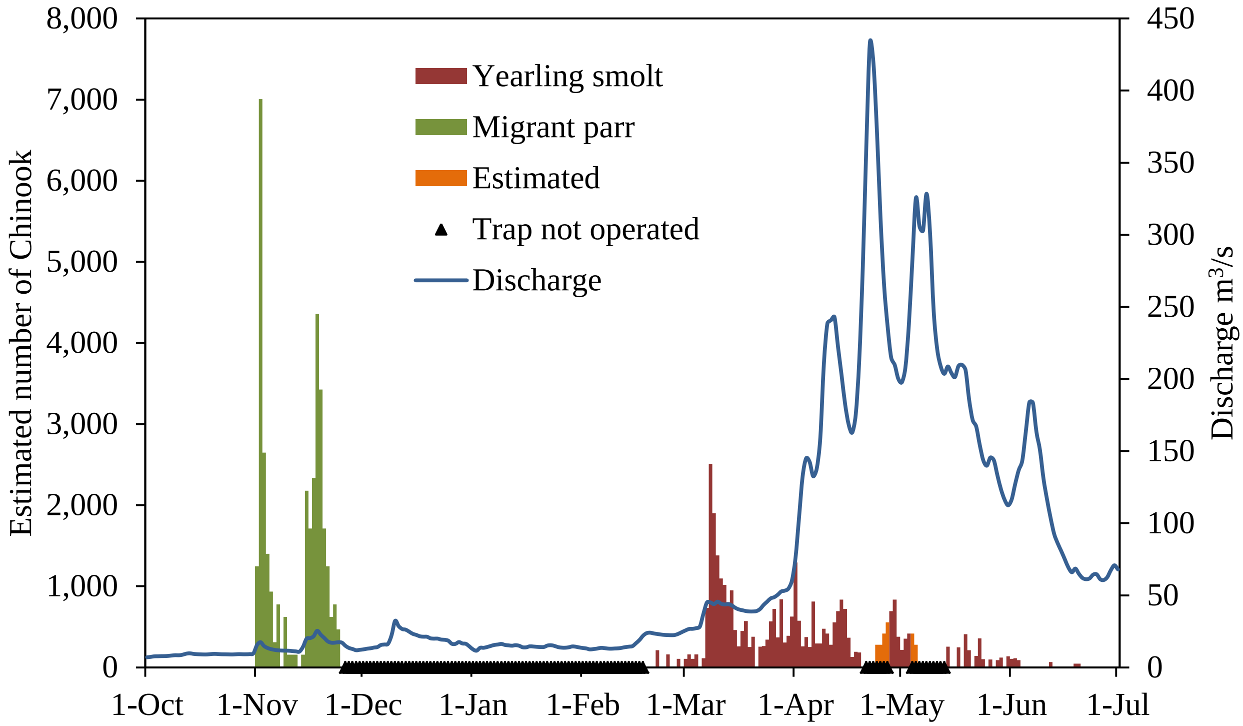

Figure 3.1. Daily emigration of 2014 brood spring Chinook from the Methow River by life stage.

Twisp Trap

Trapping at the Twisp River trap site (rkm 2) occurred between 19 February and 5 December 2016 using a rotary screw smolt trap with a 1.5 m cone diameter. Trapping at the Twisp site was interrupted on three occasions for a total of 35 days in 2016 because of high flow and debris. We captured 403 wild yearling spring Chinook emigrants at the Twisp trap between 27 February and 30 June. Peak capture occurred on 2 April (*N* = 36; Figure 3.2). We PIT tagged 397 wild yearling emigrants and no mortalities or shed tags were recorded. Overall mortality of wild yearling Chinook totaled one of the 403 fish captured (0.25%). We also captured 2,177 hatchery spring Chinook and no mortality of these fish was recorded.

We captured 1,277 subyearling spring Chinook between 27 February and 5 December at the Twisp trap with peak capture occurring on 21 October (*N* = 84). Although most subyearling Chinook were too small for PIT tagging, we implanted 612 PIT tags into Chinook parr and no mortalities occurred although one shed tag was detected (Attachment A). Overall, four mortalities of subyearling Chinook occurred (0.31%).

Two mark/recapture trials were conducted with hatchery spring Chinook smolts at the Twisp trap in the spring of 2016, but they could not be combined with historical groups to produce a significant relationship. However, a significant efficiency discharge relationship existed from release groups conducted during previous seasons ($P < 0.01$, $r^2 = 0.64$). Using the flow model regression parameters ($y = -0.00056877x + 0.529960351$) derived from these trials, we estimated that 6,519 (± 1,561, 95% CI) smolts emigrated from the Twisp River between 27 February and 30 June 2016. One redd was identified downstream of the Twisp trap in 2014 producing an estimated 48 migrants resulting in a total production estimate of 6,567 (± 1,566, 95% CI) yearling Chinook smolts. An estimated 18,290 (± 4,747, 95% CI) 2014 brood spring Chinook parr emigrated from the Twisp River in the fall of 2015 (Attachment A). In addition to the smolt trap estimates, mark/detection trials performed at the Twisp PIT tag array were used to estimate that 3,443 (± 1,272, 95% CI) spring Chinook emigrated between 21 November 2015 and 26 February 2016 when the smolt trap was not operating. Adding an estimated 153 migrants from one redd below the trap resulted in a total estimate of 28,325 (± 5,167, 95% CI) 2014 brood spring Chinook emigrants.

A single mark/recapture trial was conducted at the Twisp trap site in the fall of 2016. Combining this group with trials conducted in 2014 and 2015 showed that trap efficiency was significantly related to discharge ($P < 0.01$, $r^2 = 0.57$), and the flow model regression parameters ($y = 0.000908708x + 0.119169681$) were used to estimate that 13,831 (± 3,198, 95% CI) 2015 brood spring Chinook salmon parr emigrated past the Twisp trap between 1 July and 5 December 2016. In addition, there were no Chinook redds observed below the Twisp trap site in 2015, so no expansion to account for migrants originating from downstream of the trap was necessary.

Table 3.9. Estimated emigrant-per-redd and egg-to-emigrant survival for Methow Basin spring Chinook. Methow Basin and Twisp River estimates are for redds deposited upstream and downstream of the respective trap sites, and include redds that dewatered. Rows identified with an asterisk include an estimate of over-winter emigration derived from a PIT tag array and added to the total number of emigrants. DNOT = Did not operate trap.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants			Egg to emigrant (%)	Emigrants per redd
				Age-0	Age-1	Total		
Twisp	2003	18	81,395	DNOT	900	900	1.1	50
Twisp	2004	139	510,220	1,219	5,224	6,443	1.3	46
Twisp	2005	55	237,729	3,245	3,329	6,574	2.8	120
Twisp	2006	87	298,074	1,531	16,415	17,946	6	206
Twisp	2007	30	128,182	4,181	5,547	9,728	7.6	324
Twisp	2008	79	268,771	7,139	4,793	11,932	4.4	151
Twisp	2009	24	100,694	3,282	1,842	5,124	5.1	214
Twisp*	2010	145	568,266	4,874	3,917	9,682	1.7	67
Twisp*	2011	63	269,855	6,431	3,617	12,759	4.7	203
Twisp*	2012	139	466,182	3,953	6,043	13,690	2.9	98

Twisp*	2013	85	281,719	16,314	6,373	26,025	9.2	306
Twisp*	2014	138	490,824	18,290	6,567	28,325	5.8	205
Twisp	2015	119	524,425	13,831	--	13,831	--	--
Twisp	Mean 2003-2014	84	308,493	6,405	5,381	12,427	4.4	166
Methow	2002	1,192	4,578,109	DNOT	28,099	28,099	0.6	24
Methow	2003	474	2,215,494	8,170	15,306	23,476	1.1	50
Methow	2004	543	1,926,603	DNOT	15,869	15,869	0.8	29
Methow	2005	566	2,060,259	17,490	33,710	51,200	2.5	90
Methow	2006	929	3,375,219	2,913	28,857	31,770	0.9	34
Methow	2007	308	1,240,129	4,083	5,163	9,246	0.7	30
Methow	2008	477	1,724,592	2,948	9,302	12,250	0.7	26
Methow	2009	490	1,944,428	1,602	29,610	31,212	1.6	64
Methow	2010	1,366	5,284,533	8,979	51,325	60,304	1.1	44
Methow	2011	760	3,032,862	8,422	27,637	36,059	1.2	47
Methow	2012	895	3,065,992	9,575	38,648	48,223	1.6	54
Methow	2013	592	2,076,279	20,493	15,749	36,242	1.7	61
Methow	2014	1,140	4,211,530	34,402	35,330	69,732	1.7	61
Methow	2015	979	3,867,031	5,847	--	5,847	--	--
Methow	Mean 2003-2014	749	2,825,848	10,825	25,739	34,899	1.2	47

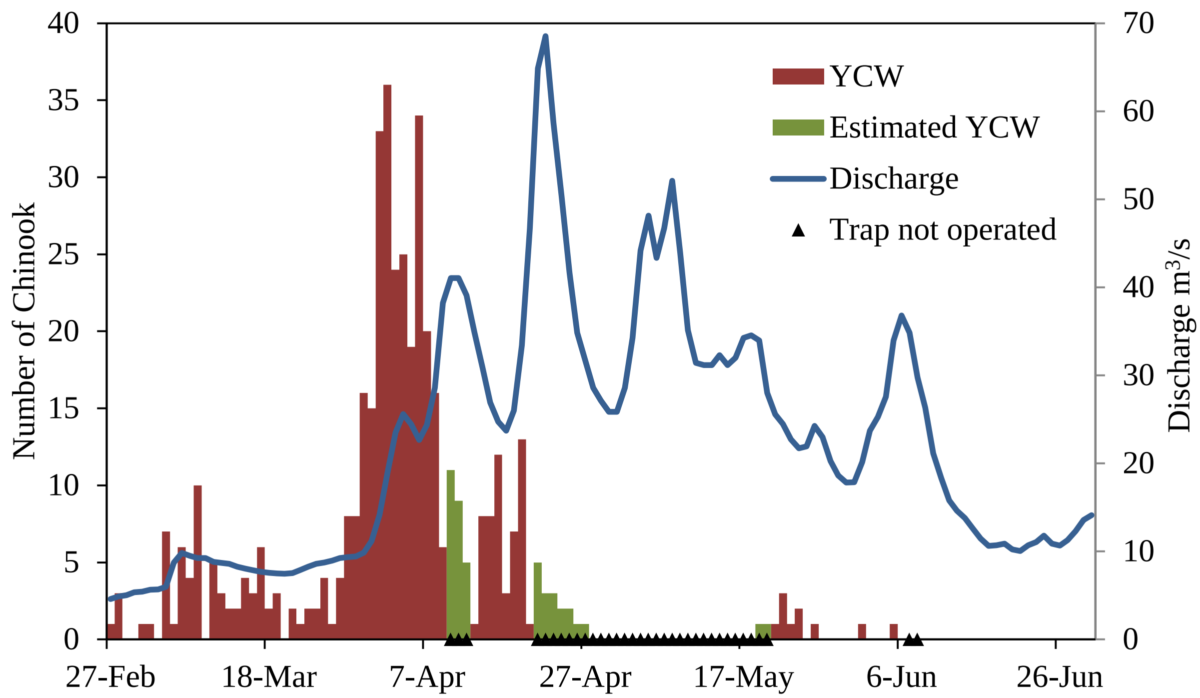

Figure 3.2. Daily emigration of 2014 brood yearling spring Chinook (YCW) from the Twisp River in 2016.

PIT Tagging and Survival

Most wild juvenile Chinook captured at the Methow and Twisp smolt traps that were in good physical condition and had a fork length greater than 65 mm were PIT tagged prior to release. Within each release year, the number of PIT tagged spring emigrants released from each trap site was used to evaluate smolt to adult survival (SAR) of smolts leaving the Methow and Twisp river basins each spring. Adult detections of PIT tagged fish at Bonneville Dam were summed and divided by the number of juvenile salmonids tagged and released at the Methow and Twisp smolt traps to determine smolt to adult survival rates. In some cases, survival to Bonneville was inferred from PIT tag detections at upriver dams (i.e., a fish passed Bonneville without being detected). Mean SAR for wild Twisp and Methow spring Chinook smolts was 0.54% and 0.64%, respectively for the 2003-2011 broods (Table 3.10). However, sample sizes for some release years and trap sites were likely too low to produce accurate estimates.

Table 3.10. Smolt to adult returns (SAR) by age at return for PIT tagged wild yearling spring Chinook smolts tagged and released from the Twisp and Methow smolt traps.

Brood	Release year	Release *N*	Age at return (*N*) to Bonneville Dam			Total	SAR %
			Age-3	Age-4	Age-5		
			Twisp trap				
2003	2005	110	0	0	0	0	0.00
2004	2006	818	0	1	0	1	0.12
2005	2007	271	0	1	0	1	0.37
2006	2008	2,494	5	18	8	31	1.24
2007	2009	630	0	9	0	9	1.43
2008	2010	953	1	4	1	6	0.63
2009	2011	304	0	1	0	1	0.33
2010	2012	606	1	1	1	3	0.50
2011	2013	435	0	1	0	1	0.23
2012	2014	664	0	2	--	2	0.30
2013	2015	434	0	--	--	0	0.00
2003-2011 brood mean							0.54
			Methow trap				
2003	2005	301	0	1	0	1	0.33
2004	2006	489	1	2	0	3	0.61
2005	2007	379	0	4	0	4	1.06
2006	2008	633	2	7	2	11	1.74
2007	2009	111	0	2	0	2	1.80
2008	2010	208	0	0	0	0	0.00
2009	2011	338	0	0	0	0	0.00
2010	2012	674	1	1	0	2	0.30
2011	2013	763	1	1	0	2	0.26

2012	2014	883	0	2	--	2	0.23
2013	2015	441	0	--	--	0	0.00
2003-2011 brood mean							0.68

In-stream PIT Tagging

Some natural origin juvenile spring Chinook were PIT tagged in each major subbasin in 2016 (Attachment B) to estimate population size, evaluate life-stage specific survival rates and estimate stray rates. Because natural origin juvenile spring Chinook rear for a single year prior to emigration, parr to smolt survival rates could be calculated for some of the parr tagged between 2010-2015 (Table 3.11). Cormack-Jolly-Seber (CJS) survival estimates were obtained from the Data Access Real Time (DART) website maintained by the University of Washington's School of Aquatic and Fishery Sciences. Survival estimates for parr tagged in the Methow, Twisp, and Chewuch rivers ranged from 8% to 52% over the five years (2011-2015 tag years) for which emigration is complete (Table 3.11). Standard error (SE) values generated for individual estimates of some groups were high however, indicating that tag rates or capture probability was not high enough for some locations and years.

Table 3.11. In-stream PIT tagging and recovery at Rocky Reach Dam juvenile bypass (RRJ) detector of natural origin juvenile spring Chinook parr from the Methow, Twisp, and Chewuch rivers. Cormack-Jolly-Seber (CJS) survival estimates with standard error (SE) and probability of survival were obtained from the Data Access Real Time website (DART) maintained by the University of Washington's School of Aquatic and Fishery Sciences.

Tag year	Parr tagged	Recovered at RRJ		CJS estimate from DART	
		Age-1 smolt	%	Probability of survival	SE
			Twisp River		
2010	141	7	4.9	0.25	0.21
2011	1,059	23	2.2	0.52	0.27
2012	983	26	2.6	0.15	0.03
2013	1,103	43	3.9	0.23	0.05
2014	924	42	4.5	0.15	0.04
2015	1,120	41	3.7	0.16	0.03
2016	517	--	--	--	--
Mean 2010-2015		30.3	3.6	0.24	0.11
			Methow River		
2010	26	1	3.8	0.08	0.06
2011	292	10	3.4	0.09	0.03
2012	633	11	1.7	0.37	0.23
2013	1,717	93	5.4	0.23	0.03

2014	62	1	1.6	--	--
2015	51	2	3.9	0.08	0.05
2016	400	--	--	--	--
Mean 2010-2015		19.7	3.3	0.17	0.08
			Chewuch River		
2010	5	0	0.0	--	--
2011	517	12	2.3	0.26	0.12
2012	771	18	2.3	0.24	0.10
2013	1,610	67	4.2	0.26	0.05
2014	3,040	143	4.7	0.19	0.03
2015	0	--	--	--	--
2016	178	--	--	--	--
Mean 2011-2015		48	2.7	0.24	0.08

3.4 Spawning Ground Surveys

Spring Chinook spawning ground surveys were conducted in the Methow River basin between 2 August and 29 September 2016 (Attachment C). Surveys are intended to provide total redd counts within the Methow, Twisp, and Chewuch watersheds. Biological and geospatial information recovered from sampled carcasses provides the data necessary to evaluate spawning distribution and timing of hatchery and natural origin Chinook.

Redd Counts

A total of 361 spring Chinook redds were constructed in the Methow Basin in 2016, lower than the overall mean number of redds found in the 2003-2015 spawning years (Table 3.12). Redd counts in most individual spawning areas were lower than the overall mean totals except for the WNFH outfall (Table 3.12). Within the 2016 spawning year, most redds were found in the Methow River and tributaries (64.0%). The Chewuch and Twisp rivers accounted for 23.3% and 12.7% of Methow Basin redds, respectively.

Table 3.12. Spring Chinook redd count totals by spawning area and year in the Methow River Basin. Surveys were conducted in the primary tributaries, and in the Methow Hatchery (MH) and Winthrop National Fish Hatchery (WNFH) outlet channels.

Year	Methow R.	Early Winters Cr.	MH outfall	WNFH outfall	Lost R.	Twisp R.	Chewuch R.	Total
2003	223	4	13	11	1	18	204	474
2004	245	10	9	8	15	139	117	543

2005	266	2	8	5	13	55	217	566
2006	431	14	75	21	28	87	273	929
2007	175	3	7	3	11	30	79	308
2008	229	2	10	25	12	79	120	477
2009	269	10	14	17	13	24	143	490
2010	782	31	50	55	17	145	286	1,366
2011	372	3	38	44	15	63	225	760
2012	414	5	55	33	13	139	236	895
2013	261	4	33	10	28	85	171	592
2014	570	7	79	81	26	138	239	1,140
2015	556	10	19	39	30	119	206	979
2016	186	5	2	29	9	46	84	361
Mean	356	8	29	27	17	83	186	706

Redd Distribution

The greatest number of spring Chinook redds within the Methow River basin were found in reach M9 of the Methow River, a nine km reach downstream of Weeman Bridge (*N* = 75; Table 3.13). This section typically has the highest annual redd count within the basin (Attachment C). Spawning in the Twisp River was primarily in section T7 (32.6%) and in section C2 of the Chewuch River (29.2%). Spawning was observed in Methow River tributaries (e.g., Early Winters Creek, Lost River), but no spawning tributaries have been identified in the Chewuch or Twisp river watersheds (Table 3.13).

Table 3.13. Spawning distribution (redd counts) and proportion of redds within primary tributaries and reaches of the Methow Basin in 2016.

Methow				Twisp				Chewuch			
Reach	Redds	Redds/ km	% within basin	Reach	Redds	Redds/ km	% within basin	Reach	Redds	Redds/ km	% within basin
M15	2	0.5	0.9	T10	0	0	0.0	C13	0	0	0.0
M14	16	3.3	6.9	T9	0	0	0.0	C12	5	1.1	6.0
M13	5	1.2	2.2	T8	0	0	0.0	C11	1	0.2	1.2
M12	5	1.6	2.2	T7	15	2.2	32.6	C10	3	0.8	3.6
M11	17	4.3	7.3	T6	14	1.9	30.4	C9	0	0	0.0
M10	25	4.8	10.8	T5	14	2.4	30.4	C8	6	2.5	7.1
M9	75	8.3	32.4	T4	0	0	0.0	C7	9	1.8	10.7
M8	2	0.9	0.9	T3	3	0.8	6.6	C6	14	2.5	16.6

M7	16	8.9	6.9	T2	0	0	0.0	C5	9	2.4	10.7
M6	15	5.6	6.5	T1	0	0	0.0	C4	12	3.2	14.3
M5,4	1	0.1	0.4					C3	2	1.1	2.4
Lost R.	9	1.4	3.9					C2	22	2.9	26.2
Early Winters Cr.	5	0.7	2.2					C1	1	0.2	1.2
Hatchery outfalls	31	39	13.5								
Other tributaries	7	0.8	3.0								
Total	231	2.9			46	1.0			84	1.5	

Spawn Timing

Fish were actively spawning in all three subbasins by the week starting on 14 August, and peak redd counts occurred earlier in the Methow subbasin than the Chewuch and Twisp subbasins (Table 3.14; Figure 3.3). Spawning in all subbasins was completed by late-September (Attachment C).

Table 3.14. Redd counts by subbasin and week starting date for spring Chinook spawning in the Methow, Twisp, and Chewuch subbasins in 2016.

Subbasin	Week starting date (Sunday)									Total
	31-Jul	7-Aug	14-Aug	21-Aug	28-Aug	3-Sep	11-Sep	18-Sep	25-Sep	
Chewuch	0	0	5	10	17	36	15	1	0	84
Methow	0	4	42	68	71	35	9	2	0	231
Twisp	0	0	10	11	9	12	4	0	0	46

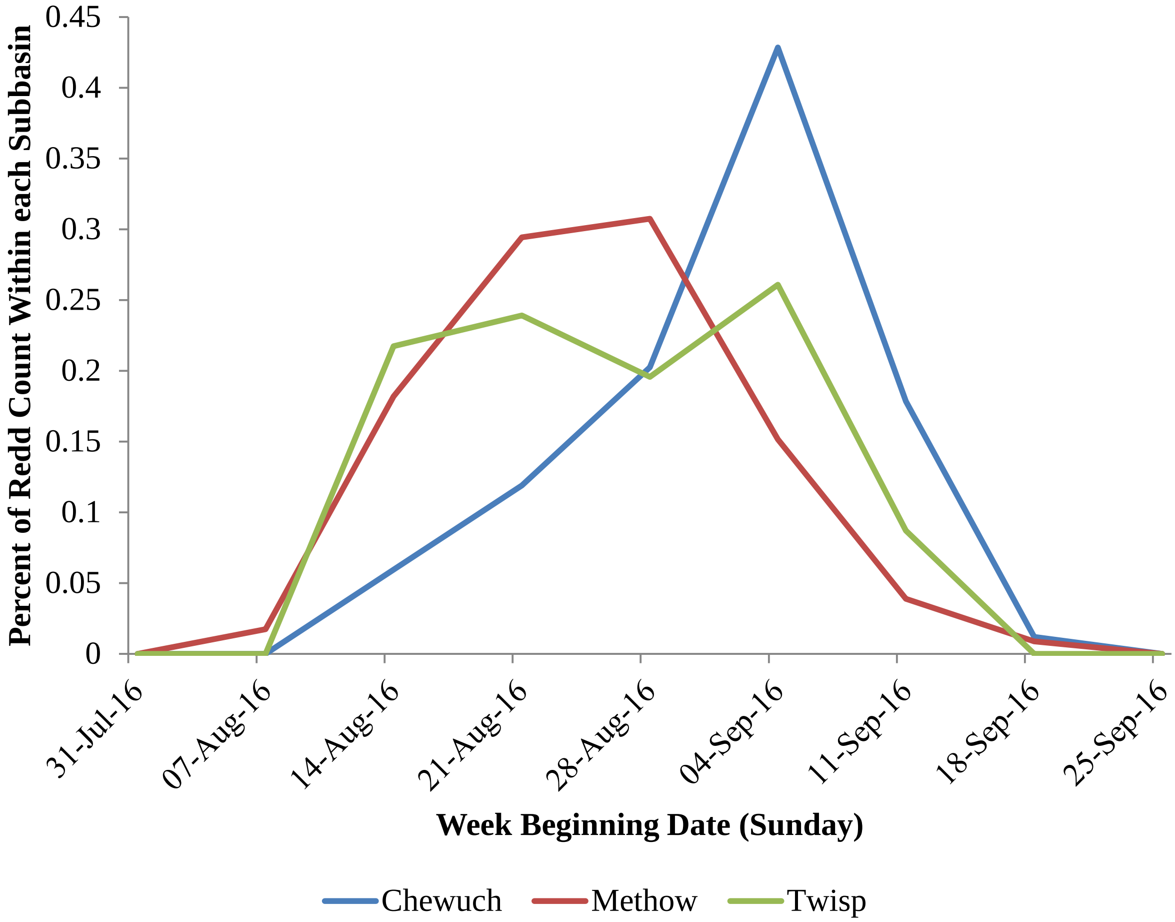

Figure 3.3. Percent of completed spring Chinook redds by subbasin and week of detection in 2016.

Spawning Escapement

Spawning escapement values were derived by expanding redd counts by a fish-per-redd (FPR) value calculated from sampling the overall spring Chinook run at Wells Dam for origin, sex, and age composition. Based on the 2016 FPR value (1.93) there were an estimated 697 spawners in the Methow River basin in 2016, of which 320 (45.9%) were estimated to be wild (NOR) fish (Table 3.15). Estimated spawning escapement does not include hatchery or wild fish collected for broodstock. Wild fish comprised 62.3%, 67.4%, and 35.7% of the estimated spawning escapement in the Chewuch, Twisp, and Methow subbasins, respectively (Attachment C).

Table 3.15. Estimated spawning escapement by stream in the Methow River Basin in 2016.

Survey stream	Redds	Estimated spawning escapement		
		H	W	Total
Chewuch River	84	61	101	162
Early Winters Creek	5	8	2	10
Hancock Creek	1	1	1	2
Lost River	9	0	17	17
Methow River	179	207	139	346
MH outfall	2	4	0	4
Suspension Creek	6	11	0	11
Twisp River	46	29	60	89
WNFH outfall	29	56	0	56
Wolf Creek	0	0	0	0
Total	361	377	320	697

Carcass Sampling and Distribution

In general, all salmon carcasses encountered during spawning ground surveys were sampled for sex, age, origin, egg retention, hatchery marks and tags, and their location was recorded using hand-held GPS devices. Most carcasses recovered in the Methow river basin were hatchery origin fish, while most carcasses recovered in the Chewuch and Twisp River basins were natural origin fish (Table 3.17). Surveyors (WDFW and USFWS) sampled 36.0% of the overall Methow Basin estimated spawning population in 2016 (Attachment C).

Egg retention was estimated for 133 of the 174 female carcasses examined. Using mean fecundities from MH broodstock (MetComp and Twisp), adjusting for mean egg-retention rates, and accounting for the proportion of hatchery and wild females by age class on the spawning grounds, an estimated total of 1,426,641 eggs were deposited in the Methow River basin in 2016 (Table 3.18).

Table 3.17. Carcass recoveries and expanded count by tributary and reach from Methow Basin spring Chinook surveys in 2016.

Reach	Redds		Estimated	Carcasses				
				Recoveries			Expanded count	
	Count	Subbasin Prop. (%)	spawning escapement	H	W	Total	H	W
			Methow River mainstem					
M15	2	0.9	4	0	2	2	0	4
M14	16	6.9	31	6	11	17	11	20
M13	5	2.2	10	0	8	9[a]	0	10
M12	5	2.2	10	4	1	5	8	2
M11	17	7.3	33	3	3	6	17	16
M10	25	10.8	48	7	3	10	34	14
M9	75	32.4	144	18	13	31	86	58
M8	2	0.9	4	3	0	4[a]	4	0
M7	16	6.9	31	10	3	13	24	7
M6	15	6.5	29	12	4	16	22	7
M5,4	1	0.4	2	1	1	2	1	1
Total	179	77.4	346	64	49	115[a]	207	139
			Lost River					
L2	8	3.5	15	0	2	2	0	15
L1	1	0.4	2	0	1	1	0	2
Total	9	3.9	17	0	3	3	0	17
			Early Winters Creek					
EW5,4	0	0.0	0	0	0	0	0	0
EW3	4	1.8	8	3	0	3	8	0
EW2,1	1	0.4	2	0	1	1	0	2
Total	5	2.2	10	3	1	4	8	2
			Methow River tributaries					
HA2	0	0.0	0	0	0	0	0	0
HA1	1	0.4	2	0	0	0	1[b]	1[b]
MH1	2	0.9	4	2	0	2	4	0
Lsusp1	0	0.0	0	0	0	0	0	0
Susp1	6	2.6	11	2	0	2	11	0
W3	0	0.0	0	0	0	0	0	0
W2	0	0.0	0	0	0	0	0	0
W1	0	0.0	0	0	0	0	0	0
WN1	29	12.6	56	16	0	16	56	0
Total	38	16.5	73	20	0	20	72	1
Grand total	231	100.0	446	87	53	142[a]	287	159

[a] Includes carcasses of unknown origin.
[b] Expanded count based on H and W proportions from M9upper.

Table 3.17. Continued.

Reach	Redds		Estimated spawning escapement	Carcasses				
				Recoveries			Expanded count	
	Count	Subbasin Prop. (%)		H	W	Total	H	W
			Chewuch River mainstem					
C13	0	0.0	0	0	0	0	0	0
C12	5	6.0	10	1	3	4	2	8
C11	1	1.2	2	0	0	0	1	1
C10	3	3.6	6	1	1	2	3	3
C9	0	0.0	0	0	0	0	0	0
C8	6	7.1	12	0	4	5[a]	0	12
C7	9	10.7	17	1	4	5	3	14
C6	14	16.6	27	6	11	17	10	17
C5	9	10.7	17	5	9	14	6	11
C4	12	14.3	23	1	10	12[a]	2	25
C3	2	2.4	4	0	0	1[a]		
C2	22	26.2	42	8	1	10	34	8
C1	1	1.2	2	0	1	1	0	2
Total	84	100.0	162	23	45	71[a]	61	101
			Twisp River mainstem					
T10	0	0.0	0	0	0	0	0	0
T9	0	0.0	0	0	0	0	0	0
T8	0	0.0	0	0	0	0	0	0
T7	15	32.6	29	0	5	6[a]	0	29
T6	14	30.4	27	6	8	14	12	15
T5	14	30.4	27	7	6	14[a]	13	14
T4	0	0.0	0	0	1	1		
T3	3	6.6	6	2	1	3	4	2
T2	0	0.0	0	0	0	0	0	0
T1	0	0.0	0	0	0	0	0	0
Total	46	100.0	89	15	21	38[a]	29	60

[a] Includes fish of unknown origin.

Table 3.18. Estimated egg deposition for spring Chinook in the Methow Basin in 2016. Mean fecundities were derived from Methow Hatchery broodstock (MetComp or Twisp) and adjusted according to hatchery and wild proportions by age class in each subbasin.

Subbasin	Females with egg retention estimated	Mean fecundity	Mean egg retention (%)	Redds	Subbasin proportion (%)	Estimated egg deposition		
						2014	2015	2016
Chewuch	36	4,221	0.90	84	23.3	907,636	819,011	351,373
Methow	84	3,764	0.40	231	64.0	2,813,070	2,523,595	866,006
Twisp	13	4,551	0.04	46	12.7	490,824	524,425	209,262
Total	133			361		4,211,530	3,867,031	1,426,641

3.5: Life History Monitoring

Adult returns to Wells Hatchery, Methow Hatchery, the Twisp River weir, and those recovered in fisheries and on spawning grounds were used to assess life history characteristics of spring Chinook stocks reared at Methow Hatchery.

Age at Maturity

Methow River basin spring Chinook adults, regardless of origin, primarily return at age-4 (Table 3.19). Average age-4 returns across river basins ranged from 73 – 76% for hatchery fish and 72 – 77% for natural origin fish. Hatchery origin fish were more likely to return at age-3 and less likely to return at age-5 than natural origin fish, on average (Table 3.19).

Table 3.19. Proportion of adult returns by total age of the 1998-2010 broods of Methow Hatchery spring Chinook and Methow Basin natural origin Chinook. Data for hatchery origin fish (H) is derived from expanded CWT recoveries from broodstock, fisheries, and spawning grounds. Chewuch releases from the 1998 and 2000 broods are included in the Methow spring Chinook category for those years. Data for natural origin fish (W) is derived from expanded escapement estimates from spawning ground surveys.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
Methow spring Chinook					
1998	H	0.08	0.53	0.39	2,279
1998	W	0.31	0.65	0.04	52
1999	H	0.10	0.83	0.07	143
1999	W	0.60	0.40	0.00	5
2000	H	0.14	0.81	0.05	850
2000	W	0.02	0.82	0.16	241
2001	H	0.22	0.73	0.05	513
2001	W	0.01	0.82	0.16	222
2002	H	0.09	0.84	0.08	532
2002	W	0.00	0.51	0.49	189
2003	H	0.04	0.83	0.13	52
2003	W	0.00	0.69	0.31	86
2004	H	0.23	0.75	0.02	308
2004	W	0.06	0.77	0.17	211
2005	H	0.17	0.83	0.00	326
2005	W	0.04	0.94	0.01	253
2006	H	0.29	0.67	0.04	1,667
2006	W	0.06	0.61	0.33	594
2007	H	0.11	0.86	0.03	512
2007	W	0.03	0.85	0.12	317
2008	H	0.41	0.56	0.02	931
2008	W	0.13	0.71	0.16	121
2009	H	0.09	0.90	0.01	749
2009	W	0.00	0.85	0.15	121
2010	H	0.26	0.71	0.03	1,227
2010	W	0.04	0.87	0.09	323
Mean	H	0.17	0.76	0.07	776
Mean	W	0.10	0.73	0.17	210
Chewuch spring Chinook					
2001	H	0.1	0.87	0.03	707
2001	W	0.00	0.81	0.19	254
2002	H	0.08	0.78	0.15	633
2002	W	0.01	0.59	0.39	153
2003	H	0.04	0.79	0.18	56
2003	W	0.00	0.31	0.69	48

Table 3.19. Continued.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Chewuch spring Chinook			
2004	H	0.29	0.66	0.04	194
2004	W	0.05	0.81	0.14	78
2005	H	0.16	0.83	0.01	308
2005	W	0.02	0.96	0.03	295
2006	H	0.30	0.64	0.06	703
2006	W	0.06	0.44	0.50	434
2007	H	0.04	0.91	0.05	810
2007	W	0.04	0.80	0.16	222
2008	H	0.43	0.53	0.04	879
2008	W	0.18	0.69	0.13	118
2009	H	0.10	0.88	0.03	349
2009	W	0.03	0.91	0.06	98
2010	H	0.23	0.76	0.01	300
2010	W	0.01	0.87	0.12	214
Mean	H	0.18	0.76	0.06	494
Mean	W	0.04	0.72	0.24	191
		Twisp spring Chinook			
1998	H	0.18	0.68	0.14	22
1998	W	0.21	0.62	0.18	117
1999	H	0.13	0.83	0.03	60
1999	W	0.00	1.00	0.00	7
2000	H	0.12	0.88	0.00	147
2000	W	0.12	0.83	0.05	318
2001	H	0.12	0.86	0.02	42
2001	W	0.22	0.62	0.16	124
2002	H	0.26	0.7	0.04	210
2002	W	0.00	0.57	0.43	82
2003	H	0.06	0.92	0.02	134
2003	W	0.00	1.00	0.00	1
2004	H	0.31	0.63	0.07	225
2004	W	0.12	0.74	0.14	65
2005	H	0.24	0.67	0.09	45
2005	W	0.11	0.76	0.14	37
2006	H	0.00	0.39	0.60	238
2006	W	0.07	0.69	0.24	259
2007	H	0.24	0.76	0.00	37
2007	W	0.04	0.89	0.07	118
2008	H	0.33	0.65	0.02	360
2008	W	0.13	0.81	0.06	77

Table 3.19. Continued.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Twisp spring Chinook			
2009	H	0.16	0.82	0.02	121
2009	W	0.16	0.73	0.10	33
2010	H	0.46	0.52	0.02	288
2010	W	0.12	0.74	0.14	142
Mean	H	0.20	0.73	0.07	148
Mean	W	0.10	0.77	0.13	106

Length at Maturity

Length at maturity of Methow Composite spring Chinook was similar to wild spring Chinook from the Methow and Chewuch Rivers (combined in Methow Composite category) for the long-term mean (1992-2010 broods; Table 3.20). Length at maturity of Twisp spring Chinook recovered in the Twisp River were similar to their wild counterparts of the same sex and age, although for both stocks, sample sizes for some sex, age, and origin comparisons were small.

Table 3.20. Mean post-eye to hypural plate (POH) length (cm) of adult Chinook Salmon by sex, age, origin, and release location (hatchery fish) or stream of recovery (wild fish). Adult data for Twisp wild fish includes those found on spawning ground surveys, retained for broodstock at the Twisp weir, and fish collected at Wells Dam for which stock was determined through genetic assessment. Wild fish collected from Fulton Dam are included in the Chewuch groups.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Methow River males					
1992	W	--	--	--	--	--	--	75	8	8
1993	H	41	3	12	61	27	3	73	13	2
1993	W	--	--	--	63	7	1	--	--	--
1995	H	45	8	2	62	44	3	74	1	--
1995	W	--	--	--	57	1	--	85	1	--
1996	H	41	45	4	60	33	5	74	2	0
1996	W	--	--	--	59	4	9	72	12	4
1997	H	43	4	3	65	166	4	78	22	4
1997	W	44	4	2	62	15	3	79	8	7
1998	W	55	2	0	73	4	5	79	1	--
1999	H	39	10	3	59	5	4	74	1	--
1999	W	58	1	--	--	--	--	66	1	--
2000	W	38	3	1	60	26	6	72	4	2
2001	H	39	73	3	58	81	5	70	3	5

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Methow River males										
2001	W	40	1	--	59	26	5	72	5	5
2002	H	42	16	3	59	75	4	73	7	6
2002	W	--	--	--	58	14	6	70	6	3
2003	H	38	2	1	55	15	5	75	1	--
2003	W	--	--	--	55	2	1	78	2	4
2004	H	39	19	2	58	36	4	--	--	--
2004	W	38	2	6	61	9	6	--	--	--
2005	H	44	31	3	61	48	4	--	--	--
2005	W	41	3	4	62	25	4	75	1	--
2006	H	43	178	4	62	145	4	75	2	5
2006	W	41	6	4	62	46	6	75	19	7
2007	H	39	19	3	60	21	5	69	1	--
2007	W	39	3	3	58	18	5	71	2	4
2008	H	40	84	3	57	105	6	53	1	--
2008	W	40	3	3	57	10	6	--	--	--
2009	H	39	30	3	59	44	5	--	--	--
2009	W	--	--	--	60	9	3	75	2	8
2010	H	42	30	4	59	88	5	74	6	4
2010	W	39	4	4	60	51	6	78	3	3
Mean	H	41	37	4	60	62	4	74	5	4
Mean	W	43	3	3	60	17	5	75	5	5
Methow River females										
1992	W	--	--	--	--	--	--	74	4	6
1993	H	--	--	--	59	61	3	73	16	6
1993	W	--	--	--	63	15	2	--	--	--
1994	H	--	--	--	63	2	6	--	--	--
1995	H	--	--	--	65	56	3	--	--	--
1995	W	--	--	--	61	7	3	74	1	--
1996	H	--	--	--	62	66	3	74	8	3
1996	W	--	--	--	64	2	6	73	12	6
1997	H	--	--	--	63	283	3	70	19	4
1997	W	--	--	--	63	33	2	77	10	4
1998	W	--	--	--	68	9	6	80	1	--
1999	H	--	--	--	61	30	4	68	2	11
1999	W	--	--	--	62	2	1	--	--	--
2000	W	--	--	--	58	41	4	71	8	3
2001	H	--	--	--	60	94	3	66	8	5

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Methow River females										
2001	W	--	--	--	59	26	3	69	5	6
2002	H	--	--	--	58	173	4	69	13	3
2002	W	--	--	--	57	12	4	67	8	4
2003	H	--	--	--	60	20	3	69	4	5
2003	W	--	--	--	57	7	3	71	5	2
2004	H	48	2	4	60	98	3	68	2	1
2004	W	--	--	--	57	31	3	69	7	4
2005	H	53	2	9	61	72	3	--	--	--
2005	W	--	--	--	59	25	2	--	--	--
2006	H	--	--	--	61	273	3	72	16	3
2006	W	--	--	--	59	73	5	72	24	5
2007	H	45	1	--	62	108	3	69	6	3
2007	W	--	--	--	60	35	3	70	8	4
2008	H	--	--	--	59	198	3	68	2	1
2008	W	--	--	--	59	16	3	69	5	2
2009	H	--	--	--	58	72	2	62	1	--
2009	W	--	--	--	58	17	3	71	5	4
2010	H	--	--	--	60	252	3	70	15	3
2010	W	--	--	--	60	52	4	69	9	3
Mean	H	49	2	7	61	116	3	69	9	4
Mean	W	--	--	--	60	24	3	72	7	4
Chewuch River males										
1992	H	--	--	--	58	15	5	--	--	--
1992	W	--	--	--	--	--	--	77	4	7
1993	H	40	16	2	58	18	4	75	6	3
1993	W	--	--	--	61	8	3	--	--	--
1996	H	42	3	3	60	5	4	70	1	--
1996	W	--	--	--	--	--	--	69	11	2
1997	H	42	24	4	62	109	5	71	7	8
1997	W	--	--	--	61	81	4	77	11	4
1998	W	47	2	8	74	5	6	77	4	3
2000	W	35	2	1	55	8	4	77	1	--
2001	H	39	32	4	59	80	5	69	3	1
2001	W	--	--	--	59	45	6	70	9	4

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Chewuch River males					
2002	H	42	18	3	59	108	4	74	12	3
2002	W	40	1	--	57	16	8	68	5	7
2003	H	34	2	1	54	17	5	70	1	--
2003	W	--	--	--	60	2	1	72	6	3
2004	H	40	16	3	60	11	6	75	2	4
2004	W	43	1	--	60	9	7	--	--	--
2005	H	43	25	3	58	29	5	--	--	--
2005	W	37	2	4	61	19	4	82	1	--
2006	H	44	65	3	62	69	4	71	2	4
2006	W	41	4	4	61	20	6	75	17	6
2007	H	40	15	4	59	96	6	74	5	1
2007	W	41	3	3	60	17	5	73	4	6
2008	H	40	89	3	56	69	6	70	2	0
2008	W	42	4	7	56	13	7	--	--	--
2009	H	39	9	4	59	40	5	67	2	11
2009	W	46	2	6	58	17	5	70	1	--
2010	H	39	16	2	59	37	6	--	--	--
2010	W	43	1	--	61	25	6	71	1	--
Mean	H	40	25	3	59	50	5	71	4	4
Mean	W	41	2	5	60	20	5	74	6	5
					Chewuch River females					
1992	H	--	--	--	59	22	3	--	--	--
1992	W	--	--	--	--	--	--	73	1	--
1993	H	--	--	--	60	24	3	71	7	3
1993	W	--	--	--	60	16	3	--	--	--
1994	H	--	--	--	65	2	3	--	--	--
1995	W	--	--	--	--	--	--	74	3	3
1996	H	--	--	--	62	10	3	75	2	4
1996	W	--	--	--	65	3	2	68	6	1
1997	H	60	1	--	63	174	4	72	5	5
1997	W	--	--	--	62	71	3	75	8	4
1998	W	53	1	--	66	3	3	73	5	3
1999	W	--	--	--	61	1	--	--	--	--
2000	W	--	--	--	59	5	3	72	5	4

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Chewuch River females					
2001	H	--	--	--	59	131	4	66	9	5
2001	W	--	--	--	59	52	3	67	10	3
2002	H	--	--	--	57	156	3	69	16	3
2002	W	--	--	--	58	19	4	70	7	2
2003	H	--	--	--	58	10	4	70	4	5
2003	W	--	--	--	57	1	--	67	8	4
2004	H	--	--	--	59	47	3	64	1	--
2004	W	--	--	--	58	14	4	66	1	--
2005	H	--	--	--	60	62	3	74	1	--
2005	W	--	--	--	59	38	3	71	2	5
2006	H	--	--	--	60	133	3	70	9	5
2006	W	--	--	--	60	37	4	72	26	4
2007	H	--	--	--	61	163	3	70	21	4
2007	W	--	--	--	61	13	5	69	11	2
2008	H	--	--	--	58	214	4	66	9	4
2008	W	--	--	--	58	25	3	69	6	2
2009	H	--	--	--	58	71	3	67	1	--
2009	W	--	--	--	57	18	3	67	1	--
2010	H	--	--	--	60	56	3	69	1	--
2010	W	--	--	--	60	37	4	70	12	3
Mean	H	60	1	--	60	85	3	69	7	4
Mean	W	53	1	--	60	22	3	70	7	3
					Twisp River males					
1992	H	--	--	--	54	7	7	--	--	--
1992	W	--	--	--	--	--	--	70	3	3
1993	H	39	6	2	58	3	10	68	1	
1994	H	--	--	--	60	3	1	--	--	--
1996	H	40	23	2	58	19	8	83	1	
1996	W	--	--	--	--	--	--	70	5	2
1997	H	42	3	3	63	21	4	--	--	--
1997	W	--	--	--	61	55	4	74	5	4
1998	H	50	2	3	65	5	5	74	1	--
1998	W	42	6	2	--	--	--	77	1	--
1999	H	38	8	2	64	2	9	--	--	--

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Twisp River males										
1999	W	--	--	--	59	2	8	--	--	--
2000	H	40	12	2	57	13	7	--	--	--
2000	W	40	14	2	56	48	6	--	--	--
2001	H	40	2	1	57	3	5	--	--	--
2001	W	36	8	2	56	10	4	71	1	--
2002	H	38	12	3	52	14	7	80	1	--
2002	W	--	--	--	54	3	9	70	2	3
2003	H	41	3	4	53	18	5	58	1	--
2003	W	--	--	--	--	--	--	--	--	--
2004	H	39	19	3	57	19	5	73	1	--
2004	W	39	1	--	58	11	3	75	2	1
2005	H	41	7	3	57	2	2	--	--	--
2005	W	41	2	1	58	8	5	--	--	--
2006	H	39	29	3	55	10	4	--	--	--
2006	W	42	13	4	57	22	6	77	2	8
2007	H	40	8	2	55	2	1	--	--	--
2007	W	39	1	--	54	10	3	--	--	--
2008	H	41	28	3	58	38	5	70	1	
2008	W	41	1	--	56	9	4	--	--	--
2009	H	37	6	2	57	12	4	--	--	--
2009	W	35	2	2	54	3	3	--	--	--
2010	H	40	32	4	54	22	3	--	--	--
2010	W	37	7	2	57	40	4	73	4	9
Mean	H	40	13	3	58	12	5	71	1	--
Mean	W	39	6	2	57	18	5	73	3	4
Twisp River females										
1992	H	--	--	--	61	13	3	--	--	--
1992	W	--	--	--	--	--	--	67	1	--
1993	H	--	--	--	61	4	5	71	2	1
1993	W	--	--	--	56	3	4	--	--	--
1994	H	--	--	--	61	2	1	--	--	--
1995	W	--	--	--	--	--	--	69	1	--
1996	H	--	--	--	61	57	4	75	3	6
1996	W	--	--	--	64	1	--	69	4	3

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Twisp River females										
1997	H	--	--	--	61	20	2	66	1	--
1997	W	--	--	--	63	38	3	75	10	6
1998	H	--	--	--	66	8	2	--	--	--
1998	W	--	--	--	65	9	3	75	7	3
1999	H	--	--	--	58	12	5	54	1	--
1999	W	--	--	--	63	1	--	77	1	--
2000	H	--	--	--	58	37	3	--	--	--
2000	W	--	--	--	60	43	5	69	7	3
2001	H	--	--	--	60	6	3	67	1	--
2001	W	--	--	--	62	18	4	68	3	2
2002	H	--	--	--	58	31	4	67	1	--
2002	W	--	--	--	56	6	5	73	5	4
2003	H	--	--	--	59	22	4	73	1	--
2003	W	--	--	--	57	1	--	--	--	--
2004	H	--	--	--	60	46	4	71	5	4
2004	W	--	--	--	60	20	3	68	1	--
2005	H	--	--	--	60	12	3	71	1	--
2005	W	--	--	--	61	8	6	74	2	0
2006	H	--	--	--	61	32	3	68	1	--
2006	W	--	--	--	62	32	4	70	11	4
2007	H	--	--	--	59	4	4	--	--	--
2007	W	--	--	--	63	11	4	74	4	2
2008	H	--	--	--	60	65	3	70	1	--
2008	W	--	--	--	58	16	4	73	3	3
2009	H	--	--	--	59	27	3	73	1	--
2009	W	--	--	--	58	6	5	62	2	4
2010	H	--	--	--	59	44	4	72	3	3
2010	W	--	--	--	60	31	4	71	9	4
Mean	H	--	--	--	60	25	3	69	2	4
Mean	W	--	--	--	61	15	4	71	5	3

Contribution to Fisheries

Spring Chinook released from Methow Hatchery were captured in ocean and Columbia River fisheries, but no freshwater fisheries upstream of Priest Rapids Dam have targeted spring Chinook except in the Wenatchee Basin. Additionally, because recent broods of Methow Hatchery spring Chinook have not been adipose fin-clipped, direct harvest should occur only in non-selective fisheries. Thus, estimates of overall harvest rates include non-selective fishery harvest and indirect harvest associated with catch-and-release mortality in selective fisheries. Harvest and catch-and-release mortality were estimated using ad-clipped and CWT'd surrogate stocks (e.g., Chiwawa, WNFH stocks) to estimate expected contribution rates of un-clipped (Methow Composite and Twisp) stocks to specific fisheries. Harvest and harvest-related mortality has been relatively high for some broods with four broods exceeding 44% harvest, and twelve exceeding 10%, while mean harvest rates have been below 11% for all stocks (Table 3.21).

Table 3.21. Adult returns of coded-wire tagged Methow Hatchery spring Chinook by brood and release location. Recoveries are expanded by tag rate and sample rate, and include estimated impacts of post-release mortality in selective fisheries for adipose-present releases (broods 2000-2010). Releases that were not tagged to denote separate release locations (Methow and Chewuch 1998 and 2000 broods) were excluded, as were those where no releases occurred (1995 Chewuch and Twisp broods).

Brood	Hatchery	Spawning ground	Ocean fishery			Freshwater fishery			Total	Harvest %
			Comm.	Sport	Tribal	Comm.	Sport	Tribal		
Methow spring Chinook										
1993	177	7	0	0	0	0	4	3	191	3.7
1994	1	0	0	0	0	0	0	0	1	0.0
1995	117	3	2	0	0	0	0	0	122	1.6
1996	258	229	0	0	0	2	0	12	501	2.8
1997	300	17	0	0	0	83	205	111	716	55.7
1999	93	42	0	0	0	3	6	0	144	6.3
2001	294	205	4	0	0	0	0	0	503	0.8
2002	284	313	4	0	0	0	0	2	603	1.0
2003	48	4	0	0	0	0	0	0	52	0.0
2004	138	143	0	0	0	0	0	23	304	7.6
2005	168	158	0	0	0	0	0	0	326	0.0
2006	488	1,031	0	0	0	3	3	182	1,707	11.0
2007	288	224	0	0	0	1	2	0	515	0.6
2008	431	490	0	0	0	23	183	79	1,206	23.6
2009	473	195	0	0	0	2	7	3	680	1.8
2010	512	654	1	0	2	1	3	8	1,181	1.3
Mean	254	232	1	0	0	7	26	26	547	7.4

Table 3.21. Continued.

Brood	Hatchery	Spawning ground	Ocean fishery			Freshwater fishery			Total	Harvest %
			Comm.	Sport	Tribal	Comm.	Sport	Tribal		
Twisp spring Chinook										
1992	21	0	0	0	0	0	0	0	21	0.0
1993	21	2	0	0	0	0	4	0	27	14.8
1994	5	0	0	0	0	0	0	0	5	0.0
1996	100	168	0	0	0	0	0	6	274	2.2
1997	16	14	0	0	0	2	9	13	54	44.4
1998	9	2	0	0	0	4	0	6	21	47.6
1999	28	28	0	0	0	4	0	0	60	6.7
2000	34	104	0	0	0	0	0	7	145	4.8
2001	3	40	0	0	0	0	0	0	43	0.0
2002	49	68	0	0	0	0	0	3	120	2.5
2003	10	34	0	0	0	0	0	0	44	0.0
2004	35	124	0	0	0	2	0	19	180	11.7
2005	11	34	0	0	0	0	0	0	45	0.0
2006	42	181	0	0	0	0	0	25	248	10.1
2007	18	19	0	0	0	0	0	0	37	0.0
2008	56	285	0	0	0	8	68	29	446	23.5
2009	40	81	0	0	0	0	1	1	123	1.6
2010	59	226	0	0	0	0	8	2	295	3.4
Mean	31	78	0	0	0	1	5	6	122	9.6
Chewuch spring Chinook										
1992	39	0	0	0	0	0	0	0	39	0.0
1993	98	11	5	0	0	0	0	1	115	5.2
1994	3	0	0	0	0	0	0	0	3	0.0
1996	30	4	0	0	0	2	0	1	37	8.1
1997	87	31	0	0	0	22	141	49	330	64.2
2001	64	639	0	0	0	0	0	2	705	0.3
2002	155	472	0	0	0	1	3	1	632	0.8
2003	26	29	0	0	0	0	0	0	55	0.0
2004	39	146	0	0	0	0	0	9	194	4.6
2005	38	265	0	0	0	4	0	0	307	1.3
2006	47	602	0	0	0	0	0	81	730	11.1
2007	182	611	0	0	0	1	3	14	811	2.2
2008	162	652	2	0	0	20	162	70	1,068	23.6
2009	78	260	0	0	0	5	4	10	357	5.3
2010	66	233	0	0	0	0	1	2	302	1.0
Mean	74	264	0	0	0	4	21	16	379	8.5

Migration Timing

The 2016 spring Chinook migration to Wells Dam was monitored between 3 May and 24 June to evaluate the run composition and age structure of returning adults (Attachment C), and to facilitate hatchery broodstock collection. However, migration timing evaluations at Wells Dam represent pooled hatchery and wild stocks because individual hatchery stocks (e.g., Methow Composite, WNFH) have received the same external mark, and CWT's are typically not collected or extracted from fish sampled at Wells Dam. Using these data, wild fish (NOR) migrated to Wells Dam similarly to hatchery fish (HOR) within the age-3 and age-4 classes, but age-5 wild fish migrated on average eight days earlier (Table 3.22). Comparisons of age-3 fish were not robust because of the small sample size of wild fish. Although the migration trend is typical, the arrival time at Wells Dam was closer for hatchery and wild fish from the 2010-2015 broods, than for the 2006-2009 broods, and mean arrival time in 2015 was the earliest in the past decade, most likely due to low flow conditions in the Columbia River during the adult migration period (Figure 3.4).

Table 3.22. Mean migration date of hatchery (H) and wild (W) spring Chinook to Wells Dam by age and percentile of the overall age-class return in 2016. Totals do not include fish of unknown origin or age.

Age	Origin	Percentile					Mean	*N*
		10	25	50	75	90		
3	H	24-May	26-May	31-May	7-Jun	9-Jun	31-May	129
3	W	24-May	24-May	8-Jun	9-Jun	9-Jun	31-May	7
4	H	11-May	19-May	24-May	26-May	7-Jun	23-May	497
4	W	12-May	17-May	19-May	26-May	2-Jun	21-May	64
5	H	10-May	11-May	19-May	19-May	25-May	31-May	44
5	W	12-May	12-May	24-May	1-Jun	8-Jun	23-May	19
All	H	8-May	12-May	16-May	19-May	21-May	23-May	670
All	W	10-May	12-May	15-May	18-May	20-May	22-May	90

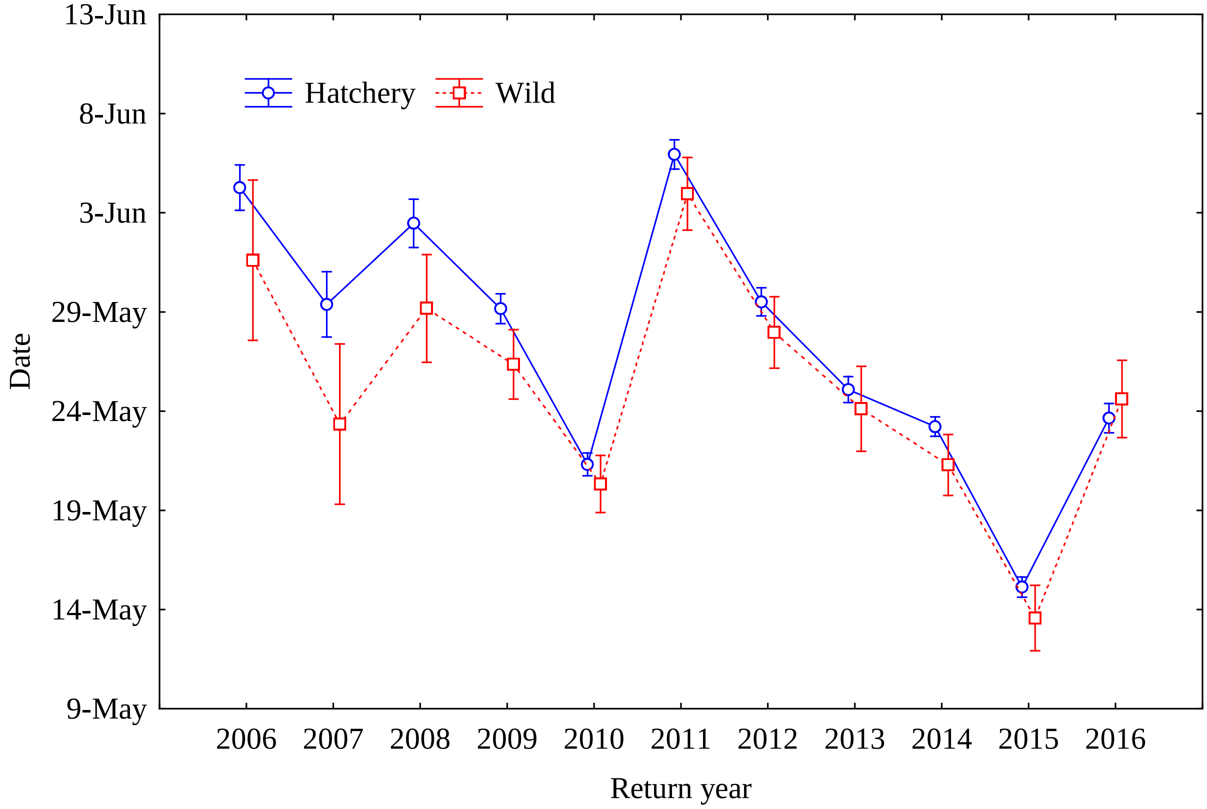

Figure 3.4. Mean (+/- 95% CI) arrival day of the year at Wells Dam of hatchery and wild spring Chinook by return year.

Straying

Targets for strays based on return year (recovery year) within the Methow River sub-basin should be less than 10% and targets for strays outside the Methow River sub-basin should be less than 5%. The target for brood year stray rates should be less than 5%.

The percentage of the spawning escapement made up of hatchery-origin Chewuch and Twisp released spring Chinook in non-target spawning areas within the Methow River sub-basin has been high in most years and exceeded the target of 10% for return year and 5% for brood year. Conversely, adult returns from Methow River (on-station) releases rarely strayed into non-target recipient populations (Table 3.23). Methow Hatchery spring Chinook have constituted less than 5% of the spawning escapement by return year of other spring Chinook populations (Table 3.24).

Table 3.23. Straying by Methow Hatchery spring Chinook released as yearling smolts by brood year, release location, and recipient area.

Brood year	Total return	Recipient (stray) area			% stray
		Stream	Hatchery	Total	
		Chewuch River releases			
1992	39	0	1	1	2.56
1993	115	3	19	22	19.13
1994	3	0	0	0	0.00
1996	37	4	15	19	51.35

Table 3.23. Continued.

Brood year	Total return	Recipient (stray) area			% stray
		Stream	Hatchery	Total	
		Chewuch River releases			
1997	330	27	39	66	20.00
2001	703	321	0	321	45.66
2002	631	299	1	300	47.54
2003	55	22	0	22	40.00
2004	194	70	0	70	36.08
2005	307	148	0	148	48.21
2006	730	262	1	263	36.03
2007	811	338	1	339	41.80
2008	1,068	409	0	409	38.30
2009	357	116	2	118	33.05
2010	302	112	6	118	39.07
Mean	379	142	6	148	33.25
		Methow River releases			
1993	191	1	0	1	0.52
1994	1	0	0	0	0.00
1995	122	0	0	0	0.00
1996	501	8	0	8	1.60
1997	716	1	0	1	0.14
1998	924	- -	- -	0	0.00
1999	144	7	0	7	4.86
2000	32	- -	- -	0	0.00
2001	503	23	0	23	4.57
2002	603	26	2	28	4.64
2003	52	0	0	0	0.00
2004	304	33	0	33	10.86
2005	326	10	1	11	3.37
2006	1,707	106	1	107	6.27

2007	515	10	0	11	2.14
2008	1,206	39	0	39	3.23
2009	761	13	2	15	1.97
2010	1,353	81	35	116	8.57
Mean	553	22	3	22	2.93
			Twisp River releases		
1992	21	0	0	0	0.00
1993	27	1	3	4	14.81
1994	5	0	0	0	0.00
1996	274	17	33	50	18.25

Table 3.23. Continued.

Brood year	Total return	Recipient (stray) area			% stray
		Stream	Hatchery	Total	
			Twisp River releases		
1997	54	0	6	6	11.11
1998	21	2	8	10	47.62
1999	60	20	25	45	75.00
2000	145	37	12	49	33.79
2001	43	7	0	7	16.28
2002	211	66	59	125	59.24
2003	44	13	2	15	34.09
2004	180	27	7	34	18.89
2005	45	9	1	10	22.22
2006	248	59	27	86	34.68
2007	37	7	9	16	43.24
2008	446	129	39	168	37.67
2009	124	24	29	53	42.74
2010	288	70	58	128	44.44
Mean	126	27	18	45	30.78

Table 3.24. Recovery number and percentage (%) of donor Methow Hatchery spring Chinook within other recipient upper Columbia tributaries. Only tributaries that had at least 1 stray were included in the table (e.g., none were encountered in Nason Creek or the White River). The Similkameen River does not have an extant spring Chinook population.

Return year	Chiwawa River	Entiat River	Similkameen River
1997	0	1[a]	0
2000	0	6 (3.43)	3
2001	0	3 (0.62)	10
2002	0	5 (1.35)	5
2003	0	6 (2.32)	1

2006	2 (0.38)	4 (1.56)	0
2007	0	6 (2.45)	0
2010	6 (0.55)	12 (2.44)	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0	0	0
2015	0	3 (0.59)	0
Mean *N* (%)	0.61 (0.07)	3.75 (1.23)	1.46 (--)

[a] Fish was recovered during WDFW genetic study trapping and was not included in spawning escapement estimate.

Smolt to Adult Survival and HRR

The overall smolt-to-adult return of Methow Hatchery spring Chinook stocks was calculated from expanded CWT recoveries including and excluding harvested fish. Overall, SAR (including harvested fish) averaged 0.22%, 0.33%, and 0.22%, respectively for Twisp, Methow, and Chewuch river releases (Table 3.25). Survival (SAR) of 2010 brood fish was above the overall mean value for all populations in the Methow River Basin. Similarly, HRR values calculated as the number of adult returns (including harvest) divided by the number of adult broodstock, were also higher than average for all 2010 brood releases, but most Methow Basin release groups had overall mean HRR values below the target value of 4.5 (Table 3.25).

Table 3.25. Smolt to adult return (SAR) and hatchery replacement rate (HRR) of Methow Hatchery spring Chinook stocks by brood year. Methow River brood years 1998 and 2000 represent combined Methow and Chewuch River releases. Number of broodstock includes all fish collected regardless of fate, including mortalities and fish not used.

Brood year	Number of broodstock	Smolts released	Harvest included			Harvest not included		
			Adults	SAR (%)	HRR	Adults	SAR (%)	HRR
			Twisp spring Chinook					
1992	25	35,853	21	0.059	0.8	21	0.059	0.8
1993	45	116,749	27	0.023	0.6	23	0.020	0.5
1994	5	19,835	5	0.025	1	5	0.025	1.0
1995	-	-	-	-	-	-	-	-
1996	51	76,687	274	0.357	5.4	268	0.349	5.3
1997	15	26,714	54	0.202	3.6	30	0.112	2.0
1998	11	15,470	21	0.136	1.9	11	0.071	1.0
1999	40	67,408	60	0.089	1.5	56	0.083	1.4
2000	69	74,717	145	0.194	2.1	138	0.185	2.0
2001	36	51,652	43	0.083	1.2	43	0.083	1.2
2002	15	20,541	120	0.584	8	117	0.570	7.8
2003	36	50,627	44	0.087	1.2	44	0.087	1.2

2004	72	71,617	180	0.251	2.5	159	0.222	2.2
2005	24	27,658	45	0.163	1.9	45	0.163	1.9
2006	28	45,892	248	0.54	8.9	223	0.486	8.0
2007	40	54,096	37	0.068	0.9	37	0.068	0.9
2008	43	78,656	446	0.567	10.4	341	0.434	7.9
2009	41	67,031	123	0.183	3	121	0.181	3.0
2010	58	81,380	295	0.362	5.1	285	0.350	4.9
Mean	36	54,588	122	0.221	3.3	109	0.197	2.9
				Methow spring Chinook				
1993	99	210,849	191	0.091	1.9	184	0.087	1.9
1994	2	4,477	1	0.022	0.5	1	0.022	0.5

Table 3.25. Continued.

Brood year	Number of broodstock	Smolts released	Harvest included			Harvest not included		
			Adults	SAR (%)	HRR	Adults	SAR (%)	HRR
				Methow spring Chinook				
1995	14	28,878	122	0.422	8.7	120	0.416	8.6
1996	150	202,947	501	0.247	3.3	487	0.240	3.2
1997	266	332,484	716	0.215	3.1	317	0.095	1.2
1998	181	435,670	2,281	0.524	12.6	1,359	0.312	7.5
1999	182	180,775	144	0.080	0.8	135	0.075	0.7
2000	256	266,392	851	0.319	3.3	819	0.307	3.2
2001	94	130,887	503	0.384	5.4	499	0.381	5.3
2002	115	181,235	603	0.333	5.2	597	0.329	5.2
2003	47	48,831	52	0.106	1.1	52	0.106	1.1
2004	81	65,146	304	0.467	3.8	281	0.431	3.5
2005	122	156,633	326	0.208	2.7	326	0.208	2.7
2006	182	211,717	1,707	0.806	9.4	1,519	0.717	8.3
2007	90	119,407	515	0.431	5.7	512	0.429	5.7
2008	137	175,699	1,206	0.686	8.8	921	0.524	6.7
2009	162	288,013	680	0.236	4.2	668	0.232	4.1
2010	217	284,389	1,181	0.415	5.4	1,166	0.410	5.4
Mean	123	184,691	661	0.333	4.8	555	0.296	4.2
				Chewuch spring Chinook				
1992	26	40,881	39	0.095	1.5	39	0.095	1.5
1993	115	284,165	115	0.040	1	109	0.038	0.9
1994	12	11,854	3	0.025	0.3	3	0.025	0.3
1995	-	-	-	-	-	-	-	-
1996	95	91,672	37	0.040	0.4	34	0.037	0.4
1997	68	132,759	330	0.249	4.9	118	0.089	1.7
2001	187	261,284	705	0.270	3.8	703	0.269	3.8
2002	161	254,238	632	0.249	3.9	627	0.247	3.9

2003	94	127,614	55	0.043	0.6	55	0.043	0.6
2004	165	204,906	194	0.095	1.2	185	0.090	1.1
2005	170	232,811	307	0.132	1.8	303	0.130	1.8
2006	152	154,381	730	0.473	4.8	649	0.420	4.3
2007	98	126,055	811	0.643	8.3	793	0.629	8.1
2008	203	260,344	1,068	0.410	5.3	814	0.313	4.0
2009	85	149,863	357	0.238	4.2	338	0.226	4.0
2010	68	88,788	302	0.340	4.4	299	0.337	4.4
Mean	113	161,441	420	0.223	3.1	338	0.199	2.7

Natural Replacement Rates

The NRR of wild spring Chinook in the Methow River basin was calculated as the number of natural origin recruits (returning adults) divided by the overall naturally spawning population of hatchery and natural origin adults of the parent brood (Attachment C). The NRR of the last brood for which complete adult return data were available (2010 brood) was < 1 and similar to the overall median NRR values in all three subbasins (Table 3.26).

Table 3.26. The Natural Replacement Rate (NRR) of Methow Basin spring Chinook populations by year and primary spawning subbasin. The NRR is calculated by dividing the number of natural origin return (NOR) recruits produced by the sum of the spawning population of hatchery- and natural-origin spawners (Est. spawning escapement).

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
			Chewuch River				
1992	422	0	25	14	41	0.1	1.5
1993	184	2	69	21	96	0.5	1.0
1994	63	0	15	3	19	0.3	0.2
1995	6	1	12	19	34	5.5	- -
1996	8	0	13	86	102	12.8	0.4
1997	123	1	662	55	921	7.5	4.3
1998	7	11	23	19	63	9.0	12.7
1999	21	0	2	0	2	0.1	- -
2000	83	6	47	13	70	0.8	3.3
2001	2,493	0	205	49	265	0.1	4.5
2002	666	2	91	60	169	0.3	4.1
2003	490	0	15	33	53	0.1	0.7
2004	335	4	63	11	92	0.3	1.2
2005	508	5	282	8	313	0.6	1.8
2006	513	25	191	224	575	1.1	4.8

2007	277	8	183	33	287	1.0	8.3
2008	252	22	76	16	142	0.6	7.9
2009	771	3	89	6	107	0.1	4.3
2010	499	2	187	25	214	0.4	5.1
Median	277	2	69	19	102	0.5	4.1
			Methow River				
1992	924	0	44	43	92	0.1	- -
1993	760	5	79	32	120	0.2	1.9
1994	172	0	23	7	30	0.2	0.5
1995	27	1	54	18	77	2.8	8.7

Table 3.26. Continued.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
			Methow River				
1996	15	1	30	230	268	17.9	3.3
1997	152	21	348	50	538	3.5	3.1
1998	23	16	34	2	61	2.6	12.7
1999	70	3	2	0	4	0.1	0.8
2000	639	5	197	39	257	0.4	3.3
2001	7,588	3	183	36	231	0.0	3.8
2002	1,730	0	96	93	209	0.1	5.5
2003	605	0	59	27	95	0.2	1.2
2004	821	13	163	35	248	0.3	3.9
2005	747	11	239	3	269	0.4	2.7
2006	1,070	33	363	198	775	0.7	9.4
2007	697	9	268	27	407	0.6	5.7
2008	584	16	57	19	155	0.3	8.8
2009	1,741	0	103	18	131	0.1	4.3
2010	1,618	13	281	29	326	0.2	6.5
Median	697	5	96	29	209	0.3	3.9
			Twisp River				
1992	317	0	54	37	96	0.3	0.8
1993	426	5	27	17	50	0.1	0.6
1994	74	0	13	9	23	0.3	1.0
1995	12	0	26	12	39	3.2	- -
1996	8	0	11	56	69	8.6	5.4
1997	72	0	460	109	729	10.2	3.6
1998	11	24	72	21	138	12.6	2.0
1999	25	0	7	0	7	0.3	1.5
2000	256	37	264	17	339	1.3	2.7
2001	890	27	77	20	129	0.1	1.2

2002	241	0	47	35	91	0.4	8.0
2003	43	0	1	0	1	0.0	1.4
2004	341	8	48	9	76	0.2	2.4
2005	121	4	28	5	39	0.3	1.9
2006	165	19	179	61	338	2.1	8.9
2007	105	5	105	8	151	1.4	0.9
2008	166	10	56	4	91	0.6	10.4
2009	129	5	25	3	35	0.3	3.0
2010	251	17	105	20	143	0.6	5.1
Median	129	5	48	17	91	0.4	2.2

Proportionate Natural Influence

The Hatchery Scientific Review Group (HSRG) developed guidelines for salmon and steelhead hatchery programs intended to provide a foundation of hatchery reform principles that should aid hatcheries in the Pacific Northwest in meeting conservation and sustainable harvest goals (HSRG 2008). These guidelines provide a means of indexing the genetic risk of hatchery programs to natural populations by calculating the proportionate natural influence (PNI) of a population. The PNI is calculated as: (the proportion of natural origin fish within the broodstock [pNOB])/(pHOS+pNOB). A PNI value > 0.5 indicates that genetic selection pressures from the natural environment have a stronger influence on the population than those from the hatchery environment. A PNI value ≥ 0.67 was recommended for conservation programs by the HSRG (2009). Data necessary to calculate PNI values are derived from spawning ground surveys (i.e., pHOS; Attachment C) and from hatchery broodstock sampling (i.e., pNOB; Attachment C). For the 2003-2016 broods, mean PNI was higher in the Twisp Basin than in the Methow or Chewuch river basins (Table 3.27). However, values for all basins are low and indicate that most genetic selection pressure on progeny produced from naturally spawning adults comes from the hatchery environment (Table 3.27).

Table 3.27. The proportion of natural influence (PNI) calculated for specific broods of spawning spring Chinook in the Methow River basin. The PNI was calculated as: pNOB/(pNOB+pHOS).

Year	Chewuch				Methow				Twisp				Total			
	H	W	pHOS	PNI	H	W	pHOS	PNI	H	W	pHOS	PNI	H	W	pHOS	PNI
2003	465	25	0.95	0.37	597	8	0.99	0.29	18	25	0.42	0.47	1,080	58	0.95	0.33
2004	289	46	0.86	0.04	622	199	0.76	0.07	98	243	0.29	0.28	1,009	488	0.67	0.11
2005	289	219	0.57	0.37	526	221	0.70	0.30	34	87	0.28	0.66	849	527	0.62	0.36
2006	378	135	0.74	0.05	942	128	0.88	0.01	100	65	0.61	0.00	1,420	328	0.81	0.02
2007	203	74	0.73	0.00	545	152	0.78	0.07	65	40	0.62	0.45	813	266	0.75	0.09
2008	166	86	0.66	0.01	412	172	0.71	0.01	126	40	0.76	0.44	704	298	0.7	0.08

2009	500	271	0.65	0.03	1,480	261	0.85	0.02	97	32	0.75	0.18	2,077	564	0.79	0.03
2010	341	155	0.69	0.04	1,331	290	0.82	0.03	96	156	0.38	0.07	1,768	601	0.75	0.03
2011	499	370	0.57	0.15	1,391	432	0.76	0.13	85	159	0.35	0.17	1,975	961	0.67	0.14
2012	261	81	0.76	0.21	691	63	0.92	0.19	146	56	0.72	0.23	1,098	200	0.85	0.20
2013	226	89	0.72	0.34	505	113	0.82	0.33	117	39	0.75	0.42	848	241	0.78	0.34
2014	267	166	0.62	0.41	1,130	251	0.82	0.32	157	92	0.63	0.49	1,556	507	0.75	0.36
2015	152	134	0.53	0.32	749	154	0.83	0.22	54	110	0.33	0.66	955	398	0.71	0.27
2016	61	101	0.38	0.32	287	159	0.64	0.24	29	60	0.33	0.62	377	320	0.54	0.31
Mean	291	140	0.67	0.19	797	189	0.80	0.16	87	87	0.51	0.37	1,175	416	0.74	0.19

Section 4: Wells Hatchery Summer Chinook Salmon

This section focuses on the last brood for which hatchery releases were completed during the report year (2014 brood) and includes data from historic broods where appropriate. Broodstock for the Wells Hatchery summer Chinook Salmon program are primarily collected from the Wells Hatchery volunteer channel trap, but natural origin fish have also been retained from the West Fish Ladder at Wells Dam in some years. Broodstock collected from these sources have been used for multiple programs in addition to the Wells Hatchery yearling and subyearling releases. These programs include the Turtle Rock Hatchery yearling and subyearling programs, Lake Chelan sport fish enhancement program, and reintroduction programs in the Entiat and Yakima rivers. Because broodstock for these various programs are from the same collection location, most adult-based metrics (e.g., extraction rate, length at age, sex composition, etc.,) include all broodstock spawned, regardless of program. However, fecundity and ELISA values are generated solely from female Chinook spawned for the Wells yearling program because individual females for subyearling programs are not typically incubated separately to allow individual fecundity estimates and the relatively short rearing period for subyearling program fish negates the need for virology sampling of adult females.

4.1: Broodstock Collection and Sampling

Trapping of the 2014 brood of Wells Hatchery summer Chinook Salmon occurred between 7 July and 29 August, 2014. During this time a total of 2,098 hatchery origin and 29 wild origin fish were collected. The overall collection represented 25% of the summer Chinook Salmon escapement between the Wells and Rocky Reach Dams based on the difference between the total summer Chinook Salmon counts at each dam. Most fish collected have historically been used for broodstock purposes, but recent collections of adult fish have included surplus fish provided to local tribes (Table 4.1).

Table 4.1. Collection of summer Chinook Salmon at Wells Hatchery and the prespawn mortality (PSM), surplus mortality (Mort), spawning (Spawn), release (Rel.) and tribal surplus totals by brood and fish origin (hatchery or wild). Released fish for the 1998-1999 broods are listed as hatchery origin by default. Fish for which the origin or disposition (PSM, Spawn, etc.) are unknown are included in the hatchery total for each brood.

Brood year	Wild Chinook Salmon					Hatchery Chinook Salmon						Total spawned
	Total	PSM	Mort	Spawn	Rel.	Total	PSM	Mort	Spawn	Rel.	Tribal surplus	
1998	114	0	0	114	0	1,093	21	0	937	134	0	1,051
1999	236	13	0	223	0	1,009	67	0	779	163	0	1,002
2000	182	9	6	167	0	1,080	74	51	955	0	0	1,122
2001	36	1	0	21	14	1,325	111	0	1,029	185	0	1,050
2002	10	0	0	7	3	1,296	115	0	1,100	81	0	1,107
2003	76	1	0	41	34	1,203	61	0	982	160	0	1,023
2004	184	9	0	142	33	1,019	33	0	859	127	0	1,001
2005	109	5	0	83	21	2,858	13	143	1,063	84	1,547	1,146
2006	90	5	0	60	25	2,280	32	0	1,060	88	1,086	1,120
2007	80	3	0	52	25	1,659	24	0	1,077	98	449	1,129
2008	206	8	0	169	29	2,655	55	0	1,143	86	1,361	1,312
2009	357	20	0	300	37	2,119	35	0	1,190	51	843	1,490
2010	160	12	15	133	0	2,447	54	65	870	0	1,458	1,003
2011	181	7	15	159	0	2,215	39	30	972	0	1,174	1,131
2012	108	1	6	101	0	3,046	18	31	658	0	2,339	759
2013	15	0	0	15	0	2,639	7	35	675	0	1,922	690
2014	29	0	5	24	0	2,098	20	121	645	0	1,312	669

Length and Age at Maturity

Most summer Chinook Salmon collected at Wells Hatchery are age-5 hatchery origin fish (Table 4.2). Within return years, wild fish generally have a greater mean fork length than hatchery origin fish of the same sex and age, although sample sizes of wild fish within these categories are often very small. For the 2014 return year, age-4 and age-5 fish were 52% and 43% of the total fish sampled, respectively. Natural origin fish within this return year had a greater mean fork length than hatchery fish of the same sex and age for most comparisons but sample sizes of wild fish were very low, precluding robust comparisons for all sex, age, and origin groupings (Table 4.2).

Table 4.2. Mean fork length (cm), number (*N*), and standard deviation (SD) by sex, age, origin, and return year of summer Chinook Salmon retained for broodstock at Wells Hatchery. Age-2 and age-7 fish are excluded because too few fish are within these categories to facilitate statistical comparisons.

Return year	Sex	Age-3			Age-4			Age-5			Age-6		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Hatchery origin													
1998	M	58	39	7	75	130	9	95	216	8	101	19	10
1998	F	--	--	--	80	34	5	95	424	5	98	32	9
1999	M	62	115	10	77	202	8	94	80	8	98	17	9
1999	F	74	20	6	83	119	6	91	169	6	98	58	6
2000	M	54	68	7	77	363	7	92	136	8	109	1	--
2000	F	72	1	--	86	214	6	92	227	5	98	8	12
2001	M	63	20	11	81	453	7	95	85	8	100	2	8
2001	F	--	--	--	83	316	5	94	198	5	99	12	6
2002	M	60	13	10	80	281	6	95	279	7	100	6	6
2002	F	78	2	7	85	81	5	94	524	5	100	10	3
2003	M	61	14	6	80	61	7	92	343	8	98	6	15
2003	F	--	--	--	84	71	5	92	494	5	97	23	4
2004	M	70	12	9	79	267	5	89	127	7	99	39	10
2004	F	68	1	--	80	106	5	90	197	5	97	104	5
2005	M	64	5	8	80	214	7	88	332	7	93	9	9
2005	F	--	--	--	82	128	5	90	443	5	95	26	5
2006	M	62	9	9	79	228	7	92	218	7	91	51	8
2006	F	75	1	--	83	94	5	92	327	5	94	120	7
2007	M	70	61	6	78	150	7	93	255	8	95	15	10
2007	F	75	11	3	81	88	6	91	415	5	93	39	5
2008	M	71	128	10	82	328	7	94	74	9	103	23	6
2008	F	75	16	6	85	262	5	91	233	5	98	58	6
2009	M	66	119	7	79	269	8	90	148	8	99	6	10
2009	F	71	4	2	86	226	6	91	362	5	94	20	7
2010	M	65	50	11	79	377	7	92	55	8	--	--	--
2010	F	74	4	7	82	275	5	91	87	5	96	9	5
2011	M	65	97	6	76	159	8	89	223	10	101	4	5
2011	F	82	5	10	82	78	6	89	428	7	91	10	8
2012	M	70	27	7	78	240	6	89	60	7	90	6	8
2012	F	79	2	3	81	209	4	88	109	5	93	16	6
2013	M	71	27	4	78	225	6	90	105	7	--	--	--
2013	F	76	1	--	82	119	4	90	225	5	90	3	9
2014	M	70	21	6	80	204	6	89	84	7	96	6	12
2014	F	75	4	3	82	159	5	90	222	5	97	2	4

Table 4.2. Continued.

Return year	Sex	Age-3			Age-4			Age-5			Age-6		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
						Natural origin							
1998	M	65	11	4	85	29	7	99	11	6	--	--	--
1998	F	--	--	--	85	18	7	98	9	5	--	--	--
1999	M	70	18	6	84	64	7	99	23	7	--	--	--
1999	F	67	2	1	84	66	6	95	43	5	--	--	--
2000	M	72	15	4	85	40	7	98	26	8	--	--	--
2000	F	--	--	--	88	36	6	95	59	4	--	--	--
2001	M	--	--	--	91	11	9	--	--	--	--	--	--
2001	F	--	--	--	88	6	7	99	4	1	92	1	--
2002	M	71	2	5	73	2	20	--	--	--	119	1	--
2002	F	--	--	--	81	1	--	--	--	--	--	--	--
2003	M	65	1	--	83	20	6	97	5	15	--	--	--
2003	F	--	--	--	86	11	4	95	2	7	--	--	--
2004	M	68	4	12	82	16	5	97	33	8	--	--	--
2004	F	65	1	--	85	9	2	94	79	5	--	--	--
2005	M	72	6	7	82	30	6	98	8	5	--	--	--
2005	F	74	1	--	84	30	5	94	11	3	100	1	--
2006	M	76	2	4	90	15	6	93	17	8	--	--	--
2006	F	--	--	--	89	9	7	96	22	6	--	--	--
2007	M	68	18	5	86	8	9	94	6	7	--	--	--
2007	F	70	3	3	79	3	4	95	15	4	--	--	--
2008	M	72	33	4	86	66	7	102	5	6	98	1	--
2008	F	72	3	2	89	57	5	96	10	3	104	1	--
2009	M	68	48	5	89	100	7	104	12	9	--	--	--
2009	F	67	1	--	87	106	5	96	34	4	--	--	--
2010	M	68	32	5	82	38	6	96	8	9	--	--	--
2010	F	80	1	--	85	52	5	95	23	5	--	--	--
2011	M	70	17	7	83	68	8	100	12	8	--	--	--
2011	F	--	--	--	85	64	6	94	12	6	--	--	--
2012	M	72	14	5	88	24	9	100	12	10	--	--	--
2012	F	--	--	--	88	20	3	94	35	5	--	--	--
2013	M	72	3	2	83	7	4	--	--	--	--	--	--
2013	F	--	--	--	89	3	4	89	1	--	--	--	--
2014	M	74	5	5	88	11	8	105	5	6	--	--	--
2014	F	--	--	--	84	5	3	94	3	2	--	--	--

Sex Ratio and Fecundity

The long-term mean sex ratio of fish retained for broodstock (excludes released fish) favored females (Table 4.3), and the sex ratio of the 2014 brood was slightly more skewed towards female fish than the average. Of the 2014 brood female Chinook sampled, overall fecundity (4,293) was less than the long-term mean fecundity (Table 4.3), and less than the mean fecundity value (4,475) used to estimate broodstock collection quotas in the broodstock collection protocols. Fecundity data from the 2014 brood was only collected from hatchery origin females because no wild females were spawned for the Wells yearling Chinook program.

Table 4.3. Sex ratio (Male/Female) and mean fecundity by return year and origin of summer Chinook Salmon retained for broodstock at Wells Hatchery. NS = not sampled.

Return year	Hatchery Chinook Salmon				Wild Chinook Salmon				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
1994	303	290	NS	1.04:1	3	4	NS	0.75:1	1.04:1	NS
1995	417	493	NS	0.85:1	41	67	NS	0.61:1	0.82:1	NS
1996	382	289	4,373	1.32:1	46	44	5,553	1.05:1	1.29:1	4,672
1997	147	210	4,788	0.70:1	22	36	4,702	0.61:1	0.69:1	4,778
1998	433	521	5,236	0.83:1	77	37	--	2.08:1	0.91:1	5,236
1999	438	408	4,015	1.07:1	112	124	3,703	0.90:1	1.03:1	3,974
2000	594	486	4,418	1.22:1	82	100	4,673	0.82:1	1.15:1	4,448
2001	590	549	4,693	1.07:1	11	11	5,415	1.00:1	1.07:1	4,713
2002	582	633	5,225	0.92:1	5	2	--	2.50:1	0.92:1	5,225
2003	441	602	4,638	0.73:1	28	14	4,368	2.00:1	0.76:1	4,630
2004	465	426	NS	1.09:1	57	94	NS	0.61:1	1.00:1	NS
2005	590	629	4,220	0.94:1	45	43	3,897	1.05:1	0.94:1	4,198
2006	525	567	4,414	0.93:1	34	31	4,155	1.10:1	0.93:1	4,421
2007	515	586	4,605	0.88:1	34	21	2,906	1.62:1	0.90:1	4,616
2008	593	605	4,652	0.98:1	106	71	4,370	1.49:1	1.03:1	4,639
2009	599	626	4,412	0.96:1	172	148	5,047	1.16:1	1.00:1	4,478
2010	532	457	4,244	1.16:1	82	78	4,371	1.05:1	1.15:1	4,259
2011	489	539	4,348	0.91:1	109	85	4,195	1.28:1	0.96:1	4,323
2012	355	352	3,894	1.00:1	50	58	4,856	0.86:1	1.01:1	3,948
2013	363	354	4,093	1.03:1	11	4	NS	2.75:1	1.04:1	4,093
2014	323	395	4,293	0.82:1	21	8	NS	2.63:1	0.85:1	4,293
Mean	461	477	4,475	0.96:1	55	51	4,444	1.06:1	0.98:1	4,497

ELISA Monitoring

Adult female Chinook Salmon spawned for yearling-release programs are screened for the presence of Bacterial Kidney Disease (BKD) using an ELISA assay. Results of this test are grouped into four general categories based on the optical density (OD) of each sample. Overall, 95% of OD values from sampled females have been in the Below-low category. For the 2014 brood, two females had OD values in the High category (Table 4.4), but all other sampled females were in the Below-low category. Eggs from both High ELISA females were culled prior to hatching.

Table 4.4. Enzyme-linked immunosorbent assay (ELISA) test results (% of sampled fish) by return year and ELISA category for female summer Chinook Salmon spawned at Wells Hatchery for yearling-release programs.

Return year	Below-low	Low	Med	High	Total number
	<0.099	0.099 - 0.199	0.20 - 0.449	> 0.450	
1993	100.0	0.0	0.0	0.0	132
1994	97.2	1.7	0.0	1.1	181
1995	78.8	12.9	1.8	6.5	170
1996	99.0	0.5	0.0	0.5	196
1997	88.6	7.6	1.1	2.7	185
1998	91.7	5.5	1.8	0.9	109
1999	99.1	0.9	0.0	0.0	106
2000	87.9	8.8	3.3	0.0	91
2001	99.3	0.0	0.0	0.7	139
2002	93.9	2.4	0.0	3.7	82
2003	94.9	2.0	2.0	1.0	99
2004	95.0	5.0	0.0	0.0	20
2005	98.9	0.5	0.0	0.5	190
2006	100.0	0.0	0.0	0.0	167
2007	98.2	1.8	0.0	0.0	166
2008	99.6	0.4	0.0	0.0	239
2009	99.7	0.3	0.0	0.0	272
2010	98.6	1.4	0.0	0.0	293
2011	98.7	1.3	0.0	0.0	312
2012	97.8	0.7	0.7	0.7	138
2013	86.1	13.9	0.0	0.0	137
2014	98.5	0.0	0.0	1.5	132
Mean	95.5	3.1	0.5	0.9	162

4.2: Within-hatchery Monitoring

Juvenile Marking and Tagging

Juvenile summer Chinook Salmon at Wells Hatchery are marked with an adipose-fin clip and tagged with a CWT prior to release. Mark retention sampling conducted prior to release in each year indicates that overall retention of applied marks and tags averaged 97.4% and 95.2% for subyearling and yearling program fish, respectively (Table 4.5). Summer Chinook Salmon for both programs are released directly from Wells Hatchery into the Columbia River. Yearling program fish are released in mid-April while subyearling program fish have historically been released in mid-June. However, a study (Snow 2015) conducted with the 2003-2007 broods of subyearling program fish determined that release-to-adult survival could be improved through earlier release (mid-May) of these fish, and thus the release time for subyearling fish was changed to mid-May beginning with the 2008 brood (2009 release; Table 4.5).

The overall mean number of fish released has been slightly higher than the release goal of 320,000 for yearling program fish, and lower than the 484,000 goal for the subyearling program fish. Releases of 2014 brood fish were similar, with subyearling program fish below the goal and yearling program fish above the release goal, although releases of both groups fell within ± 10% of the release goals (Table 4.5).

Table 4.5. Pre-release marking and tagging of Wells Hatchery summer Chinook by brood year and program. All CWT codes are prefaced by the two-digit WDFW agency code “63”. All fish also received an adipose fin-clip prior to release, and the mark rate represents the proportion of total fish released that successfully retained both the mark and tag.

Brood year	Subyearling Chinook Salmon				Yearling Chinook Salmon			
	CWT code (s)	Mark rate	Release start	Released	CWT code (s)	Mark rate	Release start	Released
1992	- -	- -	- -	- -	5005	0.632	27-Apr-94	331,353
1993	5145	0.978	28-Jun-94	187,382	4610, 5702	0.973, 0.953	15-Apr-95	388,248
1994	5546, 5703	0.972	15-Jun-95	450,935	5324, 5838	0.932, 0.979	1-Apr-96	365,000
1995	5841, 6044	0.954	13-Jun-96	408,000	4129, 4130	0.984, 0.977	1-Apr-97	290,000
1996	6054, 6323	0.978	18-Jun-97	473,000	0134, 0217	0.984	15-Apr-98	356,707
1997	602	0.975	4-Jun-98	541,923	611	0.981	15-Apr-99	381,687
1998	1018	0.978	18-Jun-99	370,617	1061	0.955	18-Apr-00	457,770
1999	267	0.964	19-Jun-00	363,600	468	0.98	16-Apr-01	312,098
2000	775	1	20-Jun-01	498,500	995	0.978	15-Apr-02	343,423
2001	1423	0.98	17-Jun-02	376,027	1549	0.991	21-Apr-03	185,200
2002	1368, 1370	0.992, 0.981	16-Jun-03	473,100	1890	0.987	19-Apr-04	306,810

2003	2370, 2371	0.955, 0.898	11-May-04	425,271	2580	0.979	11-Apr-05	313,509
2004	2285, 2286	0.978, 0.963	18-May-05	471,123	2799, 2864	0.947	21-Apr-06	312,980
2005	3298, 3299	0.978, 0.990	12-May-06	430,203	3596	0.967	23-Apr-07	333,587
2006	3385, 3386	0.992, 0.993	16-May-07	396,538	3799	0.994	6-Apr-08	311,880
2007	3872, 3871	0.978, 0.990	13-May-08	402,527	4390, 4287	0.989	15-Apr-09	310,063
2008	4876	0.972	11-May-09	427,131	5092, 5093	0.984	16-Apr-10	336,881
2009	5375	0.995	14-May-10	471,286	5280, 5364	0.707	15-Apr-11	446,313
2010	5775	1	19-May-11	442,821	5770, 5964	0.999	16-Apr-12	350,218
2011	6370	0.998	15-May-12	492,777	5773	0.998	15-Apr-13	289,998
2012	6505, 6463	0.984, 0.984	20-May-13	499,365	6504	0.998	15-Apr-14	318,902
2013	6680	0.989	16-May-14	443,636	6678	0.988	16-Apr-15	339,236
2014	6835	0.889	27-May-15	464,137	6762, 6879	0.988	15-Apr-16	350,000
Mean	--	0.974	--	432,268	--	0.952	--	336,168

Juvenile Size and Condition at Release

Size-at-release fork length and weight targets for DCPUD program fish are described in Murdoch et al. (2012). The 2014 brood yearling program fish were 101% of the target release fork length goal. Mean size-at-release of the 2014 brood subyearling program fish was 80.2 mm, but specific size-at-release targets for this program have not yet been developed that reflect the earlier release date initiated with the 2008 brood (Table 4.6). The coefficient of variation (CV) for the 2014 brood subyearling and yearling programs were at or below the yearling-release target value of nine.

Table 4.6. Mean fork length (mm), weight (g), coefficient of variation (CV), standard deviation (SD), and condition factor (K) of Wells Hatchery summer Chinook Salmon by release type and brood year prior to release. Data for subyearling program fish from the 1998-2007 broods are from mid-June release groups, and data from the 2008-2014 broods are from mid-May releases.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
				Wells yearling Chinook Salmon				
1997	202.1	19.5	9.6	75.6	- -	- -	6.0	0.92
1998	183.6	13.6	7.4	74.1	16.6	22.4	6.1	1.20
1999	159.5	9.8	6.1	44.5	8.3	18.7	10.2	1.10
2000	161.2	11.6	7.2	47.9	11.1	23.2	9.5	1.14
2001	155.7	12.3	7.9	43.8	10.0	22.8	10.3	1.16
2002	156.0	13.4	8.6	46.7	11.8	25.3	9.7	1.23
2003	157.0	19.8	12.6	45.0	16.4	36.4	10.1	1.16
2004	170.8	11.0	6.4	52.0	10.4	20.0	8.7	1.04

2005	154.9	13.4	8.6	42.1	10.6	25.1	10.7	1.13
2006	153.8	11.1	7.2	41.1	8.6	20.9	11.0	1.13
2007	173.0	9.9	5.7	52.3	9.4	18.0	8.6	1.01
2008	170.0	18.2	10.7	56.0	15.5	27.7	8.1	1.14
2009	168.0	12.6	7.5	47.9	9.7	20.2	9.5	1.01
2010	164.5	8.2	5.0	45.3	7.5	16.5	10.0	1.02
2011	163.7	13.9	8.5	50.3	12.9	25.6	9.0	1.15
2012	168.0	12.2	7.3	49.8	11.4	23.0	9.2	1.05
2013	164.2	14.8	9.0	46.6	12.5	26.8	9.7	1.05
2014	164.4	12.3	7.5	48.1	10.4	21.5	9.4	1.08
Target	162.0	- -	9.0	45.4	- -	- -	10.0	1.07
				Wells subyearling Chinook Salmon				
1998	116.5	8.0	6.9	18.3	5.1	27.9	24.7	1.16
1999	122.1	9.2	7.5	24.5	6.6	27.1	18.5	1.35
2000	111.3	8.5	7.6	16.9	4.9	28.9	26.7	1.23
2001	116.9	7.6	6.5	20.6	4.8	23.5	21.9	1.29
2002	108.1	8.0	7.4	14.7	3.6	25.0	30.9	1.16
2003	115.4	7.2	6.2	18.9	4.4	23.5	24.0	1.23
2004	109.5	6.1	5.6	15.0	2.8	18.7	30.2	1.14
2005	108.5	7.4	6.8	14.3	3.6	25.3	31.7	1.12
2006	111.0	10.3	9.3	14.9	- -	- -	30.4	1.09

Table 4.6. Continued.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
				Wells subyearling Chinook Salmon				
2007	108.1	7.3	6.7	13.5	- -	- -	33.5	1.07
2008	88.5	6.8	7.62	8.6	2.3	26.7	52.9	1.24
2009	84.0	10.9	12.9	6.7	- -	- -	67.5	1.13
2010	89.4	6.8	7.6	10.0	2.3	23.0	45.6	1.40
2011	92.1	5.9	6.4	9.1	1.9	21.1	49.9	1.17
2012	87.6	6.4	7.3	8.2	1.7	21.2	55.4	1.22
2013	78.8	4.8	6.0	5.8	1.1	19.0	77.6	1.19
2014	80.2	5.1	6.3	6.5	1.4	20.9	69.7	1.26
Target	- -	- -	- -	- -	- -	- -	- -	- -

Survival Estimates

In-hatchery survival from fertilization to release of the 2014 brood fish was greater than the target value for both the subyearling and yearling releases (Table 4.7). Subyearling survival was lower than target values for most of the post-ponding categories, while yearling program fish were above survival targets in all categories. Yearling program fish typically did not meet unfertilized-egg-to-release survival targets in years when egg losses were higher than usual, while subyearling program fish were usually below the target value because of losses after ponding.

Table 4.7. Survival (%) of Wells Hatchery summer Chinook Salmon by brood and survival category. Adult survival (collection to spawning) for each brood is listed under the yearling program.

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
Wells summer Chinook Salmon yearling									
1999	97.3	96.3	92.3	97.1	98.0	98.0	97.5	--	87.4
2000	98.3	95.2	93.8	99.9	99.5	99.4	99.0	--	92.9
2001	97.1	93.9	95.3	98.8	99.4	99.4	35.9	--	33.8
2002	94.2	97.0	94.1	100.0	99.6	99.6	92.4	--	87.0
2003	96.8	98.4	86.4	99.8	99.2	99.2	97.7	--	84.4
2004	98.3	98.2	92.0	100.0	99.0	98.9	96.7	--	89.0
2005	96.8	98.9	87.5	100.0	99.2	99.0	92.0	--	80.5
2006	96.4	97.3	82.0	99.3	99.4	99.2	97.8	--	79.7

Table 4.7. Continued.

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
Wells summer Chinook Salmon yearling									
2007	97.2	98.2	87.9	98.3	99.9	99.7	93.0	--	80.4
2008	97.0	94.6	93.2	97.6	99.8	99.4	92.0	--	83.8
2009	96.0	97.2	95.2	100.0	97.6	97.5	95.5	--	90.9
2010	92.9	82.4	95.0	99.9	98.3	97.9	97.1	--	92.2
2011	96.0	96.5	87.7	100.0	97.2	78.3	83.9	--	70.7
2012	99.4	96.2	93.1	98.7	99.8	94.7	94.7	--	87.0
2013	99.6	99.4	95.3	98.4	99.9	99.7	98.9	--	92.7
2014	97.3	97.4	94.4	99.1	98.5	98.2	97.7	--	91.4

Target	90.0	85.0	92.0	98.0	97.0	93.0	90.0	95.0	81.0
Wells summer Chinook Salmon subyearling									
1999	--	--	90.9	100.0	96.7	96.3	96.2	--	87.5
2000	--	--	94.1	100.0	97.6	97.4	97.1	--	91.4
2001	--	--	94.6	100.0	95.6	94.2	94.1	--	89.1
2002	--	--	93.8	99.9	88.1	87.3	87.1	--	81.7
2003	--	--	85.7	100.0	87.9	87.9	87.8	--	75.3
2004	--	--	93.6	98.4	94.3	94.4	94.3	--	87.0
2005	--	--	87.1	100.0	82.7	82.4	82.2	--	71.6
2006	--	--	90.0	100.0	94.3	80.5	78.6	--	70.8
2007	--	--	91.7	86.5	99.5	99.1	98.3	--	78.0
2008	--	--	95.0	84.2	99.4	94.3	94.1	--	75.3
2009	--	--	94.9	98.6	92.0	86.9	85.9	--	80.3
2010	--	--	95.2	98.4	82.8	81.7	80.4	--	75.3
2011	--	--	94.8	99.9	85.6	85.5	85.5	--	90.0
2012	--	--	95.0	99.5	92.3	81.6	81.5	--	77.1
2013	--	--	96.1	90.0	91.1	90.8	90.5	--	78.3
2014	--	--	93.4	95.9	91.3	90.9	90.9	--	81.4
Target	90.0	85.0	92.0	98.0	97.0	93.0	90.0	95.0	81.0

4.3: Life History Monitoring

Because the Wells summer Chinook Salmon program is a harvest augmentation program and not a conservation program, monitoring life history traits in relation to those of a natural population is not appropriate. However, assessing life history monitoring indicators such as age at return, length at return, and sex ratio at return is valuable from a management perspective to assess stock-specific factors that may affect broodstock collection, fecundity, and other in-hatchery metrics. Adult returns to Wells Hatchery and those recovered in fisheries and on spawning grounds were used to assess life history characteristics of Wells yearling and subyearling summer Chinook Salmon releases.

Age at Maturity

Wells Hatchery summer Chinook Salmon are considered a segregated harvest program where comparisons between the hatchery stock and naturally-produced fish are not applicable.

Releases of subyearling fish from the 2009 brood returned primarily as age-4 adults, while those released as yearlings returned about equally at age-4 and age-5 (Table 4.8). Overall, yearling fish typically had an older total age at return than subyearling program fish, but subyearling fish spent more of their life in saltwater (Figure 4.1).

Table 4.8. Proportion of adult returns by total age of the 1992-2009 broods of Wells Hatchery summer Chinook Salmon released as subyearling or yearling migrants. Data is from RMIS recovery of CWTs in the broodstock, freshwater fisheries (sport, commercial, and tribal), and spawning ground categories, although juvenile fish captured within their year of release were excluded.

Brood year	Release type	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Total
1992	Yearling	0.000	0.029	0.357	0.559	0.052	0.002	411
1993	Subyearling	0.000	0.041	0.412	0.548	0.000	0.000	25
1993	Yearling	0.000	0.029	0.357	0.559	0.052	0.002	1,258
1994	Subyearling	0.000	0.000	0.731	0.269	0.000	0.000	11
1994	Yearling	0.057	0.044	0.254	0.587	0.058	0.000	104
1995	Subyearling	0.014	0.102	0.675	0.208	0.000	0.000	70
1995	Yearling	0.000	0.019	0.373	0.579	0.029	0.000	651
1996	Subyearling	0.052	0.211	0.662	0.075	0.000	0.000	369
1996	Yearling	0.007	0.040	0.314	0.569	0.069	0.000	834
1997	Subyearling	0.019	0.057	0.842	0.083	0.000	0.000	106
1997	Yearling	0.003	0.044	0.402	0.535	0.015	0.000	3,535
1998	Subyearling	0.054	0.105	0.742	0.100	0.000	0.000	110
1998	Yearling	0.006	0.019	0.476	0.480	0.018	0.001	2,375
1999	Subyearling	0.005	0.115	0.390	0.445	0.045	0.000	184

Table 4.8. Continued.

Brood year	Release type	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Total
1999	Yearling	0.011	0.015	0.270	0.553	0.150	0.001	599
2000	Subyearling	0.000	0.051	0.425	0.524	0.000	0.000	99
2000	Yearling	0.009	0.074	0.201	0.586	0.126	0.003	4,233
2001	Subyearling	0.000	0.102	0.511	0.381	0.006	0.000	453
2001	Yearling	0.000	0.002	0.232	0.586	0.176	0.003	1,539
2002	Subyearling	0.000	0.092	0.816	0.092	0.000	0.000	76
2002	Yearling	0.000	0.033	0.291	0.617	0.059	0.000	2,475
2003	Subyearling	0.000	0.144	0.773	0.083	0.000	0.000	94
2003	Yearling	0.000	0.015	0.333	0.574	0.078	0.000	1,177
2004	Subyearling	0.029	0.247	0.615	0.109	0.000	0.000	529
2004	Yearling	0.008	0.039	0.344	0.586	0.021	0.002	2,548
2005	Subyearling	0.058	0.323	0.527	0.089	0.002	0.000	1,722
2005	Yearling	0.007	0.077	0.599	0.305	0.012	0.000	1,030

2006	Subyearling	0.037	0.199	0.645	0.119	0.000	0.000	366
2006	Yearling	0.015	0.070	0.363	0.520	0.033	0.000	4,969
2007	Subyearling	0.004	0.218	0.718	0.061	0.000	0.000	821
2007	Yearling	0.003	0.045	0.547	0.395	0.009	0.000	791
2008	Subyearling	0.105	0.391	0.450	0.054	0.000	0.000	367
2008	Yearling	0.006	0.095	0.428	0.439	0.031	0.000	2,621
2009	Subyearling	0.000	0.160	0.726	0.113	0.000	0.000	980
2009	Yearling	0.003	0.099	0.441	0.446	0.011	0.000	2,484
Mean	Subyearling	0.022	0.150	0.627	0.197	0.003	0.000	375
Mean	Yearling	0.008	0.044	0.366	0.526	0.056	0.001	1,868

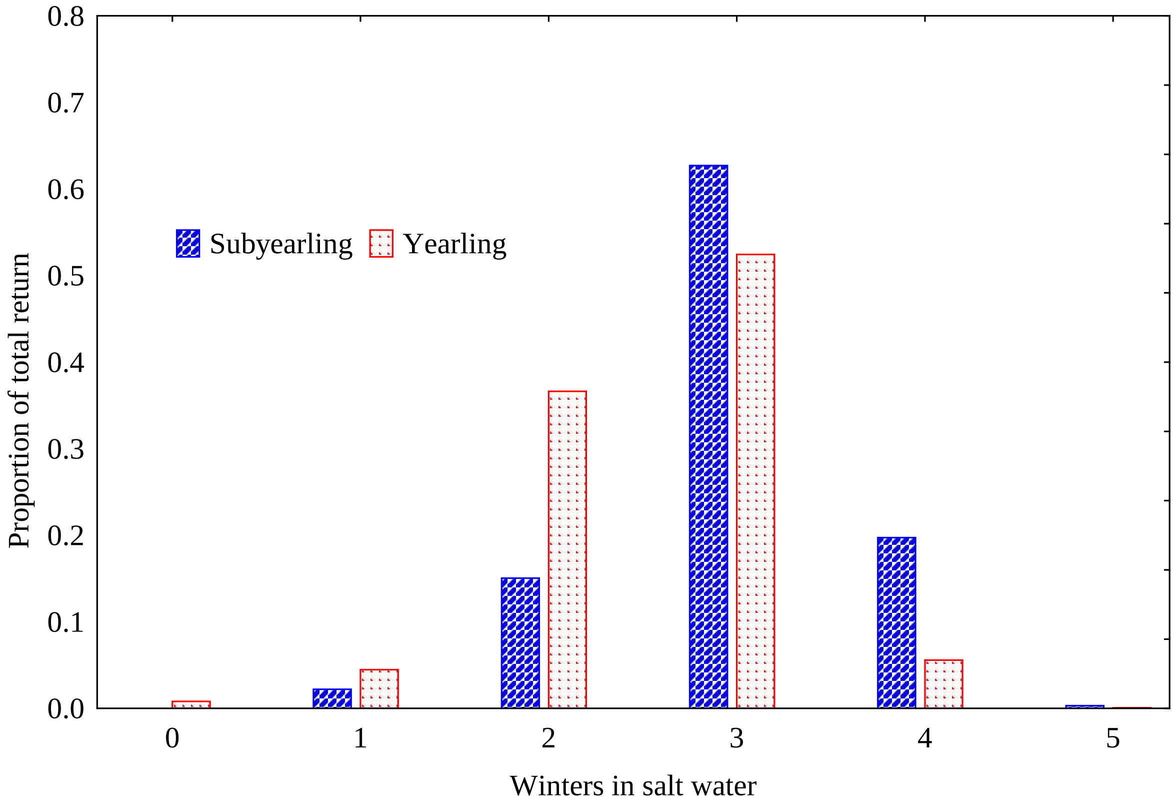

Figure 4.1. Mean salt water age of Wells Hatchery summer Chinook Salmon from the 1992-2009 broods released as subyearling or yearling program fish. Adult returns are from broodstock, spawning ground, or freshwater sport, commercial, and tribal fisheries.

Length at Maturity

Because Wells summer Chinook Salmon are considered a segregated harvest program, comparisons between the hatchery stock and naturally-produced fish are not applicable. Lengths of returning yearling and subyearling releases by age were collected primarily from broodstock fish spawned at Wells Hatchery and are presented in Table 4.9. Juvenile Chinook Salmon released as subyearlings had a greater mean POH length at younger adult return ages than juveniles released as yearlings, but the differences decreased as age-at-return increased (Figure 4.2).

Table 4.9. Mean post-eye to hypural plate (POH) length (cm), number (*N*), and standard deviation (SD) of adult returns by sex and total age of subyearling and yearling Chinook Salmon releases from Wells Hatchery from the 1993-2009 broods.

Brood	Sex	Mean length (POH; cm) of adult returns											
		Age-3			Age-4			Age-5			Age-6		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Subyearling program													
1993	M	--	--	--	--	--	--	73	2	7	--	--	--
1993	F	--	--	--	61	1	0	74	4	5	--	--	--
1994	M	--	--	--	70	2	13	--	--	--	--	--	--
1994	F	--	--	--	69	2	0	71	3	7	--	--	--
1995	M	52	5	3	66	19	6	82	2	5	--	--	--
1995	F	--	--	--	67	22	4	72	9	5	--	--	--
1996	M	54	58	6	66	46	4	88	1	0	--	--	--
1996	F	--	--	--	59	17	6	71	121	4	78	13	3
1997	M	52	4	8	68	17	5	81	1	0	--	--	--
1997	F	--	--	--	71	14	5	76	4	3	--	--	--
1998	M	--	--	--	54	6	9	69	15	7	--	--	--
1998	F	--	--	--	71	15	2	73	6	4	--	--	--
1999	M	55	5	4	65	15	5	70	5	5	81	1	0
1999	F	--	--	--	68	25	6	74	33	3	76	2	4
2000	M	51	4	4	66	10	4	73	4	7	--	--	--
2000	F	--	--	--	69	11	5	73	13	4	--	--	--
2001	M	58	10	5	67	26	5	74	14	4	74	1	0
2001	F	--	--	--	68	47	3	75	35	3	72	1	0
2002	M	61	1	0	66	5	2	--	--	--	--	--	--
2002	F	--	--	--	69	7	3	75	5	5	--	--	--
2003	M	60	2	6	65	17	5	81	1	0	--	--	--
2003	F	--	--	--	63	1	0	69	14	5	74	3	3
2004	M	57	29	3	69	21	5	72	3	4	--	--	--
2004	F	--	--	--	70	47	5	74	15	4	--	--	--
2005	M	58	98	5	68	60	6	80	3	1	--	--	--
2005	F	--	--	--	71	156	4	74	7	3	--	--	--
2006	M	55	31	4	63	7	4	69	2	13	--	--	--
2006	F	--	--	--	65	14	3	74	10	3	--	--	--
2007	M	70	29	8	83	42	8	88	4	2	--	--	--
2007	F	72	6	6	84	48	5	89	2	1	--	--	--
2008	M	56	33	4	67	8	5	--	--	--	--	--	--
2008	F	66	5	7	70	16	4	69	2	6	--	--	--
2009	M	56	17	5	63	42	4	70	5	5	--	--	--
2009	F	63	2	2	67	59	3	73	18	4	--	--	--

Mean	M	57	23	5	67	21	6	76	4	4	78	1	0
Mean	F	67	4	5	68	30	3	74	18	4	75	5	3
						Yearling program							
1993	M	41	22	5	59	2	11	73	145	7	78	16	6
1993	F	--	--	--	60	5	4	75	127	4	78	53	6

Table 4.9. Continued.

Brood	Sex	Mean length (POH; cm) of adult returns											
		Age-3			Age-4			Age-5			Age-6		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
						Yearling program							
1994	M	33	1	0	61	17	9	75	24	7	--	--	--
1994	F	--	--	--	63	2	0	72	30	4	76	3	14
1995	M	43	17	4	60	119	6	71	77	6	78	2	5
1995	F	--	--	--	65	51	4	74	107	4	80	6	5
1996	M	41	34	5	59	200	5	74	65	6	80	2	8
1996	F	--	--	--	67	48	4	75	134	4	81	7	2
1997	M	42	43	4	64	376	5	75	239	6	77	5	13
1997	F	--	--	--	66	265	4	76	438	4	80	16	4
1998	M	43	11	3	63	241	5	73	279	6	77	33	7
1998	F	--	--	--	68	62	4	75	419	4	78	86	5
1999	M	41	6	3	61	17	4	71	43	5	78	3	3
1999	F	--	--	--	66	6	3	73	51	4	77	13	4
2000	M	46	9	3	62	222	4	69	292	5	72	50	6
2000	F	--	--	--	65	85	4	73	393	4	75	99	6
2001	M	44	1	0	63	88	4	72	105	5	69	7	5
2001	F	--	--	--	64	35	3	74	178	5	76	22	4
2002	M	51	2	2	63	171	4	72	175	6	79	15	4
2002	F	--	--	--	66	62	4	74	297	4	79	31	3
2003	M	--	--	--	60	75	5	72	33	7	80	3	2
2003	F	--	--	--	64	57	5	72	112	5	75	10	6
2004	M	50	20	2	63	249	5	70	77	6	--	--	--
2004	F	--	--	--	67	164	4	73	205	4	--	--	--
2005	M	44	17	3	61	123	5	70	37	6	77	2	1
2005	F	--	--	--	65	38	4	72	54	3	79	3	4
2006	M	50	58	5	62	318	5	71	164	8	--	--	--
2006	F	--	--	--	65	217	4	95	312	401	--	--	--
2007	M	57	14	5	71	65	6	85	21	8	77	4	12
2007	F	--	--	--	76	18	8	85	57	6	81	4	8
2008	M	49	23	3	61	108	4	71	68	5	--	--	--
2008	F	--	--	--	65	108	4	72	143	4	--	--	--
2009	M	49	1	--	60	98	5	68	53	5	--	--	--
2009	F	--	--	--	65	40	4	72	120	4	--	--	--
Mean	M	45	17	3	62	146	5	72	112	6	77	12	6
Mean	F	--	--	--	66	74	4	75	187	28	78	27	5

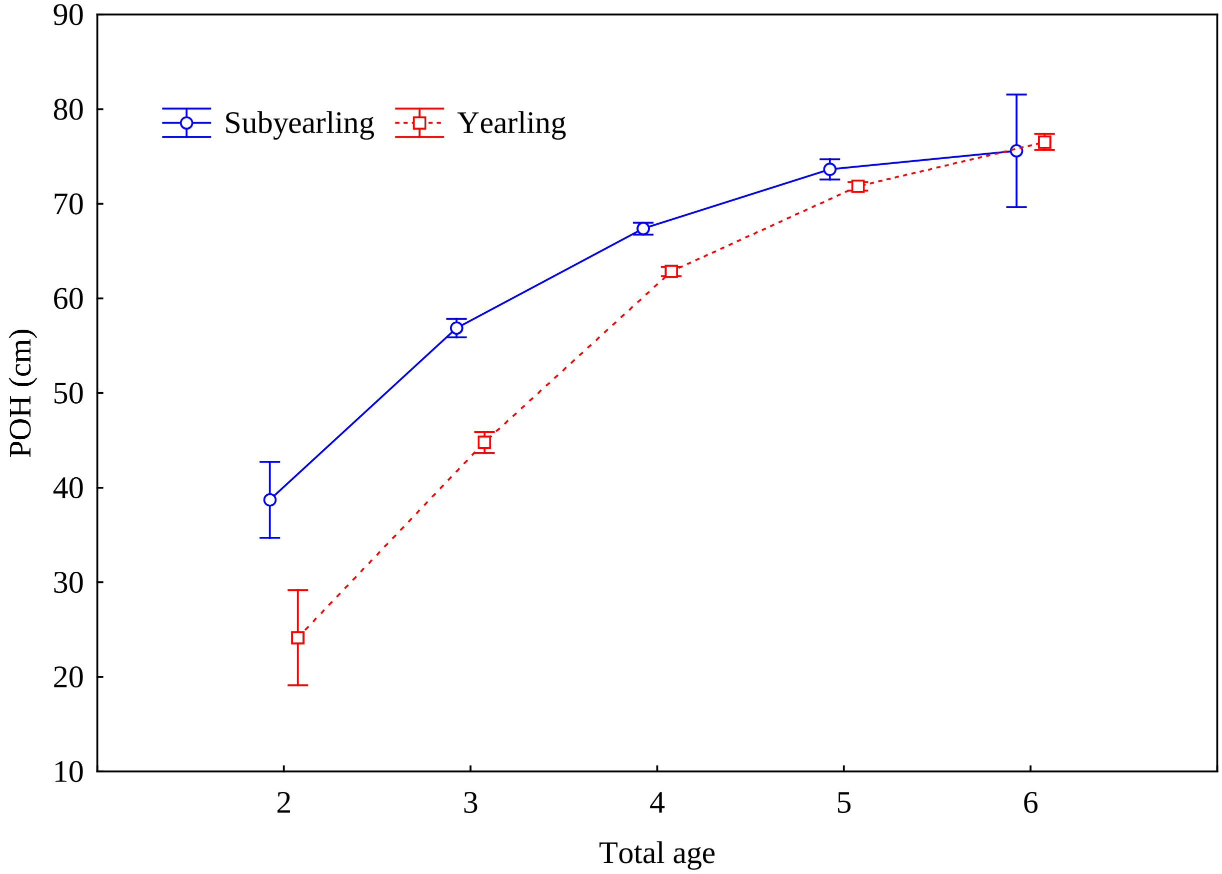

Figure 4.2. Mean (+/- 95% CI) POH length (cm) of adult returns of summer Chinook Salmon released as subyearling or yearling fish from the 1992-2009 broods.

Contribution to Fisheries

Based on expanded CWT recoveries, most Wells Hatchery summer Chinook Salmon prior to 2002 were captured in ocean fisheries, regardless of release type (Table 4.10). However, for the last five broods for which complete adult return data are available (2005-2009), harvest was primarily in freshwater fisheries for subyearling releases (36% freshwater; 31% ocean). Yearling releases were primarily captured in ocean fisheries (31% freshwater; 35% ocean; Table 4.10), but freshwater fishery extraction has been increasing (Figure 4.3). This change is primarily attributable to increases in freshwater sport and tribal harvest rates.

Table 4.10. Recovery of Wells Hatchery summer Chinook by brood, release type, and recovery category. Recovery values are derived from expanded CWT data.

Brood year	Broodstock		Freshwater commercial		Freshwater sport		Freshwater tribal		Ocean fisheries		Spawning ground		Total
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*
Subyearling program													
1993	22	54	0	0	0	0	3	7	16	39	0	0	41
1994	8	57	0	0	0	0	3	21	3	21	0	0	14
1995	67	53	1	1	0	0	3	2	53	42	2	2	126
1996	288	42	2	0	5	1	3	0	309	45	79	12	686
1997	47	20	1	0	23	10	6	3	125	54	30	13	232
1998	44	13	3	1	19	5	8	2	236	68	39	11	349
1999	97	19	0	0	30	6	32	6	325	63	31	6	515
2000	64	34	2	1	5	3	20	11	88	47	8	4	187
2001	294	37	15	2	62	8	68	8	338	42	24	3	801
2002	37	29	3	2	16	13	21	16	51	40	0	0	128
2003	66	43	7	5	12	8	15	10	49	32	3	2	152
2004	248	35	13	2	114	16	106	15	166	23	63	9	710
2005	628	27	80	3	304	13	499	21	597	26	232	10	2,340
2006	138	26	38	7	49	9	112	21	168	31	32	6	537
2007	279	22	57	4	158	12	282	22	433	34	60	5	1,269
2008	169	32	4	1	57	11	124	24	148	28	24	5	526
2009	487	32	46	3	251	17	173	12	510	34	29	2	1,496
Mean	175	34	16	2	65	8	87	12	213	39	39	5	595
Yearling program													
1993	1,175	72	2	0	14	1	60	4	322	20	54	3	1,627
1994	95	67	0	0	0	0	10	7	35	25	2	1	142
1995	415	37	7	1	37	3	21	2	457	41	183	16	1,120
1996	530	34	2	0	7	0	0	0	734	46	309	20	1,582
1997	1,538	14	25	0	217	2	81	1	7,191	67	1,730	16	10,782
1998	1,238	12	21	0	420	4	223	2	7,670	76	565	6	10,137
1999	176	11	3	0	259	16	103	6	1,000	62	66	4	1,607
2000	2,200	26	143	2	990	12	649	8	3,992	48	345	4	8,319
2001	900	33	96	4	340	12	177	7	1,171	43	39	1	2,723
2002	1,303	34	149	4	578	15	401	10	1,325	35	75	2	3,831
2003	566	29	45	2	242	13	305	16	721	38	43	2	1,922
2004	1,414	39	146	4	479	13	505	14	923	26	147	4	3,614
2005	595	35	49	3	137	8	203	12	665	39	66	4	1,715
2006	2,592	38	394	6	669	10	1,167	17	1,785	26	159	2	6,766
2007	385	33	45	4	160	14	193	16	386	33	14	1	1,183
2008	1,209	27	103	2	705	16	521	12	1,895	42	97	2	4,530
2009	1,579	28	168	3	725	13	957	17	2,072	37	94	2	5,595
Mean	1,054	33	82	2	352	9	328	9	1,903	41	235	5	3,953

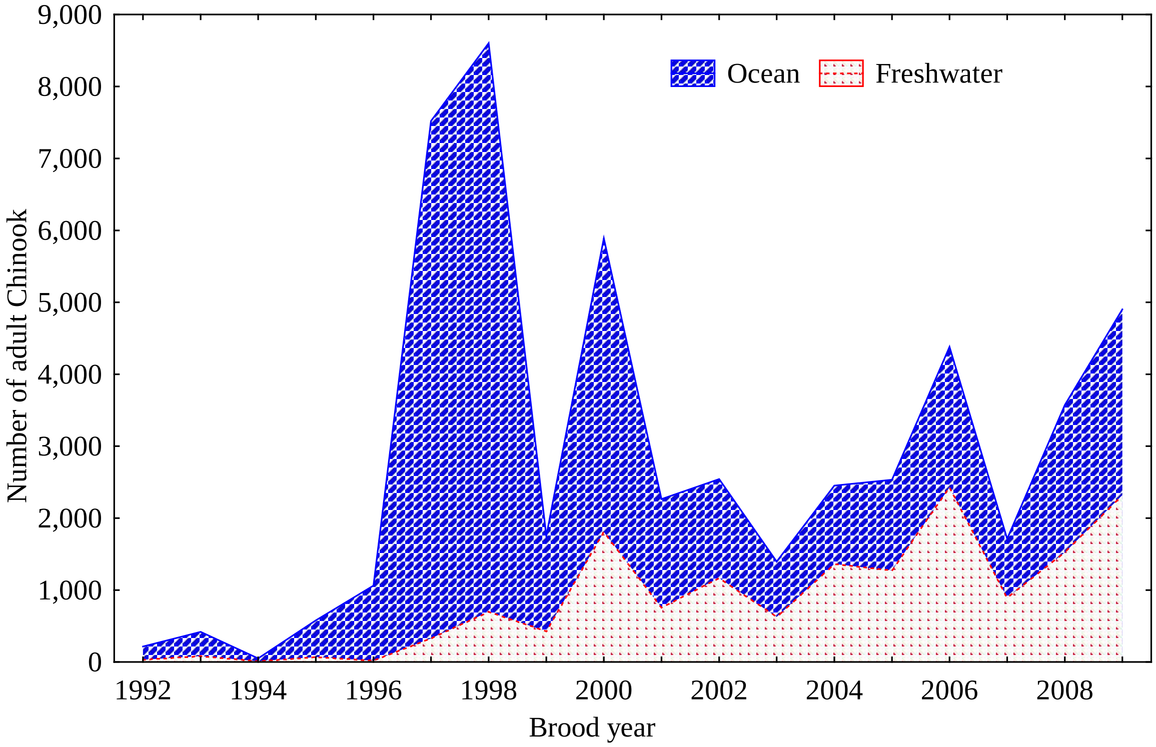

Figure 4.3. Cumulative retention of Wells summer Chinook Salmon by brood year in commercial, sport, and tribal fisheries in ocean and freshwater areas.

Straying

Because the Wells Hatchery summer Chinook Salmon program is a harvest augmentation programs and not a conservation program, all spawning ground recoveries were considered to be in non-target (i.e., stray) areas. Adult fish collected from the Wells Hatchery volunteer fish ladder were not considered strays, but the east and west fish ladders at Wells Dam were categorized as non-target recipient hatchery areas because trapping in those locations target Methow and Okanogan river stocks. However, recent broodstock collections in those locations only target adipose-present fish, thus excluding Wells adipose-clipped fish. Overall, stray rates from adult return of subyearling and yearling releases from the 1992-2009 broods averaged 7.4%, slightly above the 5% target value (Table 4.11). Returns from Wells releases seldom constituted greater than 5% of the spawning escapement by return year of other recipient summer Chinook populations, with the exception of the Chelan River, which is not considered an extant population (Table 4.12).

Table 4.11. Straying by Wells Hatchery summer Chinook Salmon released as subyearling and yearling smolts by brood year and recipient stray category.

Brood year	Total brood return	Recipient category			% stray
		Stream	Hatchery	Total	
1992	835	61	14	74	8.86
1993	1,668	56	36	87	5.22
1994	156	2	5	7	4.49
1995	1,246	185	28	212	17.01
1996	2,268	388	50	438	19.31
1997	10,795	1,730	132	1,889	17.5
1998	10,505	604	44	647	6.16
1999	2,128	97	17	112	5.26
2000	8,509	353	2	355	4.17
2001	3,524	63	0	63	1.79
2002	3,959	75	0	75	1.89
2003	2,076	47	0	47	2.26
2004	4,327	210	5	214	4.95
2005	4,071	298	24	322	7.91
2006	7,319	191	167	358	4.89
2007	2,459	74	115	189	7.69
2008	5,089	121	356	477	9.37
2009	7,089	122	136	258	3.64
Mean	4,335	260	63	324	7.35

Table 4.12. Recovery number and proportion (*N* (%)) of Wells Hatchery summer Chinook Salmon released as yearling and subyearling smolts within other summer Chinook Salmon spawning areas by return year.

Return year	Entiat River		Methow River		Okanogan River		Similkameen River		Wenatchee River		Chelan River	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
1997	0	0.0	0	0.0	61	11.4	0	0.0	0	0.0	0	0.0
1998	0	0.0	42	15.9	12	4.5	0	0.0	3	0.1	0	0.0
1999	0	0.0	6	0.7	0	0.0	0	0.0	0	0.0	16	11.5
2000	0	0.0	40	3.0	110	8.3	0	0.0	8	0.1	124	26.4
2001	0	0.0	492	10.8	316	7.0	21	0.3	0	0.0	332	33.7
2002	42	8.4	532	8.7	310	5.1	0	0.0	11	0.1	173	29.7
2003	65	9.4	146	5.8	25	1.0	0	0.0	13	0.1	87	20.8
2004	0	0.0	47	1.6	47	1.6	7	0.2	6	0.1	25	6.0
2005	11	3.0	83	1.8	69	1.5	9	0.2	14	0.2	83	15.8
2006	0	0.0	48	0.9	13	0.2	0	0.0	0	0.0	32	7.6
2007	3	1.2	46	1.6	3	0.1	0	0.0	0	0.0	22	11.6
2008	11	3.4	67	1.8	70	1.9	7	0.2	6	0.1	46	9.3
2009	3	1.2	128	3.0	78	1.8	0	0.0	0	0.0	0	0.0
2010	10	2.3	71	2.5	71	2.5	4	0.1	6	0.1	98	8.8
2011	0	0.0	32	0.6	12	0.2	5	0.1	0	0.0	38	3.0
2012	0	0.0	52	1.1	29	0.6	0	0.0	0	0.0	42	3.2
2013	0	0.0	93	1.8	0	0.0	0	0.0	0	0.0	18	1.1
2014	0	0.0	0	0.0	22	0.3	0	0.0	0	0.0	31	2.8
2015	6	1.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Mean	8	1.6	101	3.2	66	2.5	3	0.1	4	0.0	61	10.1

Smolt to Adult Survival and HRR

The smolt-to-adult return of Wells summer Chinook Salmon yearling and subyearling program fish was calculated from expanded CWT recoveries and averaged 1.1% and 0.1%, respectively (Table 4.13). The mean HRR, calculated as the number of adult returns divided by the number of adult broodstock, was also much greater for yearling releases (19.9) than for subyearling releases (2.2). Yearling releases on average were greater than the M&E Plan HRR target of 5.3, while subyearling releases were equal to the M&E Plan HRR target of 2.2. For the latest brood for which adult return information is expected to be complete (2009 brood) the HRR rate was above expected values for both release groups.

Table 4.13. Smolt-to-adult survival (SAR) and hatchery replacement rate (HRR) of Wells summer Chinook Salmon released as yearling and subyearling smolts by broodyear.

Brood	Program	Broodstock	Released	Adult returns	SAR (%)	HRR
1992	Yearling	205	331,353	527	0.159	2.6
1993	Yearling	225	388,248	1,568	0.404	7.0
1994	Yearling	185	365,000	138	0.038	0.7
1995	Yearling	144	290,000	1,099	0.379	7.6
1996	Yearling	193	356,707	1,556	0.436	8.1
1997	Yearling	189	381,867	10,529	2.757	55.7
1998	Yearling	207	457,770	9,608	2.099	46.4
1999	Yearling	176	312,098	1,571	0.503	8.9
2000	Yearling	175	343,423	8,101	2.359	46.3
2001	Yearling	248	185,200	2,723	1.470	11.0
2002	Yearling	182	306,810	3,796	1.237	20.9
2003	Yearling	144	313,509	1,922	0.613	13.3
2004	Yearling	176	312,980	3,614	1.155	20.5
2005	Yearling	164	333,587	1,657	0.497	10.1
2006	Yearling	200	311,880	6,750	2.164	33.8
2007	Yearling	179	318,902	1,174	0.368	6.6
2008	Yearling	191	336,881	4,513	1.345	23.7
2009	Yearling	164	350,000	5,595	1.599	34.1
Mean	Yearling	186	333,123	3,691	1.088	19.9
1993	Subyearling	173	187,382	40	0.021	0.2
1994	Subyearling	255	450,935	15	0.003	0.1
1995	Subyearling	221	408,000	120	0.029	0.5
1996	Subyearling	336	473,000	671	0.142	2.0
1997	Subyearling	274	541,923	228	0.042	0.8
1998	Subyearling	179	370,617	341	0.092	1.9
1999	Subyearling	212	363,600	498	0.137	2.3
2000	Subyearling	257	498,500	186	0.037	0.7
2001	Subyearling	210	376,027	801	0.213	3.8
2002	Subyearling	265	473,100	128	0.027	0.5
2003	Subyearling	224	425,271	152	0.036	0.7
2004	Subyearling	293	471,123	710	0.151	2.4
2005	Subyearling	262	430,203	2,337	0.543	8.9
2006	Subyearling	333	396,538	537	0.135	1.6
2007	Subyearling	334	499,365	1,262	0.253	3.8
2008	Subyearling	279	427,131	526	0.123	1.9
2009	Subyearling	254	464,137	1,496	0.322	5.9
Mean	Subyearling	257	426,874	591	0.136	2.2

Section 5: Wells Hatchery Summer Steelhead

This section focuses on the last brood for which releases were completed during the report year (2015 brood) and includes data from historic broods where appropriate. Broodstock for the Wells Hatchery summer steelhead program are primarily collected from the fish ladders at Wells Dam, or more recently, from the Twisp River Weir and the outfall channels at the Methow (WDFW) and Winthrop (USFWS) fish hatcheries. Returning adult steelhead from the Wells Hatchery Complex programs support salmon recovery goals and provide harvest opportunities in years of high abundance.

5.1: Broodstock Collection and Sampling

Trapping of the 2015 brood of Wells Hatchery summer steelhead occurred between 6 August and 9 November 2014 at Wells Dam. During this time a total of 191 adipose fin-clipped hatchery origin fish were retained, representing 5.3% of the estimated adipose fin-clipped hatchery fish returning to Wells Dam during the trapping period. Overall, pre-spawn mortality totaled 0.4% of the total hatchery fish collected. In addition to fish collected at Wells Dam, broodstock were also collected from the Twisp River weir, the Omak Creek weir, and from the Methow Hatchery outfall channel. Spring 2015 trapping at the Twisp River weir and the Methow Hatchery outfall provided 30 and 37 hatchery origin fish for Wells Hatchery safety-net programs, respectively. Natural origin fish were also retained from the Twisp River weir for the Twisp River conservation program, and no pre-spawn mortalities were recorded from broodstock collected at tributary sites (Table 5.1).

Table 5.1. Collection of summer steelhead at Wells Hatchery and the prespawn mortality (PSM), surplus mortality (Mort), spawning (Spawn), and release (Rel.) totals by brood and fish origin (hatchery or wild). Table excludes fish released prior to the implementation of spawning.

Brood year	Wild steelhead					Hatchery steelhead					Total spawned
	Total	PSM	Mort	Spawn	Rel.	Total	PSM	Mort	Spawn	Rel.	
					Wells Hatchery broodstock						
1999	31	2	0	27	2	385	2	0	381	2	408
2000	44	3	0	38	3	348	8	0	326	14	364
2001	32	1	0	25	6	366	11	0	312	43	337
2002	19	0	0	18	1	384	10	0	364	10	382
2003	27	1	0	26	0	274	4	9	261	0	287
2004	117	3	0	112	2	246	8	0	237	1	349
2005	69	6	0	63	0	346	11	0	305	30	368
2006	91	5	0	86	0	324	18	0	292	14	378
2007	46	0	0	44	2	320	21	0	298	1	342

Table 5.1. Continued.

Brood year	Wild steelhead					Hatchery steelhead					Total spawned
	Total	PSM	Mort	Spawn	Rel.	Total	PSM	Mort	Spawn	Rel.	
					Wells Hatchery broodstock						
2008	94	2	0	88	4	277	6	0	264	7	352
2009	73	1	2	67	3	302	27	0	230	45	297
2010	91	2	2	69	18	277	6	39	232	0	301
2011	56	3	0	50	3	270	4	10	256	0	306
2012	63	4	3	56	0	261	23	22	216	0	272
2013	19	2	0	17	0	230	5	12	212	0	229
2014	0	0	0	0	0	452	179	33	240	0	240
2015	0	0	0	0	0	258	1	18	239	0	239
Mean	51	2	0	46	3	313	20	8	274	9	321
					Okanogan broodstock						
2014	0	0	0	0	0	42	2	0	40	0	40
2015	0	0	0	0	0	43	0	0	43	0	43
Mean	--	--	--	--	--	43	1	0	42	0	42
					Omak Creek broodstock						
2014	16	1	0	15	0	0	0	0	0	0	15
2015	15	0	0	15	0	0	0	0	0	0	15
Mean	16	1	0	15	0	0	0	0	0	0	15
					Twisp River broodstock						
2011	26	1	0	25	0	--	--	--	--	--	25
2012	26	0	0	26	0	--	--	--	--	--	26
2013	23	0	0	23	0	--	--	--	--	--	23
2014	23	0	0	23	0	--	--	--	--	--	23
2015	18	0	0	18	0	23	0	14	9	0	27
Mean	23	0	0	23	0	23	0	14	9	0	25

Age at Maturity

Most summer steelhead collected for Wells Hatchery broodstock were fish that had spent a single winter in salt water before returning to Wells Dam (1-salt; Table 5.2). The overall mean proportion of 1-salt and 2-salt fish was similar between hatchery and natural origin fish, although differences within years were observed. Broodstock collected at the Twisp River weir were typically natural origin fish, and were mostly 2-salt fish on average, similar to the 2015 brood age ratio (Table 5.2). Hatchery origin fish collected for broodstock at the Twisp River weir in 2015 were equally represented by 1-salt and 2-salt fish, although not all the collected fish were spawned for the Twisp program.

Table 5.2. Proportion of hatchery and wild steelhead by saltwater age retained for broodstock for Wells Hatchery or Twisp River (T) programs.

Brood	Hatchery			Wild		
	1-salt	2-salt	*N*	1-salt	2-salt	*N*
			Wells Hatchery Collection			
1998	0.46	0.54	434	0.75	0.25	12
1999	0.51	0.49	371	0.37	0.63	27
2000	0.62	0.38	332	0.63	0.37	41
2001	0.58	0.42	322	0.81	0.19	26
2002	0.42	0.58	374	0.44	0.56	18
2003	0.17	0.83	269	0.00	1.00	27
2004	0.97	0.03	310	0.92	0.08	117
2005	0.39	0.61	315	0.46	0.54	67
2006	0.39	0.61	309	0.33	0.67	87
2007	0.81	0.19	339	0.52	0.48	44
2008	0.74	0.26	267	0.82	0.18	89
2009	0.73	0.27	251	0.64	0.36	70
2010	0.54	0.46	235	0.71	0.29	70
2011	0.54	0.46	261	0.38	0.62	52
2012	0.49	0.51	249	0.33	0.66	66
2013	0.42	0.58	185	0.37	0.63	19
2014	0.55	0.45	332	--	--	--
2015	0.27	0.73	236	--	--	--
Average	0.53	0.47	300	0.53	0.47	52
			Twisp Weir Collection			
2011	--	--	--	0.16	0.84	25
2012	--	--	--	0.54	0.46	26
2013	--	--	--	0.29	0.71	23
2014	--	--	--	0.57	0.43	23
2015	0.50	0.50	22	0.31	0.69	16
Average	0.50	0.50	22	0.37	0.63	23

Sex Ratio and Fecundity

The overall mean sex ratio of the steelhead retained for broodstock (excludes released fish) favored females regardless of fish origin or collection location (Table 5.3). The sex ratio of the 2015 brood was skewed towards female fish regardless of origin, although comparisons between wild and hatchery fish could not be made at most locations because broodstock collections generally targeted either hatchery or wild fish (Table 5.3). Of the female fish spawned, fecundity of the 2015 brood was generally higher than overall mean values for hatchery and wild females by collection location and above mean values used in broodstock protocol calculations for hatchery (6,022) and wild (5,737) females for most locations (Table 5.3).

Table 5.3. Sex ratio (Male/Female) and mean fecundity by return year and origin of summer steelhead spawned for the Wells, Twisp River, Okanogan, and Omak Creek programs.

Brood year	Hatchery steelhead				Wild steelhead				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
2000	146	188	5,497	0.78:1	17	24	4,813	0.71:1	0.77:1	5,452
2001	149	174	5,686	0.86:1	16	10	4,815	1.60:1	0.90:1	5,639
2002	174	200	6,255	0.87:1	4	14	5,921	0.29:1	0.83:1	6,232
2003	119	155	6,236	0.77:1	9	18	6,954	0.50:1	0.74:1	6,312
2004	186	133	4,743	1.40:1	53	65	4,627	0.82:1	1.21:1	4,704
2005	147	169	6,214	0.87:1	24	45	6,098	0.53:1	0.80:1	6,191
2006	156	154	6,550	1.01:1	37	54	6,028	0.69:1	0.93:1	6,377
2007	147	197	5,027	0.75:1	18	26	5,644	0.69:1	0.74:1	5,108
2008	142	128	6,090	1.11:1	34	56	5,612	0.61:1	0.96:1	5,946
2009	130	128	6,221	1.02:1	30	40	5,752	0.75:1	0.95:1	6,102
2010	138	139	5,930	0.99:1	44	29	5,366	1.52:1	1.08:1	5,836
2011	129	141	6,153	0.91:1	20	33	6,681	0.61:1	0.86:1	6,252
2012	121	136	5,837	0.89:1	21	46	5,615	0.46:1	0.78:1	5,775
2013	78	151	5,953	0.52:1	8	11	6,089	0.73:1	0.53:1	5,961
2014	115	125	5,257	0.92:1	--	--	--	--	0.92:1	5,257
2015	94	145	5,859	0.65:1	--	--	--	--	0.65:1	5,859
Mean	136	154	5,844	0.90:1	24	34	5,715	0.75:1	0.85:1	5,813
Okanogan broodstock										
2014	19	21	5,615	0.90:1	--	--	--	--	0.90:1	5,615
2015	21	22	5,868	0.95:1	--	--	--	--	0.95:1	5,868
Mean	20	22	5,742	0.93:1	--	--	--	--	0.93:1	5,742
Omak Creek broodstock										
2014	--	--	--	--	7	8	4,248	0.88:1	0.88:1	4,248
2015	--	--	--	--	7	8	6,162	0.88:1	0.88:1	6,162
Mean	--	--	--	--	7	8	5,205	0.88:1	0.88:1	5,205
Twisp River broodstock										
2011	--	--	--	--	13	12	5,258	1.08:1	1.08:1	5,258
2012	--	--	--	--	13	13	5,629	1.00:1	1.00:1	5,629
2013	--	--	--	--	9	14	5,825	0.64:1	0.64:1	5,825
2014	--	--	--	--	10	13	4,573	0.77:1	0.77:1	4,573
2015	7	2	6,808	3.5:1	4	14	4,934	0.29:1	0.69:1	5,168
Mean	7	2	6,808	3.5:1	9	13	5,244	0.76:1	0.84:1	5,291

5.2: Within-hatchery Monitoring

Juvenile Marking and Tagging

Juvenile releases from the 2015 brood were above the overall release goal of 408,000 fish for PUD programs (Tonseth 2014), but releases in all locations were within 10% of the release goals (range 98%-109%) except for Twisp River releases (121%; Table 5.4). The overall release goal was slightly above the target (108%) because releases into the Twisp, Columbia, and Okanogan rivers were slightly above target values. Steelhead releases into the Okanogan River basin from the 2015 brood were marked and tagged with adipose fin-clips, and coded- and blank-wire tags in the snout or in the caudle peduncle in various combinations to evaluate mark and tag loss. Twisp River releases received a snout CWT, but were not adipose fin-clipped (Table 5.5). All other fish released by Wells Hatchery were marked with an adipose fin-clip but were not tagged prior to release.

Table 5.4. Release of Wells Hatchery complex summer steelhead by brood year and release stream. Release values include fish transferred to other agencies for acclimation purposes (e.g., Omak Creek).

Brood	Release location										Total
	Methow R.	Twisp R.	Chewuch R.	Columbia R.	Similk. R.	Omak Cr.	Okan. R.	Salmon Cr.	Aeneas Cr.	Antoine Cr.	
1992	392,815	0	0	0	51,360	0	67,120	0	0	0	511,295
1993	324,200	0	0	0	49,800	0	46,110	0	0	0	420,110
1994	359,170	0	0	0	50,350	0	40,875	0	0	0	450,395
1995	242,400	0	0	18,200	37,500	0	30,000	0	0	0	328,100
1996	310,480	0	0	17,500	49,800	0	49,920	0	0	0	427,700
1997	127,020	126,000	125,300	64,703	50,002	10,005	39,998	0	0	0	543,028
1998	350,431	113,583	116,403	34,099	71,820	10,635	73,401	4,900	0	0	775,272
1999	139,900	136,680	138,300	47,782	68,580	19,440	46,235	10,395	0	0	607,312
2000	116,830	109,950	99,490	0	82,415	19,950	112,605	13,800	0	0	555,040
2001	94,020	84,475	85,615	0	39,545	0	87,310	0	0	0	390,965
2002	96,420	105,323	117,495	0	50,860	25,110	65,920	0	0	0	461,128
2003	80,580	117,545	78,205	0	57,750	9,855	12,000	0	0	0	355,935
2004	86,041	96,405	82,280	0	68,940	10,000	0	0	0	0	343,666
2005	99,820	107,245	119,500	0	146,862	0	0	0	0	0	473,427
2006	96,219	111,770	107,545	0	106,024	0	16,403	13,120	0	0	451,081
2007	99,464	100,446	92,670	0	108,477	0	14,200	25,105	0	0	440,362
2008	103,236	104,903	100,373	0	120,230	0	0	26,403	0	0	455,145
2009	125,801	74,766	92,760	0	61,090	0	0	40,000	0	0	394,417
2010	154,370	93,227	83,858	0	73,623	0	3,960	50,000	0	0	459,038

Table 5.4. Continued.

Brood	Release location										Total
	Methow R.	Twisp R.	Chewuch R.	Columbia R.	Similk. R.	Omak Cr.	Okan. R.	Salmon Cr.	Aeneas Cr.	Antoine Cr.	
2011	205,330	41,170	0	31,860	10,080	41,423	0	50,000	0	0	379,863
2012	99,933	51,473	0	55,541	26,350	9,070	0	40,032	2,010	0	284,409
2013	106,716	50,787	0	179,885	29,730	25,110	0	41,273	2,000	10,114	445,615
2014	100,335	51,983	0	129,463	30,000	41,068	0	40,000	2,000	0	394,849
2015	99,909	57,916	0	174,443	20,800	42,989	0	44,887	0	0	440,944

Table 5.5. Release of juvenile summer steelhead from Wells Hatchery complex facilities marked with blank-wire tags (BWT), freeze brands (FB), left ventral fin-clip, (LV-only), peduncle coded-wire tag (PCWT), snout coded-wire tag (CWTO), adipose fin-clip and snout coded-wire tag (Ad+CWT) or yellow elastomer behind the left (LYE) or right (RYE) eye. All other releases from Wells Hatchery were marked with an adipose fin-clip.

Brood year	Mark	CWT code(s)	Release location	Mark rate	*N*
1998	BWT		Chewuch River	Unknown	105,903
1998	BWT		Twisp River	Unknown	113,583
1999	BWT		Chewuch River	0.9312	138,300
1999	BWT		Twisp River	0.9312	136,680
1999	FB		Methow River	0.9574	139,900
2000	FB		Methow Basin	0.9222	326,270
2001	LYE		Methow Basin	0.9411	264,110
2002	RYE		Twisp River	0.8679	105,323
2003	LYE		Twisp River	0.8970	117,545
2004	LYE		Twisp River	0.9324	96,405
2005	Ad+CWT	632895	Methow Basin	0.9712	235,126
2005	Ad+CWT	632895	Okanogan Basin	0.9712	85,180
2005	RYE		Methow Basin	0.9290	91,439
2006	LYE		Methow Basin	0.9317	86,994
2007	Ad+CWT	633398	Methow Basin	0.6229	185,654
2007	RYE		Methow Basin	0.9012	106,926
2008	LYE		Methow Basin	0.9035	89,469
2009	Ad+CWT	635083	Okanogan Basin	0.5493	101,090
2009	LYE		Methow Basin	0.8789	76,044
2009	RYE		Methow Basin	0.8789	13,419
2010	Ad+CWT		Methow Basin	0.9521	232,796

Table 5.5. Continued.

Brood year	Mark	CWT code(s)	Release location	Mark rate	*N*
2010	LYE		Methow Basin	0.7512	98,659
2011	CWTO	635583	Twisp River	0.9820	41,170
2011	LV-only		Methow River	0.4717	52,993
2011	PCWT	634192	Omak Creek	0.9518	41,423
2012	Ad+CWT	636187; 6194	Okanogan Basin	0.9654; 0.9731	68,392
2012	CWTO	636387	Twisp River	0.9812	51,473
2012	PCWT	635490	Omak Creek	0.9710	9,070
2013	CWTO	636462; 6572	Twisp River	0.9290	50,787
2013	Ad+CWT	636478	Okanogan Basin	0.9822	83,117
2013	PCWT	636460	Omak Creek	0.9187	25,110
2014	Ad+CWT	636754	Okanogan Basin	0.9720	81,984
2014	Ad+CWT+BWT	636754	Omak Creek	0.9720	10,000
2014	PCWT+BWT	636754	Omak Creek	0.9720	21,084
2014	CWTO	636545; 6685	Twisp River	0.9869	51,983
2015	Ad+CWT	636902	Okanogan Basin	0.9783	65,687
2015	PCWT+BWT	636767	Omak Creek	0.9981	11,200
2015	PCWT	636767	Omak Creek	0.9981	31,789
2015	CWTO	636602;6768;6875	Twisp River	0.9674	57,916

Juvenile Size and Condition at Release

Size-at-release fork length and weight targets for DCPUD program fish are described in Murdoch et al. (2012). The 2015 brood Wells and Twisp program fish were 105.6% and 87.9% of the target release fork length goal, respectively (Table 5.6). Coefficient of variation (CV) of fork length for Wells 2015 brood releases was higher than the target value of nine for both Wells and Twisp program releases.

Table 5.6. Mean fork length (mm), weight (g), coefficient of variation (CV), standard deviation (SD), and condition factor (K) of Wells Hatchery complex summer steelhead by stock and brood year prior to release. An asterisk denotes a sample collected at time of transfer to an acclimation pond instead of immediately prior to release. SN = safety-net program.

Brood	Stock	Fork length (mm)			Weight (g)				K
		Mean	SD	CV	Mean	SD	CV	FPP	
1999	Wells HxH	189.4	18.1	9.6	76.8	20.8	27.1	5.9	1.13
1999	Wells HxW	195.4	18.2	9.3	83.0	21.3	25.7	5.4	1.11
2000	Wells HxH	172.9	22.4	13.0	60.0	21.3	35.5	7.5	1.16
2000	Wells HxW	178.6	20.9	11.7	66.7	21.7	32.5	6.7	1.17
2001	Wells HxW	181.8	26.9	14.8	72.9	30.5	41.9	6.2	1.21
2001	Wells HxH	194.7	15.4	7.9	87.3	20.7	23.7	5.1	1.18
2002	Wells HxW	187.9	24.1	12.8	73.1	26.7	36.5	6.2	1.10
2002	Wells HxH	188.5	19.6	10.4	75.9	22.6	29.8	5.9	1.13
2003	Wells HxW	163.2	29.7	18.2	62.1	--	--	7.3	1.42
2003	Wells HxH	189.9	19.4	10.2	79.9	23.4	29.3	5.6	1.16
2004	Wells HxW	184.5	24.3	13.1	72.2	29.1	40.2	6.2	1.14
2004	Wells HxH	192.4	21.7	11.3	82.4	28.8	34.9	5.4	1.15
2005	Wells HxW	168.4	16.4	9.7	53.3	15.0	28.3	8.5	1.12
2005	Wells HxH	171.4	18.7	10.9	56.8	17.1	30.1	7.9	1.13
2006	Wells HxW	181.5	20.4	11.2	68.8	23.1	33.1	6.5	1.15
2006	Wells HxH	180.6	21.9	12.1	65.7	22.3	33.8	6.9	1.12
2007	Wells HxW	178.3	16.1	9.0	63.5	17.4	27.4	7.1	1.12
2007	Wells HxH	181.4	15.3	8.4	67.3	16.6	24.7	6.7	1.13
2008	Wells HxW	189.7	22.4	11.8	77.0	27.2	35.3	5.8	1.13
2008	Wells HxH	185.7	24.5	13.1	69.0	26.8	38.9	6.5	1.10
2009	Wells HxW	183.4	29.2	15.9	74.8	35.7	47.7	6.1	1.21
2009	Wells HxH	172.5	28.6	16.6	63.6	32.5	51.1	7.1	1.24
2010	Wells HxW	199.3	22.9	11.5	83.5	27.7	33.2	5.4	1.05
2010	Wells HxH	192.3	23.7	12.3	76.8	27.3	35.5	5.9	1.08
2011	Wells HxW	189.9	24.9	13.1	72.5	28.6	39.4	6.3	1.06
2011	Wells HxH	187.3	24.9	13.5	72.8	31.3	43.0	6.2	1.11
2011	Twisp WxW	179.1	28.7	16.0	61.5	25.1	40.8	7.4	1.07
2012	Wells HxW	187.9	25.9	13.8	75.3	31.7	42.1	6.0	1.14
2012	Twisp WxW	182.3	18.1	9.9	67.9	19.2	28.3	6.7	1.12
2012	Omak WxW	179.0	30.4	17.0	56.4	24.9	44.1	6.6	0.98
2013	Wells HxW	194.2	25.4	13.1	81.2	33.3	41.1	5.6	1.11
2013	Twisp WxW	159.9	18.8	11.8	43.5	14.1	32.5	10.5	1.06
2013	Omak WxW	179.3	27.8	15.5	62.3	24.6	39.5	7.8	1.08

Table 5.6. Continued.

Brood	Stock	Fork length (mm)			Weight (g)				K
		Mean	SD	CV	Mean	SD	CV	FPP	
2014	Wells SN	189.7	24.1	12.7	74.1	28.2	38.0	6.1	1.08
2014	Twisp WxW	164.6	18.4	11.2	47.3	15.8	33.4	9.6	1.06
2014	Omak WxW*	172.7	24.1	13.9	55.8	22.2	39.7	8.1	1.08
2015	Wells SN	201.8	29.0	14.4	80.1	32.7	40.9	5.7	0.97
2015	Twisp WxW	167.9	24.6	14.6	52.6	22.1	42.1	8.6	1.11
2015	Omak WxW*	180.6	37.6	20.8	67.9	35.9	52.9	6.7	1.15
Target		191.0	17.2	9.0	75.6	- -	- -	6.0	1.08

Survival Estimates

Collection to spawning survival of adult broodstock has historically been above target levels, and survival of the 2015 brood adults for all programs was above 99% (Table 5.7). Survival from eyed egg to ponding was below target levels for all 2015 brood programs, but survival values for most other categories were above target levels. Transportation to release values for the 2015 brood were calculated for the Methow Hatchery release group (Wells program; Table 5.7), St. Mary's Acclimation Pond (Omak program; Table 5.8), and the Twisp River Acclimation Pond (Twisp program; Table 5.7).

Table 5.7. Survival (%) of Wells Hatchery and Twisp River summer steelhead by brood and survival category.

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
				Wells Hatchery program					
1999	99.3	99.8	77.0	98.0	97.1	96.6	92.8	- -	70.0
2000	98.0	99.2	85.2	97.4	98.1	98.7	95.3	- -	79.1
2001	98.0	99.0	83.9	98.6	97.0	96.9	95.0	- -	78.6
2002	98.0	99.5	82.2	96.2	99.0	98.7	97.8	- -	77.3
2003	99.0	99.3	83.5	99.9	93.6	77.6	73.5	- -	61.3
2004	98.6	98.4	86.2	94.0	99.4	95.5	94.0	- -	76.1
2005	96.4	99.5	87.4	95.9	96.9	92.2	85.7	- -	71.8
2006	95.2	93.3	86.6	99.5	92.7	89.8	80.4	- -	69.3
2007	92.8	95.8	80.8	99.0	97.8	96.2	85.6	- -	68.4
2008	98.9	96.6	85.2	85.2	99.3	99.5	92.9	- -	67.5
2009	91.2	93.1	79.8	99.1	97.7	97.2	88.4	- -	69.9
2010	97.2	98.4	84.6	99.7	93.7	90.2	84.0	- -	67.9
2011	95.4	94.0	83.9	80.4	92.1	91.3	76.5	- -	51.6

Table 5.7. Continued.

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
				Wells Hatchery program					
2012	95.8	88.5	80.1	99.8	97.1	94.6	65.4	- -	52.6
2013	96.3	98.8	91.0	99.3	95.7	94.4	69.5	- -	62.7
2014	8.7	18.8	87.4	90.7	100.0	97.8	75.9	--	60.2
2015	99.6	100.0	83.3	95.3	98.7	97.0	97.0	99.8	77.0
				Twisp River program					
2011	92.3	100.0	81.3	100.0	95.3	94.7	93.9	99.9	76.4
2012	100.0	100.0	90.5	84.8	96.1	95.8	95.2	99.9	73.0
2013	100.0	100.0	75.0	94.6	92.4	91.5	90.9	100.0	64.5
2014	100.0	100.0	94.8	97.4	93.2	87.7	83.3	99.9	76.9
2015	100.0	100.0	94.5	95.1	99.1	98.7	98.0	99.9	88.1
Target	90	85	92	98	97	93	90	95	81

Table 5.8. Survival (%) of Omak Creek summer steelhead by brood and survival category.

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
2014	87.5	100.0	79.3	94.7	96.8	96.4	95.8	99.8	72.0
2015	100.0	100.0	95.0	97.5	98.4	96.9	94.3	98.5	87.3

5.3 Natural Origin Juvenile Productivity

Smolt trapping was conducted in 2016 in the Methow and Twisp Rivers to estimate the productivity (smolts per redd) of steelhead spawning in the Methow and Twisp river basins. Because steelhead juveniles spend an extended period of time rearing in freshwater prior to migrating seaward, smolts captured each spring from these rivers represent multiple broods of spawning adults. Complete productivity estimates, therefore, require multiple years of smolt monitoring.

Emigrant and Smolt Estimates

Methow Trap

Trapping at the Methow River trap site (rkm 30) occurred between 19 February and 5 December 2016 using smolt traps with a 1.5 m or 2.4 m cone diameter. These traps were operated in two different trapping positions depending on the river discharge at the site. Trapping at the Methow site was interrupted on two occasions for a total of 17 days because of high flow and debris. Steelhead production estimates were based on daily capture of wild steelhead emigrants, expanded by the estimated trap efficiency derived from a trap efficiency/flow model developed for each trap configuration (Attachment A).

We captured 190 wild summer steelhead emigrants (smolt and transitional) between 19 February and 30 June in the Methow River trap, with peak capture on 2 April (N = 26). We PIT tagged 179 wild steelhead emigrants and no shed tags or mortalities were recorded. Overall mortality of emigrant steelhead totaled one of the 190 fish captured (0.53%). We also captured 473 hatchery steelhead juveniles at the Methow River trap, and no mortalities occurred.

We captured 23 wild fry and 112 wild summer steelhead parr during trapping in 2016 at the Methow trap site. Steelhead parr greater than 65 mm and in good physical condition were PIT tagged (N = 104), and 103 were releases after subtracting a single mortality. Overall mortality of fry (N = 1) and parr (N = 1) totaled (1.5%) of the total fry and parr captured.

Due to low capture numbers of migratory steelhead, no mark/recapture trials were conducted with steelhead in 2016 at the Methow trap. Because no significant regression model existed for steelhead, we used the yearling Chinook flow models to estimate steelhead production for each trap position. Combining estimates from all positions, we calculated that 16,943 (± 4,393, 95% CI) summer steelhead emigrated from the Methow River basin. However, an additional 696 migrants were estimated from redds located downstream of the trap in 2012 through 2015, which resulted in a total estimated migration of 17,639 (± 4,482, 95% CI) summer steelhead from the Methow River basin in 2016. We estimated the entire 2012 brood migration to be 25,726 (± 4,629, 95% CI) fish, including 392 migrants that were expected from redds (N = 9) located downstream of the Methow trap in 2012. The mean number of emigrants (smolts) produced per redd in the Methow Basin for the 2003-2012 broods was 19 (Table 5.9).

Twisp Trap

Trapping at the Twisp River trap site (rkm 2) occurred between 27 February and 5 December 2016 using a rotary screw smolt trap with a 1.5 m cone diameter. Trapping at the Twisp site was interrupted on three occasions for a total of 35 days between 27 February and 5 December because of high flow and debris. Steelhead production estimates were based on daily capture of wild steelhead emigrants, expanded by the estimated trap efficiency derived from a trap efficiency/flow model developed for each trap configuration (Attachment A).

We captured 160 wild summer steelhead emigrants at the Twisp trap between 27 February and 30 June. Peak capture occurred on 2 April (N = 21). We PIT tagged 139 wild steelhead emigrants and no shed tags or mortalities were recorded (Attachment A). Non-migrant summer steelhead captured at the Twisp trap included 51 wild fry and 276 wild parr. We PIT tagged 242 steelhead parr with a fork length greater than 65 mm and no shed tags or mortalities were detected. Overall mortality of fry ($N = 0$) and parr ($N = 1$) represented 0.31% of the total fry and parr captured ($N = 327$). Wild summer steelhead parr had a mean fork length of 102.7 mm. A total of 2,100 juvenile hatchery summer steelhead were captured at the Twisp River trap and no mortalities were recorded.

Numerous mark/recapture trials were conducted with wild summer steelhead at the Twisp site in 2016, but none of them contained more than 35 fish. A flow efficiency relationship from previous years' release groups was used to estimate steelhead emigration at the Twisp site in 2016. The flow model regression ($y = -0.00029758x + 0.410040455$; $P < 0.01$, $r^2 = 0.52$) was used to estimate that 5,132 (± 1,733, 95% CI) wild summer steelhead migrated past the Twisp River trap between 27 February and 30 June 2016. An additional 594 migrants were estimated from redds located downstream of the trap in 2012 through 2015, which provides a total estimated migration of 5,726 (± 1,831, 95% CI) summer steelhead from the Twisp River in 2016. Most 2016 migrants were age-2 fish (74.6%) from the 2014 brood (Table 5.8). Combining numbers from the last four years, the entire 2012 brood migration is estimated to be 5,882 (± 1,514, 95% CI) fish, which includes 446 expected migrants produced from redds ($N = 10$) that were identified downstream of the Twisp trap in 2012. The mean number of emigrants (smolts) produced per redd in the Twisp Basin for the 2004-2012 broods was 38 (Table 5.10).

Table 5.9. Estimated emigrant-per-redd and egg-to-emigrant survival of Methow Basin steelhead. Methow Basin estimates are for redds deposited upstream and downstream of the trap site. Emigrant-per-redd values were not calculated for incomplete brood years.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants					Egg to emigrant (%)	Emigrants per redd
				Age-1	Age-2	Age-3	Age-4	Total		
Methow	2003	2,019	12,824,688	1,602	4,895	2,471	109	9,076	0.07	4
Methow	2004	997	4,580,218	1,989	9,592	1,319	365	13,265	0.29	13
Methow	2005	1,784	11,075,072	2,144	13,413	913	1,136	17,606	0.16	10
Methow	2006	808	5,161,504	644	6,503	3,932	328	11,406	0.22	14
Methow	2007	740	3,779,180	3,255	25,588	4,774	122	33,739	0.89	46
Methow	2008	867	5,136,975	1,430	13,229	1,884	131	16,674	0.32	19
Methow	2009	1,030	6,283,000	3,425	13,133	1,858	660	19,076	0.30	19
Methow	2010	1,720	10,022,440	1,214	7,243	8,641	116	17,214	0.17	10
Methow	2011	854	5,339,208	303	10,162	1,761	275	12,501	0.23	15
Methow	2012	591	3,402,387	402	21,827	3,396	101	25,726	0.76	44
Methow	2013	810	4,834,890	1,649	15,155	2,474	--	19,278	--	--
Methow	2014	878	4,630,572	1,008	11,569	--	--	12,577	--	--
Methow	2015	991	5,776,539	3,495	--	--	--	3,495	--	--

Table 5.9. Continued.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants					Egg to emigrant (%)	Emigrants per redd
				Age-1	Age-2	Age-3	Age-4	Total		
Mean 2003-2012		1,141	6,760,467	1,641	12,559	3,095	334	17,629	0.34	19

Table 5.10. Estimated emigrant-per-redd and egg-to-emigrant survival of Twisp River steelhead. Twisp River estimates are for redds deposited upstream and downstream of the trap site. Emigrant-per-redd values were not calculated for incomplete brood years. DNOT = Did not operate trap.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants					Egg to emigrant (%)	Emigrants per redd
				Age-1	Age-2	Age-3	Age-4	Total		
Twisp	2003	696	4,420,992	DNOT	2,284	1,497	65	3,846	0.09	6
Twisp	2004	256	1,176,064	183	3,200	504	202	4,089	0.35	16
Twisp	2005	484	3,004,672	344	2,870	2,254	127	5,595	0.19	12
Twisp	2006	389	2,484,932	82	4,788	2,256	341	7,467	0.30	19
Twisp	2007	82	418,774	41	10,338	2,845	445	13,669	3.26	167
Twisp	2008	182	1,078,350	73	2,363	795	33	3,264	0.30	18
Twisp	2009	352	2,147,200	59	4,766	1,084	38	5,947	0.28	17
Twisp	2010	332	1,934,564	22	2,675	2,488	21	5,206	0.27	16
Twisp	2011	190	1,187,880	0	5,759	608	0	6,367	0.54	34
Twisp	2012	132	759,924	41	4,839	963	39	5,882	0.77	45
Twisp	2013	140	835,660	183	4,542	990	--	5,715	--	--
Twisp	2014	144	759,465	288	4,273	--	--	4,561	--	--
Twisp	2015	161	938,469	424	--	--	--	424	--	--
Mean 2003-2012		301	1,861,335	94	4,388	1,529	131	6,133	0.64	35

PIT Tagging and Survival

Most wild juvenile steelhead captured at the Methow and Twisp smolt traps that were in good physical condition and had a fork length greater than 65 mm were PIT tagged prior to release. Within each release year, the number of PIT tagged emigrants (smolt and transitional fish) released from each trap site were used to evaluate smolt to adult survival (SAR) of smolts leaving the Methow and Twisp river basins each spring. Adult detections of PIT tagged fish at Wells Dam were summed and divided by the number of juvenile salmonids tagged and released at the Methow and Twisp smolt traps by species to determine smolt to adult survival rates. Mean

SAR for wild Twisp and Methow steelhead smolts was 1.18% and 1.07%, respectively for the 2006-2014 release years (Table 5.11). However, sample sizes for some release years and trap sites were likely too low to produce accurate estimates.

Table 5.11. Smolt to adult returns (SAR) by salt age for PIT tagged wild steelhead smolts tagged and released from the Twisp and Methow smolt traps.

Release year	Released	Age at return (*N*) to Wells Dam		Total	SAR (%)
		1-Salt	2-Salt		
		Twisp trap			
2006	486	0	0	0	0.00
2007	332	2	5	7	2.11
2008	642	7	5	12	1.87
2009	640	3	5	8	1.25
2010	454	2	2	4	0.88
2011	321	1	0	1	0.31
2012	135	1	2	3	2.22
2013	243	2	2	4	1.65
2014	328	1	0	1	0.30
2015	271	1	--	1	0.37
Mean 2006-2014					1.18
		Methow trap			
2006	319	0	0	0	0.00
2007	166	0	1	1	0.60
2008	108	2	2	4	3.70
2009	395	0	0	0	0.00
2010	319	0	1	1	0.31
2011	175	0	0	0	0.00
2012	178	4	2	6	3.37
2013	432	1	4	5	1.16
2014	591	2	1	3	0.51
2015	442	1	--	1	0.23
Mean 2006-2014					1.07

In-stream PIT Tagging

Natural origin juvenile steelhead were primarily PIT tagged in the Twisp subbasin in 2016 (Attachment B) to evaluate population size, life-stage specific survival rates, and to complete sampling requirements of an on-going relative reproductive success study of steelhead in the Twisp River. Because natural origin juvenile steelhead may rear for multiple years in freshwater prior to emigrating, parr to smolt survival rates may be incomplete for fish tagged in recent years. Survival to detection at Rocky Reach Dam juvenile bypass was similar for tag groups between basins, although sample sizes for some years and locations were low (Table 5.12).

Table 5.12. In-stream PIT tagging and recovery at Rocky Reach Dam juvenile bypass detector of natural origin juvenile summer steelhead (SHR) from the Methow, Twisp, and Chewuch rivers. Cormack-Jolly-Seber (CJS) survival estimates with standard error (SE) and probability of survival were obtained from the Data Access Real Time website (DART) maintained by the University of Washington's School of Aquatic and Fishery Sciences.

Tag year	SHR tagged	Recovered at Rocky Reach juvenile bypass							CJS survival (SE)
		2011	2012	2013	2014	2015	2016	Total	
					Twisp River				
2010	1,496	160	6	--	--	--	--	166	0.32 (0.04)
2011	1,861	--	98	17	--	--	--	115	0.30 (0.05)
2012	2,366	--	--	90	22	2	--	114	0.10 (0.01)
2013	1,988	--	--	--	191	22	--	213	0.27 (0.19)
2014	2,891	--	--	--	--	253	36	289	0.17 (0.02)
2015	3,803	--	--	--	--	--	177	177	0.14 (0.01)
2016	2,236	--	--	--	--	--	--	--	--
					Methow River				
2010	318	31	2	--	--	--	--	33	0.30 (0.07)
2011	516	--	37	3	--	--	--	40	0.34 (0.09)
2012	1,029	--	--	19	13	--	--	32	0.28 (0.15)
2013	1,849	--	--	--	95	24	--	119	0.20 (0.04)
2014	20	--	--	--	--	--	1	1	0.05 (0.05)
2015	108	--	--	--	--	--	1	1	0.02 (0.01)
2016	175	--	--	--	--	--	--	--	--
					Chewuch River				
2010	508	52	3	--	--	--	--	55	0.34 (0.06)
2011	1,059	--	50	17	--	--	--	67	0.25 (0.05)
2012	2,034	--	--	73	18	5	--	96	0.17 (0.03)
2013	2,321	--	--	--	193	60	5	258	0.21 (0.02)
2014	0	--	--	--	--	--	--	--	--
2015	0	--	--	--	--	--	--	--	--
2016	606	--	--	--	--	--	--	--	--

5.4 Spawning Ground Surveys

Steelhead spawning ground surveys were performed to estimate the relative abundance, distribution, and timing of spawning within the Methow River basin (Attachment D). Surveys were conducted between 4 March and 3 June 2016 in the Twisp River and in the Methow River between about the town of Winthrop and the confluence with the Columbia River. Some smaller sections of tributaries were also surveyed if spawning areas existed downstream of active PIT tag arrays.

Escapement estimates

Overall, a total of 1,814 steelhead were estimated to have spawned in the Methow River Basin in 2016 (Table 5.13), with most spawners found in the Lower Methow subbasin (*N* = 925). The 2016 escapement estimates were derived from redd counts and from PIT tag detections at arrays located throughout the Methow Basin (Attachment D). Escapement estimates in the upper Methow and Twisp rivers were lower than the overall mean values, while lower Methow and Chewuch river escapement estimates were above overall mean values (Table 5.11).

Table 5.13. Estimated steelhead escapement by sample year for the four major subbasins in the Methow River watershed. Upper and Lower Methow subbasins are divided by the Highway 20 bridge in Winthrop, Washington. Lower Methow escapements combine PIT-based estimates and redd count estimates expanded by fish per redd values.

Sample year	Steelhead escapement				Total
	Upper Methow	Lower Methow	Twisp	Chewuch	
2002	774	128	648	210	1,760
2003	1,185	574	1,204	529	3,492
2004	1,053	414	564	165	2,196
2005	1,158	1,061	860	104	3,183
2006	287	304	653	112	1,356
2007	597	308	143	240	1,288
2008	577	479	388	403	1,847
2009	512	390	628	307	1,837
2010	1,081	1,196	710	693	3,680
2011	594	264	295	172	1,325
2012	503	295	247	60	1,105
2013	442	306	224	325	1,297
2014	340	534	237	336	1,447
2015	394	1,217	629	300	2,540
2016	178	925	403	308	1,814
Mean	645	560	522	284	2,011

Redd Distribution

Because most of the spawning escapement of steelhead in 2016 was determined through the use of PIT tag arrays, assessing redd distribution by stream reach is not possible for most spawning areas (Attachment D). Based on spawning escapement estimates from stream surveys and PIT tag expansions in the Lower Methow subbasin, tributaries such as Gold Creek and Beaver Creek were important spawning areas (Table 5.14). In the Twisp River, most redds were found in the mainstem, and relatively few redds were found in tributary sections (Table 5.15).

As part of an on-going reproductive success study in the Twisp River, female steelhead captured and release upstream of the Twisp River weir received a Floy tag and an abdominal-planted PIT tag prior to release. Additionally, some steelhead in 2016 were radio-tagged prior to release and tracked to spawning locations. Subsequent observations of Floy-tagged or radio-tagged fish on the spawning grounds, or detection of PIT tags in completed redds allowed us to evaluate the spawning distribution of hatchery and wild steelhead in the Twisp River. Using these methods, we were able to determine female origin for five of 33 redds (15%) based on Floy tag or radio-telemetry detections. Wild female steelhead spawned farther upstream than hatchery steelhead females in 2016 but no significant differences were found in spawning location between hatchery and wild females from 2009 to 2016 (Goodman et al. 2017; Figure 5.1).

Table 5.14. Lower Methow River steelhead escapement estimates based on redd counts or PIT tags by reach. Redd totals in Methow River mainstem reaches (MRW1-8) are direct counts only; escapement for this area is derived from PIT-based escapement estimates (Truscott et al. 2017) using 1.92 fish per redd. Ns = not surveyed.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Methow River (MRW PIT array – Red Barn)	MRW8	4	376	150
Methow River (Red Barn – Halderman Hole)	MRW7	2		
Methow River (Halderman Hole – Braids)	MRW6	3		
Methow River (Braids – Carlton Bridge)	MRW5	0		
Methow River (Carlton Bridge – WDFW Access)	MRW4	0		
Methow River (WDFW Access – Upper Burma Br.)	MRW3	0		
Methow River (Upper Burma Br. – Lower Burma Br.)	MRW2	2		
Methow River (Lower Burma Bridge – Pateros)	MRW1	0		
Chewuch River (CRW PIT array to – Confluence)	CRW1	Ns	--	--
Methow Hatchery outfall	MH1	23	--	--
Winthrop NFH Outfall	WN1	100	--	--

Table 5.14. Continued.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
1890's channel	18N	10	--	--
Beaver Creek (above PIT antenna)	Beaver	6	12 (0-74)	0 (0-0)
Beaver Creek (below PIT antenna)	BV1	Ns	--	--
Libby Creek (above PIT antenna)	Libby	36	17 (3-40)	52 (24-84)
Gold Creek (above PIT array)	Gold	33	24 (7-49)	39 (17-70)
Total		219	--	--

Table 5.15. Twisp River mainstem and tributary census redd counts by section number and survey year. Ns = not surveyed.

Stream reach	Code	Length (km)	2010	2011	2012	2013	2014	2015	2016
Twisp River mainstem									
Road's End C.G. - South Creek Bridge	T10	4.6	0	Ns	Ns	Ns	Ns	Ns	Ns
South Creek Bridge - Poplar Flats C.G.	T9	3.2	3	0	0	0	0	2	0
Poplar Flats C.G. - Mystery Bridge	T8	3.2	4	0	0	1	1	2	1
Mystery Bridge - War Creek Bridge	T7	6.9	18	8	5	8	4	9	2
War Creek Bridge - Buttermilk Bridge	T6	7.4	97	43	43	21	36	30	3
Buttermilk Bridge - Little Bridge Creek	T5	5.9	62	33	26	18	25	10	4
Little Bridge Creek - Twisp weir	T4	3.8	27	13	5	7	3	10	1
Twisp weir - Upper Poorman Bridge	T3	3.5	70	46	20	46	30	44	7
Up. Poorman Br. - Lower Poorman Br.	T2	5.0	35	30	12	23	23	18	1
Lower Poorman Bridge - Confluence	T1	2.9	13	4	11	7	12	11	2
Twisp River mainstem total		46.4	329	177	122	131	134	136	21
Twisp River tributaries									
Little Br. Cr. (Road's End - Vetch Cr.)	LBC4	1.3	0	Ns	Ns	Ns	Ns	Ns	Ns
Little Br. Cr. (Vetch Cr. - 2nd Culvert)	LBC3	3.0	1	0	3	0	0	0	1
Little Br. Cr. (2nd Culvert - 1st Culvert)	LBC2	2.4	3	0	0	1	0	0	0
Little Br. Cr. (1st Culvert - Confluence)	LBC1	2.4	4	0	7	4	1	13	0
MSRF pond outfalls[1]	MSRF1	0.1	1	3	0	3	6	12	11
War Creek (log jam barrier - Conf.)	WR1	0.5	0	0	0	0	0	0	0
Eagle Creek (Rd 4430 - Confluence)	EA1	0.3	0	0	0	0	0	0	0
W. Fork Buttermilk Creek	BMW1	3.1	Ns	Ns	Ns	Ns	1	0	Ns
Buttermilk Cr. (Fork - Cattle Guard)	BM2	2.1	3	0	1	0	0	0	0
Buttermilk Cr. (Cattle Guard - Conf.)	BM1	2.0	1	0	0	0	2	0	0
South Creek (Falls - Confluence)	SO1	0.6	0	Ns	Ns	Ns	0	0	Ns
Twisp River tributary total		14.7	13	3	11	8	10	25	12

[1] Methow Salmon Recovery Foundation pond outfall.

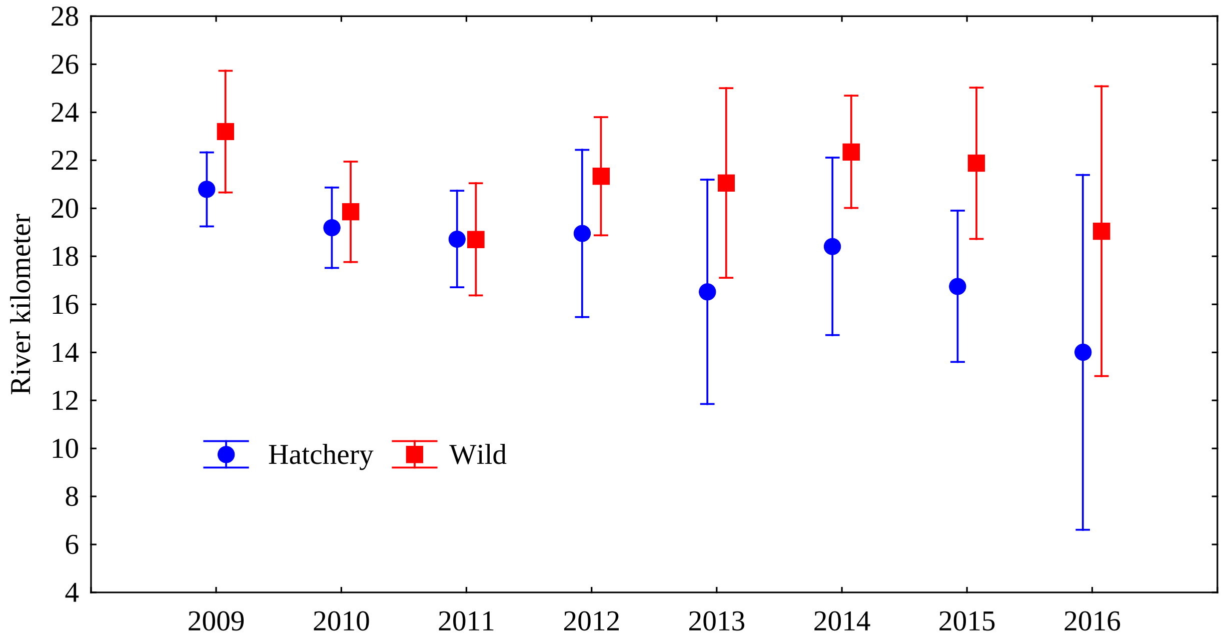

Figure 5.1. Mean spawning location (rkm; center point) and 95% CI (whiskers) by origin of female steelhead released upstream of the Twisp River weir based on PIT tag detections and Floy tag observations in 2009 (H = 45; W = 19), 2010 (H = 40; W = 27), 2011 (H = 26; W = 20), 2012 (H = 10; W = 19), 2013 (H = 5; W = 7), 2014 (H = 8; W = 18), 2015 (H = 11; W = 11), and 2016 (H = 2; W = 3).

Spawn Timing

Steelhead spawn timing was assessed as part of an on-going reproductive success study in the Twisp River. Female steelhead captured and release upstream of the Twisp River weir received an external Floy tag prior to release. Additionally, some steelhead in 2016 were radio-tagged prior to release and tracked to spawning locations. Subsequent observations of Floy-tagged or radio-tagged fish on the spawning grounds, allowed us to evaluate the spawn timing of hatchery and wild steelhead in the Twisp River (Figure 5.2). No significant differences in spawn timing were observed between hatchery and wild female steelhead from 2009 to 2016 (Goodman et al. 2017).

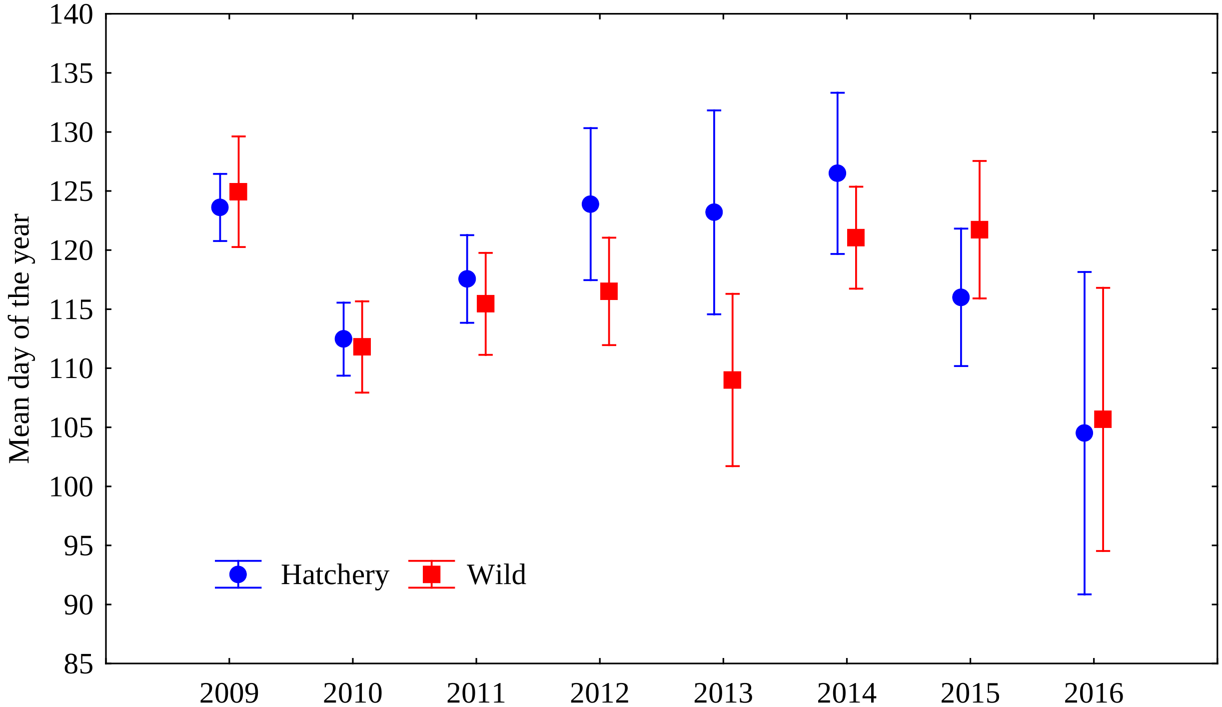

Figure 5.2. Mean spawn timing (day of year; center point) and 95% CI (whiskers) of female steelhead by origin and year released upstream of the Twisp River weir based on PIT tag, Floy tag, or radio telemetry observations in 2009 (H = 44; W = 17), 2010 (H = 38; W = 24), 2011 (H = 27; W = 20), 2012 (H = 8; W = 17), 2013 (H = 5; W = 7), 2014 (H = 8; W = 19), 2015 (H = 11; W = 11), and 2016 (H = 2; W = 3).

5.5: Life History Monitoring

Monitoring the life history characteristics of hatchery summer steelhead adults occurs throughout their upstream migration to spawning grounds. Stock assessment sampling at Priest Rapids Dam, Wells Dam, the Twisp River weir, and PIT tag detection locations provide the data necessary to evaluate migration timing and straying, and contribute to the determination of survival rates and spawning ground demographics. Because steelhead carcasses are seldom recovered during spawning ground surveys, age and length at maturity information is derived primarily from adult fish sampled during hatchery broodstock spawning at Wells Dam. Age at maturity information is reported in section 5.1. Removal of adult hatchery steelhead in local sport fisheries is monitored through creel census and provides the information necessary to estimate harvest rates of hatchery fish and the effects of harvest on spawning ground demographics.

Length at Maturity

Wild and hatchery-origin steelhead were sampled at Wells Dam to determine mean length by sex, saltwater-age, and fish origin, although some age and sex categories of wild fish were not represented in some years (Table 5.16). Hatchery-origin fish had similar or shorter mean fork lengths than wild fish for most age and origin comparisons within years and amongst all years examined (Table 5.16).

Table 5.16. Mean fork length (cm), number (*N*), and standard deviation (SD) by sex, salt-age, and origin of steelhead sampled at Wells Dam by return year.

Return year	Origin	Male						Female					
		1-Salt			2-Salt			1-Salt			2-Salt		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
2002	H	62	30	4	79	89	5	60	17	4	75	133	4
2002	W	64	53	3	82	9	4	-	0	-	76	18	4
2003	H	61	183	3	73	3	7	60	118	3	68	6	3
2003	W	-	0	-	-	0	-	62	55	4	73	9	6
2004	H	60	93	3	74	53	3	59	31	2	72	138	3
2004	W	62	15	3	76	9	3	62	15	3	73	27	4
2005	H	60	98	3	76	58	4	60	22	4	71	123	4
2005	W	65	21	4	77	16	4	61	8	5	73	42	3
2006	H	62	133	3	75	10	5	60	142	3	72	54	5
2006	W	64	8	5	76	6	2	62	17	3	74	17	4
2007	H	63	131	3	78	11	4	61	67	3	72	58	4
2007	W	64	31	4	77	4	1	63	72	3	76	21	4
2008	H	63	116	3	78	12	5	61	66	3	74	57	4
2008	W	63	32	3	82	8	3	62	43	4	74	24	4
2009	H	64	75	4	76	27	4	61	51	4	72	82	3
2009	W	64	42	3	73	8	6	63	37	4	73	19	3
2010	H	61	86	3	76	34	5	60	54	4	72	86	4
2010	W	61	27	4	76	13	6	61	20	3	74	65	4
2011	H	59	77	3	73	39	4	59	53	3	71	83	3
2011	W	61	15	3	76	16	5	61	16	3	72	34	4
2012	H	60	58	3	75	22	5	60	45	4	73	114	4
2012	W	61	19	3	77	14	5	63	6	4	74	32	4
2013	H	59	43	3	73	15	4	58	43	2	70	76	4
2013	W	60	40	3	71	20	5	60	50	3	72	41	5
2014	H	59	43	3	73	15	4	58	43	2	70	76	9
2014	W	60	40	3	71	20	5	60	50	3	72	41	5
2015	H	61	153	2	72	19	5	60	101	3	70	75	4
2015	W	63	24	4	76	12	3	62	27	4	71	20	2
Average	H	61	94	3	75	29	5	60	61	3	72	83	4
Average	W	62	26	3	76	11	4	62	30	4	73	29	4

Migration Timing

Evaluating the migration timing of hatchery and wild steelhead to Wells Dam is difficult because not all returning hatchery origin fish are adipose fin-clipped. Further, run monitoring is conducted concurrent with broodstock collection activities under protocols that limit the number of days, location (e.g., east or west ladders), and season (August through October) in which trapping occurs. Because of this we used observations of hatchery and wild steelhead PIT tagged at Priest Rapids Dam to evaluate migration timing to Wells Dam and into Methow River basin tributaries. To remove stray hatchery fish from the analysis, only hatchery fish marked with an adipose fin-clip (with or without a CWT), a snout CWT-only, and left- and right side yellow elastomer were included. For the 2006-2015 run years overall, wild fish arrived at Wells Dam an average of four days earlier than hatchery fish (Figure 5.3). Wild steelhead PIT tagged in 2015 had an earlier mean passage date (22 October) than hatchery steelhead (1 November) over the Lower Methow PIT array (LMR), but mean run-timing of hatchery and wild fish was similar at most other sites (Figure 5.4), regardless of salt-age at return (Figure 5.5).

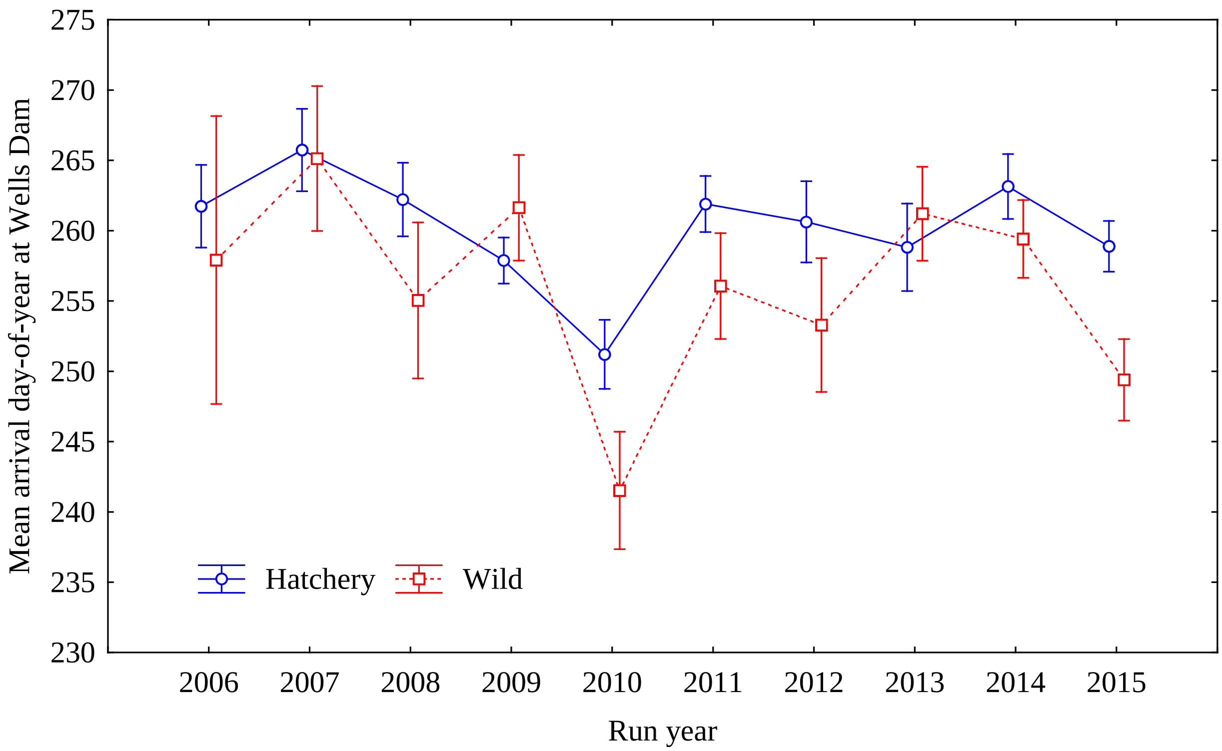

Figure 5.3. Migration timing (mean +/- 95% CI) by run year at Wells Dam of hatchery and wild steelhead PIT tagged and released from Priest Rapids Dam. Hatchery origin fish included those marked with an adipose fin-clip, an adipose fin-clip+CWT, a CWT-only, and left- or right-side yellow elastomer.

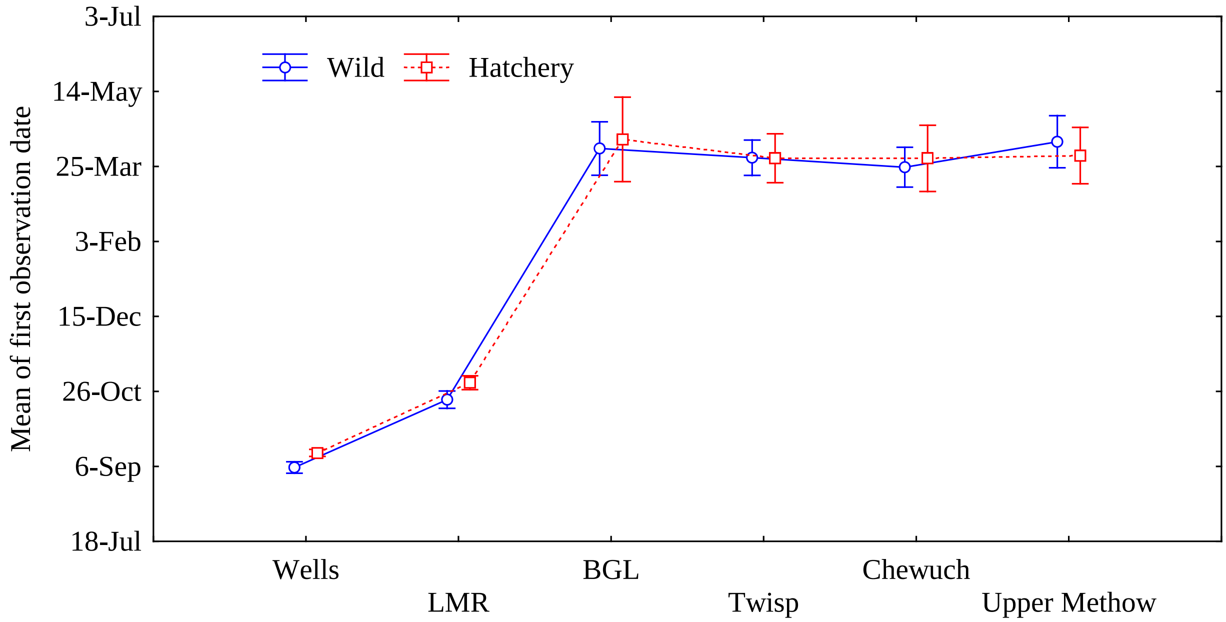

Figure 5.4. Mean (+/- 95% CI) migration timing of hatchery and wild steelhead PIT tagged at Priest Rapids Dam in 2015. Hatchery origin fish included those marked with an adipose fin-clip, an adipose fin-clip+CWT, or a CWT-only. Detection locations include the Lower Methow River (LMR), and the Beaver, Gold, and Libby Creek (BGL) antenna arrays. The Upper Methow category includes the Lost River, Early Winters Creek, Wolf Creek, and the Methow River at Winthrop PIT tag arrays.

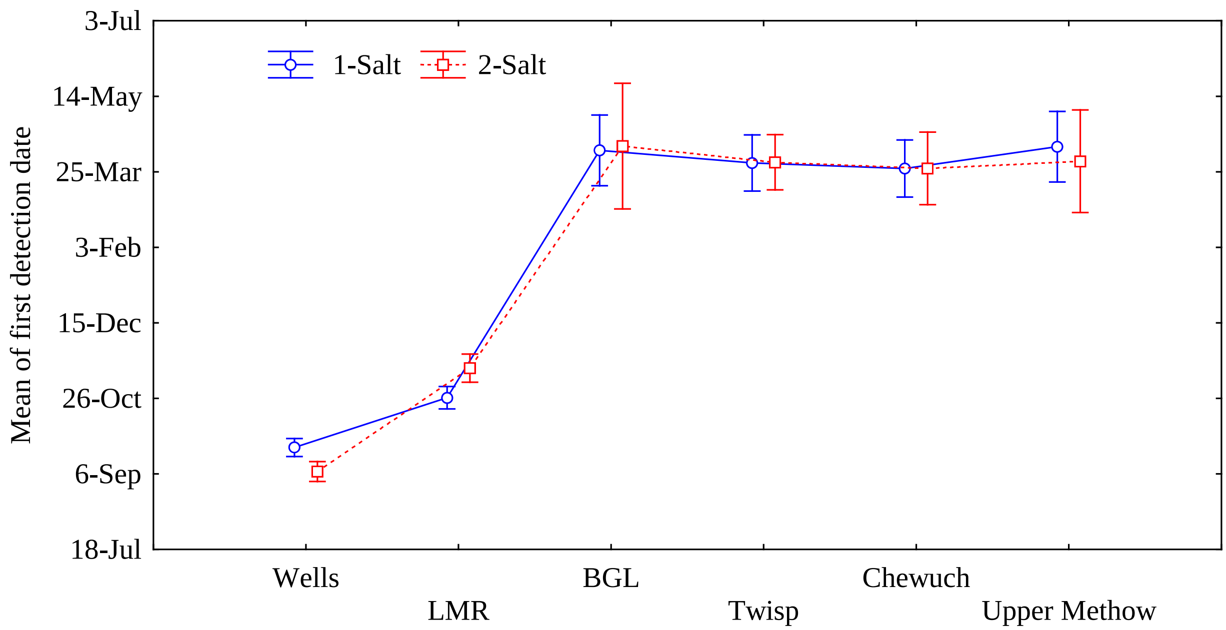

Figure 5.5. Mean (+/- 95% CI) migration timing based on salt-age of hatchery and wild steelhead PIT tagged at Priest Rapids Dam in 2015. Detection locations include the Lower Methow River (LMR), and the Beaver, Gold, and Libby Creek (BGL) antenna arrays. The Upper Methow category includes the Lost River, Early Winters Creek, Wolf Creek, and Methow River at Winthrop PIT tag arrays.

Contribution to Fisheries

Hatchery and wild steelhead returning to Wells Dam are removed for broodstock, may fallback below Wells Dam, or be removed in fisheries in the Columbia River upstream of Wells Dam before entering natal tributaries (Methow and Okanogan rivers). Sport fisheries in the Columbia River upstream of Wells Dam over the past 14 years have allowed the harvest of adipose fin-clipped hatchery origin steelhead, and have estimated the incidental take of wild steelhead through creel monitoring (e.g., WDFW 2016). Columbia River fisheries (including tribal harvest) have extracted about 7% of the hatchery steelhead and 2% of the wild steelhead upstream of Wells Dam on average (Table 5.17).

Table 5.17. Estimated tributary escapement of the hatchery and wild steelhead return to Wells Dam after broodstock removal, removal of fallback and double-counted fish based on PIT tag detections (escapement adjustments), and the impact of sport fisheries in the Columbia River.

Brood	Run to Wells Dam		Wells broodstock		Escapement adjustments		Columbia R. fisheries		Net tributary escapement	
	H	W	H	W	H	W	H	W	H	W
2002	18,241	900	374	18	-	-	23	-	17,844	882
2003	8,962	821	274	27	-	-	455	9	8,233	785
2004	9,388	1,161	325	120	-	-	298	4	8,765	1,037
2005	9,098	861	346	69	-	-	292	1	8,460	791
2006	6,901	765	324	91	-	-	237	1	6,340	673
2007	6,702	631	345	46	-	-	164	6	6,193	579
2008	7,033	1,283	289	90	-	-	978	36	5,766	1,157
2009	9,148	1,236	300	75	557	73	721	32	7,570	1,056
2010	24,091	2,120	279	88	1,790	153	1,787	65	20,235	1,814
2011	11,728	2,085	272	55	839	313	1,304	48	9,313	1,669
2012	11,164	1,732	259	67	1,123	339	731	25	9,051	1,301
2013	9,138	1,288	229	22	692	368	1,229	56	6,988	842
2014	5,530	2,318	209	0	410	499	471	56	4,440	1,763
2015	5,645	2,503	191	0	433	502	567	110	4,454	1,891
2016	7,915	2,264	211	0	1,006	540	582	48	5,530	1,535
Mean	10,046	1,465	282	51	856	348	656	36	8,612	1,185

Fisheries in tributaries upstream of Wells Dam are authorized when certain run composition and abundance measures have been met (see WDFW 2016). Under these criteria, sport fisheries targeting hatchery origin steelhead have been authorized in 13 of the last 15 years (Table 5.18). In addition to extraction in sport fisheries, some hatchery and wild fish were removed for broodstock to support local conservation hatchery programs or to reduce the proportion of hatchery origin fish (pHOS) on the spawning grounds. Tributary fisheries in the Methow and Okanogan river basins have removed about 21% of the estimated hatchery escapement and 2% of the wild escapement within the Methow and Okanogan tributaries between 2002 and 2016 (Table 5.18). Estimates of pHOS for the 2016 brood in both the Methow and Okanogan rivers were lower than the overall mean values for those rivers, due primarily to the relatively high return of wild fish.

Table 5.18. Estimated hatchery and wild steelhead escapement to the Methow and Okanogan river basins and the proportion of hatchery origin fish on the spawning grounds (pHOS) after local broodstock and fishery extraction. Tributary escapement was estimated utilizing radio-telemetry research (Attachment D), and accounts for 90.4% of hatchery fish and 91.6% of wild fish reported in Table 5.15.

Brood	Tributary escapement		Local broodstock		Tributary fisheries		Net escapement		pHOS
	H	W	H	W	H	W	H	W	
					Methow Basin				
2002	10,350	624	-	-	-	-	10,350	624	0.943
2003	4,775	556	-	-	254	13	4,521	543	0.893
2004	5,084	734	-	-	336	10	4,748	724	0.868
2005	4,907	560	-	-	679	9	4,228	551	0.885
2006	3,677	476	-	-	683	8	2,994	468	0.865
2007	3,592	410	-	-	-	-	3,592	410	0.898
2008	3,344	819	14	-	470	9	2,860	810	0.779
2009	4,391	748	8	8	636	11	3,747	729	0.837
2010	11,736	1,284	322	12	4,002	48	7,412	1,224	0.858
2011	5,402	1,182	141	33	2,913	53	2,348	1,096	0.682
2012	5,250	921	135	46	1,302	20	3,813	855	0.817
2013	4,053	596	117	34	904	14	3,032	548	0.847
2014	2,575	1,248	79	92	791	43	1,694	1,113	0.603
2015	2,583	1,339	289	71	601	32	1,693	1,236	0.578
2016	3,548	1,186	320	94	736	25	2,492	1,067	0.700
Mean	5,018	846	158	49	1,101	23	3,968	800	0.804
					Okanogan Basin				
2002	5,781	183	-	-	-	-	5,781	183	0.969
2003	2,667	163	1	4	120	2	2,546	157	0.942
2004	2,840	216	11	5	385	1	2,444	210	0.921
2005	2,741	165	15	3	528	3	2,198	159	0.933
2006	2,054	140	10	3	492	5	1,552	132	0.922
2007	2,007	120	4	7	-	-	2,003	113	0.946
2008	1,868	241	5	3	288	7	1,575	231	0.872
2009	2,453	220	5	11	446	5	2,002	204	0.908
2010	6,556	377	4	13	3,110	16	3,442	348	0.908
2011	3,017	347	-	16	899	15	2,118	316	0.870
2012	2,933	271	10	5	400	5	2,523	261	0.906
2013	2,264	175	8	4	534	3	1,722	168	0.911
2014	1,439	367	42	16	223	8	1,174	343	0.774
2015	1,443	393	42	16	255	11	1,146	366	0.758
2016	1,982	349	42	16	152	3	1,788	330	0.844
Mean	2,803	248	15	9	602	6	2,268	235	0.892

Straying

Determining stray rates of hatchery summer steelhead is difficult because adults are not recovered as carcasses on spawning grounds. We used PIT tag antenna arrays to evaluate the spawning distribution of 2012 and 2013 brood PIT tagged hatchery origin summer steelhead reared at Wells Hatchery and released into the Columbia, Methow, and Twisp rivers (Attachment D). Fish that entered tributaries on a date consistent with a spawning migration (March-May) and resided in the tributary for a period when spawning was on-going, were considered to have spawned in the tributary. Hatchery fish that met these criteria within a tributary other than their tributary of release were considered to have strayed. Based on completed adult return data from the 2012 brood, stray rates for Methow Basin steelhead releases (Methow and Twisp) averaged 9.5% (Table 5.19). These estimates should be considered preliminary values because efficiency of the antenna arrays are highly variable between sites, and PIT tag detections were very low for some release groups (e.g., 2012 Columbia River releases).

Table 5.19. Detection of adult hatchery summer steelhead released from Wells Hatchery into Methow Basin tributaries. Adult returns were detected in the Twisp River (TWR), Chewuch River (CRW), Methow River (MRW, GLC [Gold Creek], EWC [Early Winters Creek], and LOR [Lost River]) antenna arrays and at Zosel Dam in the Okanogan River basin. Detections of 2013 brood releases are considered incomplete because they include only 1-salt returns.

Brood	Release river (donor pop.)	Recipient river, river area, or tributary							Total	% stray
		Upper Methow	Twisp	Chewuch	Lower Methow tribs	Lower Methow / Wells Pool	Foster Creek / tribs below Wells	Okanogan Basin		
2012	Columbia	0	0	0	0	1	0	0	1	N/A
2012	Methow	2	0	0	0	18	0	2	22	9.1
2012	Twisp	0	26	0	0	10	0	4	40	10.0
2013	Columbia	0	0	0	1	45[a]	3	2	51	11.8
2013	Methow	6	0	0	0	23	1	0	30	3.3
2013	Twisp	0	5	0	1	4	0	0	10	10.0

[a] Includes one return to Wells tailrace.

Smolt to Adult Survival and HRR

The smolt-to-adult return of summer steelhead was calculated from run evaluation monitoring conducted at Wells Dam and broodstock sampling conducted at Wells Hatchery. The HRR is calculated as the number of hatchery adult returns divided by the number of adult broodstock used to produce the return cohort. The HRR for the most recent brood where complete adult return data were available (2012 brood) was 13.4 for Wells Hatchery releases, and 24.2 for Twisp River conservation program releases (Table 5.20). These values were below the HRR target of 19.6 for Wells releases but above the target value for Twisp River releases.

Table 5.20. Number of broodstock spawned (including pre-spawn mortalities) and smolts released by brood year from Wells Complex hatchery facilities, including the Twisp conservation program (T). Adult returns from Winthrop National Fish Hatchery and Cassimer Bar Hatchery were indistinguishable from Wells Hatchery releases for the 1996-2006 broods and are thus included in all categories for those years.

Brood year	Number of broodstock	Smolts released	Adult returns	SAR (%)	# Smolts/ adult	HRR
			Wells Releases			
1996	207	531,798	2,779	0.523	191	13.4
1997	316	543,028	4,702	0.866	115	14.9
1998	377	888,180	14,076	1.585	63	37.3
1999	310	712,822	14,691	2.061	49	47.4
2000	277	653,874	1,752	0.268	373	6.3
2001	277	541,453	11,218	2.072	48	40.5
2002	288	580,498	4,577	0.788	127	15.9
2003	228	468,538	6,129	1.308	76	26.9
2004	272	467,266	4,878	1.044	96	17.9
2005	273	557,259	7,478	1.255	75	27.4
2006	247	592,468	7,889	1.332	75	31.9
2007	218	557,259	19,919	3.574	28	91.4
2008	229	455,145	6,020	1.323	76	26.3
2009	199	394,417	6,051	1.543	65	30.4
2010	247	459,038	3,958	0.862	116	16.0
2011	195	297,270	4,545	1.529	65	23.3
2012	162	155,474	2,176	1.400	71	13.4
Mean	254	520,929	7,226	1.373	101	28.3
			Twisp Releases			
2011	25	41,170	379	0.921	109	15.2
2012	26	51,473	629	1.222	82	24.2
Mean	26	46,322	504	1.072	95	19.7

Natural Replacement Rates

The natural replacement rate (NRR) of wild summer steelhead in the Methow River basin was calculated as the number of natural origin recruits divided by the overall spawning population of hatchery and natural origin adults of the parent brood (Attachment D). The NRR of the last brood for which complete adult return data was available (2010 brood) was 0.245 (Table 5.21), which is slightly lower than the mean NRR of the 1996-2010 broods (0.294).

Table 5.21. Natural replacement rate (NRR) of Methow River basin steelhead spawners. The NRR is calculated by dividing the number of natural origin return (NOR) recruits produced by the sum of the spawning population of hatchery origin (HOR) and natural origin (NOR) spawners.

Parent brood year	Methow Basin run escapement (parent brood)			Methow Basin recruits	
	HOR	NOR	Total	NOR	NRR
1996	363	66	429	319	0.744
1997	1,787	185	1,972	715	0.363
1998	2,264	77	2,341	745	0.318
1999	1,485	151	1,636	194	0.119
2000	1,806	279	2,085	1,011	0.485
2001	3,385	373	3,758	651	0.173
2002	10,350	624	10,974	395	0.036
2003	4,521	543	5,064	448	0.088
2004	4,748	724	5,472	1,006	0.184
2005	4,228	551	4,779	1,163	0.243
2006	2,994	468	3,462	1,565	0.452
2007	3,338	410	3,748	1,524	0.406
2008	2,860	810	3,670	883	0.241
2009	3,749	729	4,475	1,262	0.282
2010	7,412	1,224	8,637	2,113	0.245
Median	3,338	468	3,748	883	0.245

Proportionate Natural Influence

The Hatchery Scientific Review Group (HSRG) developed guidelines for salmon and steelhead hatchery programs intended to provide a foundation of hatchery reform principals that should aid hatcheries in the Pacific Northwest in meeting conservation and sustainable harvest goals (HSRG 2008). These guidelines provide a means of assessing the genetic risk of hatchery programs to natural populations by calculating the proportionate natural influence (PNI) of a population. The PNI is calculated as: (the proportion of natural origin fish within the broodstock [pNOB])/(pHOS+pNOB). A PNI value > 0.5 indicates that genetic selection pressures from the natural environment have a stronger influence on the population than those from the hatchery environment, and a PNI ≥ 0.67 was recommended for conservation programs (HSRG 2009). For the 2002-2016 broods, PNI has been slightly higher in the Methow Basin than in the Okanogan Basin, but mean values for both basins are low and indicate that most genetic selection pressure on the populations comes from the hatchery environment (Table 5.22).

Table 5.22. The proportionate natural influence (PNI) calculated for specific broods of spawning steelhead in the Methow and Okanogan river basins. The proportion of hatchery origin spawners (pHOS) in the escapement of each tributary was derived from Table 5.16. The net proportion of natural origin fish within each brood (pNOB) was estimated as the sum of the proportion of each salt-age of hatchery origin spawners (HOS) multiplied by the pNOB for that salt age. The PNI was calculated as: pNOB/(pNOB+pHOS).

Brood	Net tributary escapement		HOS age proportion		pNOB		Net pNOB	PNI
	Total	pHOS	1-Salt	2-Salt	1-Salt	2-Salt		
				Methow Basin				
2002	10,974	0.94	0.42	0.58	0.07	0.03	0.05	0.05
2003	5,064	0.89	0.17	0.83	0.10	0.07	0.08	0.08
2004	5,472	0.87	0.97	0.03	0.07	0.10	0.07	0.08
2005	4,779	0.88	0.39	0.61	0.05	0.07	0.06	0.07
2006	3,463	0.86	0.39	0.61	0.09	0.05	0.07	0.07
2007	4,002	0.90	0.81	0.19	0.27	0.09	0.24	0.21
2008	3,670	0.78	0.74	0.26	0.17	0.27	0.20	0.20
2009	4,475	0.84	0.73	0.27	0.23	0.17	0.21	0.20
2010	8,637	0.86	0.54	0.46	0.12	0.23	0.17	0.17
2011	3,443	0.68	0.54	0.46	0.25	0.12	0.19	0.22
2012	4,668	0.82	0.49	0.51	0.23	0.25	0.24	0.23
2013	3,580	0.85	0.42	0.58	0.23	0.23	0.23	0.21
2014	2,807	0.60	0.49	0.51	0.27	0.23	0.25	0.29
2015	2,929	0.58	0.29	0.71	0.28	0.26	0.27	0.32
2016	3,559	0.70	0.72	0.28	0.18	0.31	0.22	0.24
Mean	4,768	0.80	0.54	0.46	0.17	0.17	0.17	0.18

Table 5.22. Continued.

Brood	Net tributary escapement		HOS age proportion		pNOB		Net pNOB	PNI
	Total	pHOS	1-Salt	2-Salt	1-Salt	2-Salt		
				Okanogan Basin				
2002	5,965	0.97	0.42	0.58	0.07	0.03	0.05	0.05
2003	2,704	0.94	0.17	0.83	0.10	0.07	0.08	0.07
2004	2,654	0.92	0.97	0.03	0.07	0.10	0.07	0.07
2005	2,357	0.93	0.39	0.61	0.05	0.07	0.06	0.06
2006	1,684	0.92	0.39	0.61	0.09	0.05	0.07	0.07
2007	2,116	0.95	0.81	0.19	0.27	0.09	0.24	0.20
2008	1,806	0.87	0.74	0.26	0.17	0.27	0.20	0.18
2009	2,205	0.91	0.73	0.27	0.23	0.17	0.21	0.19
2010	3,790	0.91	0.54	0.46	0.12	0.23	0.17	0.16
2011	2,435	0.87	0.54	0.46	0.25	0.12	0.19	0.18
2012	2,783	0.91	0.49	0.51	0.23	0.25	0.24	0.21
2013	1,890	0.91	0.42	0.58	0.23	0.23	0.23	0.21
2014	1,495	0.77	0.49	0.51	0.27	0.23	0.25	0.25
2015	1,512	0.76	0.29	0.71	0.28	0.26	0.27	0.26
2016	2,118	0.84	0.72	0.28	0.18	0.31	0.22	0.21
Mean	2,501	0.89	0.54	0.46	0.17	0.17	0.17	0.16

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Attachment A. 2016 Twisp and Methow River Smolt Estimates.

WASHINGTON STATE
DEPARTMENT OF FISH AND WILDLIFE
FISH PROGRAM - SCIENCE DIVISION
METHOW RESEARCH TEAM
20268 HWY 20, Twisp, WA 98856
Voice (509) 997-0048 FAX (509) 997-0072

17 May, 2017

To: Charlie Snow

From: David Grundy

Subject: 2016 Twisp and Methow River Smolt Estimates.

Smolt trapping in the Methow River basin was conducted to estimate the number of emigrating spring Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) from the Twisp and Methow Rivers. This information should assist in estimating the freshwater productivity and survival of target stocks and provide the productivity indicator information necessary to evaluate Objective 2 of the M&E Plan adopted by the Wells HCP Hatchery Committee (Hillman et al. 2013):

Objective 2: Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of supplemented stocks.

Methods

Rotary smolt traps of different sizes were operated in several configurations depending on the specific requirements of each site. The Twisp River trap is located at approximately rkm 2 and used a single trap with a 1.5 m cone diameter because of low stream flow and a relatively narrow stream channel. The Methow River trap is located at approximately rkm 30 and used traps with cone diameters of 2.4 m and 1.5 m to increase trap efficiency over a greater range of river discharge. Large variation in discharge in the Methow River also required the use of two trapping positions due to the channel configuration and safety of personnel and fish. A 1.5 m trap was deployed in the lower position at the Methow site at discharges below 45.3 m^3/s. At discharges greater than 45.3 m^3/s, an additional 2.4 m trap was installed and operated in tandem with the 1.5 m trap. The tandem traps were operated approximately 30 m upstream of the low position (i.e., upper position).

The Twisp trap was operated continuously during all hours of the day if debris and river discharge allowed. Trapping occurred only during nighttime hours at the Methow site. Trap cones were lowered 1-2 hours before sunset and raised 1-2 hours after sunrise. The traps were also pulled to the bank during the day to avoid debris as well as to allow easier access for boaters and recreational users as stated in our Okanogan County Conditional Use Permit. During periods of minimal catch, fish were removed from the traps each morning. During periods of greater discharge and/or fish abundance, traps were monitored throughout the night to minimize mortality of captured fish and avoid equipment damage from debris. Debris was removed from the catch box by a small rotating drum-screen powered directly by the rotation of the cone (2.4-m trap) or by the cone contacting a rubber tire that caused the drum-screen to rotate (1.5-m traps). Traps were either connected to a main cable spanning the river (Methow River site), or to a single point on the right bank (Twisp River site).

Biological Sampling

Captured fish were retained in a 0.37 m^3 live box and were sorted, counted by species, and classified as hatchery or wild origin at each trap. Fish utilized for mark/recapture trials or tagged with passive integrated transponder (PIT) tags were held in 0.11 m^3 or 1.0 m^3 auxiliary live boxes affixed to the rear section of each trap. Salmonids were anesthetized in a solution of MS-222 prior to sampling and allowed to recover prior to release. Salmonids were visually classified as fry, parr, transitional, or smolt. Fry were defined as newly emerged fish without a visible yolk sac and largely underdeveloped pigmentation, with a fork length less than 50 mm. Parr had a fork length equal to or greater than 50 mm and distinct parr marks on their sides. Transitional migrants had faded parr marks, bright silver coloration, and some scale loss. Salmonids lacking or having highly faded parr marks, bright silver color, and deciduous scales were classified as smolts.

Hatchery origin fish were identified by the presence of marks (i.e., adipose fin-clip, ventral fin-clip), tags (i.e., coded-wire tags [CWT], PIT tags, elastomer tags), or by eroded fins or scale samples if no other marks or tags were identified. Juvenile salmonids lacking any marks, tags, or fin erosion were considered wild.

Sampling protocols differed by origin and species, although all fish were scanned for PIT tags prior to release. Hatchery-origin fish were counted by mark type, while most wild-origin fish were counted, measured to the nearest millimeter, and weighed to the nearest 0.1 g. Scale samples were collected from the majority of wild summer steelhead captured throughout the migration period. Scale samples were analyzed by the WDFW Scale Lab to estimate the contribution of different age classes to the migrating population. Most wild spring Chinook salmon and steelhead were PIT tagged prior to release, and all PIT tagging information was uploaded to a regional PIT tag database (PTAGIS) maintained by the Pacific States Marine Fisheries Commission. Non-salmonids were counted by species or by family if they were too small to identify to species (e.g., *Catostomidae*).

Age, trap location, and DNA analysis was used to determine race (spring or summer) of captured juvenile Chinook salmon. All Chinook salmon captured in the Twisp River trap were considered spring Chinook, regardless of size because summer Chinook have not been documented spawning upstream of the trap. All yearling (i.e., age-1) Chinook captured at the Methow River trap during the spring migration period were considered spring Chinook because spring Chinook are yearling migrants and summer Chinook are typically subyearling migrants. All age-0 Chinook salmon fry and parr captured at the Methow River trap during spring were considered summer Chinook.

During periods when the trap was not operating (e.g., mechanical problems, high debris, or high discharge) the number of spring Chinook, summer Chinook, and summer steelhead captured was estimated. The estimated daily number of fish that would have been captured had the trap been fishing was calculated using the average number of fish captured two days prior to the day being estimated and two days after redeployment of the trap. During extended non-trapping periods at the Twisp site, we estimated emigration using the Twisp PIT tag antenna array (PTAGIS code TWR) by expanding run-of-the-river PIT tag detections at the site by the estimated tag rate determined from smolt trap captures, and the estimated antenna array efficiency based on discharge/detection efficiency modeling as conducted for the smolt traps.

Population Estimates

Groups of at least 50 juvenile salmonids were used for trap efficiency trials whenever possible. However, low abundance of target species and low trap efficiency, resulting in low number of captured individuals, required the use of some groups with fewer than 50 fish. Mark/recapture fish were marked using a top or bottom caudal fin-clip, PIT tag, or were stained with Bismarck brown dye. Fish used in trap efficiency trials were anesthetized prior to marking and then held in an auxiliary live box for up to three days until the day of the trial. Marked fish were transported upstream of the trap in a 1,211 L two-chamber transport tank, or 18.9 L snap-lid buckets. Fish were divided into two equal groups and released on both stream banks to increase the likelihood that marked fish were uniformly mixed with unmarked fish and therefore representative of the population when recaptured. Releases of marked fish occurred in the evening after the trap was set. Marked fish from the Methow River trap were transported and released approximately 5.6 km upstream of the trap (rkm 36). Fish marked for Twisp River trap mark groups were transported and released approximately 5.8 km upstream of the trap (rkm 8). Recaptured fish were recorded by mark type, measured, and released. Marked groups of fish were released over the greatest range of discharge possible in order to best represent the range of flows in the trap efficiency-flow regression model used to estimate the daily trap efficiency. The mean daily discharge for each trapping period was calculated based on the start and end time of trap operation. Discharge was measured and recorded every 15 min at USGS gauging station No. 12449950 (Methow River near Pateros, Washington) and station No. 12448998 (Twisp River near Twisp, Washington).

Emigration estimates were calculated using estimated daily trap efficiency, which was derived from a weighted regression formula using trap efficiency (dependent variable) and discharge (independent variable). Trap efficiency was calculated using the following formula:

Trap efficiency = $E_i = R_i + 1 / M_i$

Where E_i is the trap efficiency during time period i; M_i is the number of marked fish released during time period i; and R_i is the number of marked fish recaptured during time period i. The number of fish captured was expanded by the estimated daily trap efficiency (e) to estimate the daily number of fish migrating past the trap (N_i) using the following formula:

Estimated daily migration = $\hat{N}_i = \dfrac{(C_i + 1)}{\hat{e}_i}$

Where N_i is the estimated number of fish passing the trap during time period i; C_i is the number of unmarked fish captured during time period i; and e_i is the estimated trap efficiency for time period i based on the regression equation.

The variance for the total daily number of fish migrating past the trap was calculated using the following formula:
Variance of daily migration estimate =

$$Var\left(\sum_{i=1}^{n}\hat{N}_i\right) \doteq \sum_i \hat{N}_i^2\left(\frac{N_i\hat{e}_i(1-\hat{e}_i)}{(C_i+1)^2} + \frac{4(1-\hat{e}_i)}{\hat{e}_i}M\hat{S}E\left(1+\frac{1}{n}+\frac{(x_i-\overline{x})^2}{(n-1)s_x^2}\right)\right) +$$
$$\sum_i\sum_j 4\left(\hat{N}_i(1-\hat{e}_i)\right)\left(\hat{N}_j(1-\hat{e}_j)\right)\cdot\left[\hat{V}ar(b_0) + x_i x_j \hat{V}ar(b_1)\right]$$

Where x_i is the discharge for time period i, and n is the sample size (number of mark/recapture trials used in model). If a relationship between discharge and trap efficiency was not present (i.e., $P < 0.05$; $r^2 \approx 0.5$), pooled trap efficiency was used to estimate daily emigration:

Pooled trap efficiency = $E_p = \dfrac{\sum_{k=1}^{n} r_k}{\sum_{k=1}^{n} m_k}$

Where $\sum_{k=1}^{n} m_k$ = the total number of marked fish for all k mark/recapture events;

$\sum_{k=1}^{n} r_k$ = the total number of marked fish that were recaptured from all k mark/recapture events.

The daily emigration estimate was calculated using the formula:

Daily emigration estimate = $\hat{N}_i = C_i / E_p$

The variance for daily emigration estimates using the pooled trap efficiency was calculated using the formula:

Variance for daily emigration estimate = $\text{var}\left[\hat{N}_i\right] = \hat{N}_i^2 \dfrac{E_p(1-E_p)/\sum M}{E_p^2}$

The total emigration estimate and confidence interval were calculated using the following formulas:

Total emigration estimate = $\sum \hat{N}_i$

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

A valid estimate would require the following assumptions to be true concerning the trap efficiency trials:

1. All marked fish passed the trap or were recaptured during time period *i*.
2. The probability of capturing a marked or unmarked fish is equal.
3. Marked individuals were randomly dispersed in the population before recapture.
4. All marked fish recaptured were identified.
5. Marks were not lost between the time of release and recapture.

Ideally, a species-specific discharge/capture efficiency model (i.e., flow model) was developed at each trap site within each year for each trap position used. When this was not possible, we used the following protocols in order of priority to determine the methodology used to develop production estimates for each trap site and species:

1. Flow model using target species within current year.
2. Flow model using target species over multiple years.
3. Flow model using target and surrogate species within current year.
4. Flow model using target and surrogate species over multiple years.
5. Flow model using surrogate species within current year.
6. Flow model using surrogate species over multiple years.
7. Pooled efficiency estimate using target species within current year.
8. Pooled efficiency estimate from previous year.

Juveniles Per Redd

Production estimates for each cohort age class, by trapping location, were summed to produce a total brood year emigration estimate. For spring Chinook, the estimate of fall-migrant parr was added to the estimate of yearling emigrants the following spring to produce a total emigrant estimate for each brood year. Additionally, to estimate over-winter emigration the daily number of PIT tagged juvenile Chinook detected at the Twisp River PIT tag array was expanded by a tag rate estimated from smolt trap captures of yearling Chinook captured during the entire migration period. This estimate was expanded by the estimated daily detection efficiency based on flow at the PIT tag array. The flow/efficiency relationship of the PIT tag array was determined through mark/recapture efficiency trials conducted at different flows with PIT tagged fish released above the array and detected at sites downstream of the PIT array (e.g., Rocky Reach Dam). The resulting over-winter emigration estimate was added to the juvenile production estimate from trap captures. Spring Chinook fry that emigrate during the spring past the Twisp and Methow smolt traps are not included in production estimates at those sites, thus their contribution to overall juvenile production is unknown.

The steelhead emigration estimate at each trap location was multiplied by the proportion of migrants from each brood determined through scale pattern analysis. Because juvenile steelhead potentially emigrate at age-4 or later, determining the total number of emigrants produced from one brood of spawning adults requires at least four years of emigration estimates. The number of emigrants per redd for each brood year was calculated by dividing the total brood year emigrant production estimate by the total number of redds located above the trap in that brood year estimated through spawning ground surveys.

For spring Chinook salmon, egg deposition values used to calculate egg-to-emigrant survival were derived from carcass surveys and hatchery broodstock sampling. For each brood examined, the number of eggs deposited was estimated using the proportions by age and origin of the female spawning population within each basin as determined through spawning ground surveys. Each redd was then multiplied by the mean fecundity values by age and origin determined through sampling of Methow Hatchery broodstock, and adjusted by the mean percent of eggs retained in the body cavity determined through spawning ground (carcass) surveys. For summer steelhead, egg deposition values were derived by multiplying the total number of redds in each basin by mean fecundity values according to age and origin of the female steelhead population as determined through run composition and hatchery broodstock sampling at Wells Hatchery.

Spawning ground surveys identified summer steelhead and spring Chinook redds downstream of the Methow and Twisp rivers trap sites in some years. It was assumed that redds located downstream from each trap site did not contribute to production estimates calculated at upstream smolt traps. To calculate total production and emigration estimates for the populations, the egg-to-emigrant survival rates calculated for redds upstream of the trap were applied to the estimated number of eggs deposited downstream of the trap. Confidence intervals (95%) were adjusted in a similar manner. Total brood year emigration estimates were calculated by adding the estimated number of emigrants produced downstream of the trap to the estimate of emigrants produced upstream of the trap location.

Results

Smolt Trap Operation

Trapping in the Methow River basin in 2016 began at the Methow River site on 19 February and at the Twisp River site on 27 February. Trapping at both locations was interrupted over the course of the trapping season due to high river discharge. Trapping at the Methow site was interrupted on two occasions for a total of 17 days between 19 February and 5 December. Trapping at the Twisp site was interrupted on three occasions for a total of 35 days between 27 February and 5 December. River discharge peaked earlier in the spring than average. River discharge at both trapping locations were above the historical daily values for all but four days during the month of April. The early peak was followed by below average discharge for the majority of the late spring period from late-May through July (Figures 1 and 2). Near or above average discharge during the summer and fall months allowed fairly consistent trap operation until ice accumulation in early December.

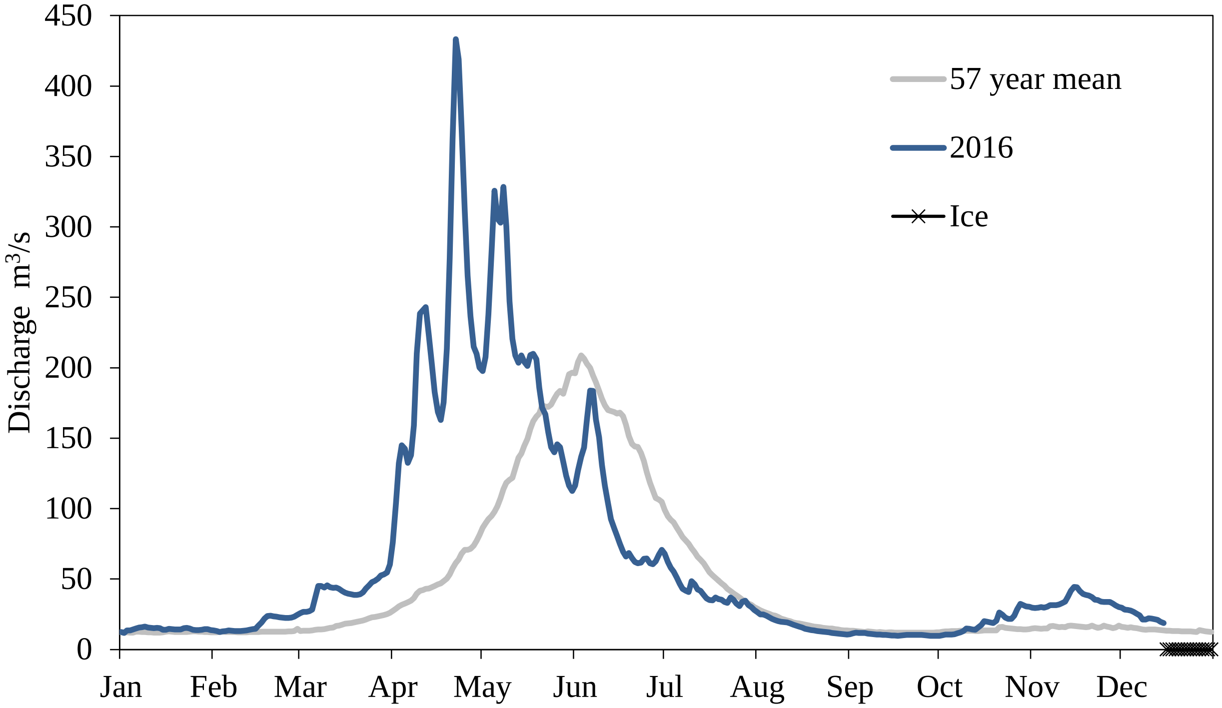

Figure 1. Methow River 2016 daily discharge and 57-year mean as measured at the USGS gauging station No. 12449950 (Methow River near Pateros, Washington).

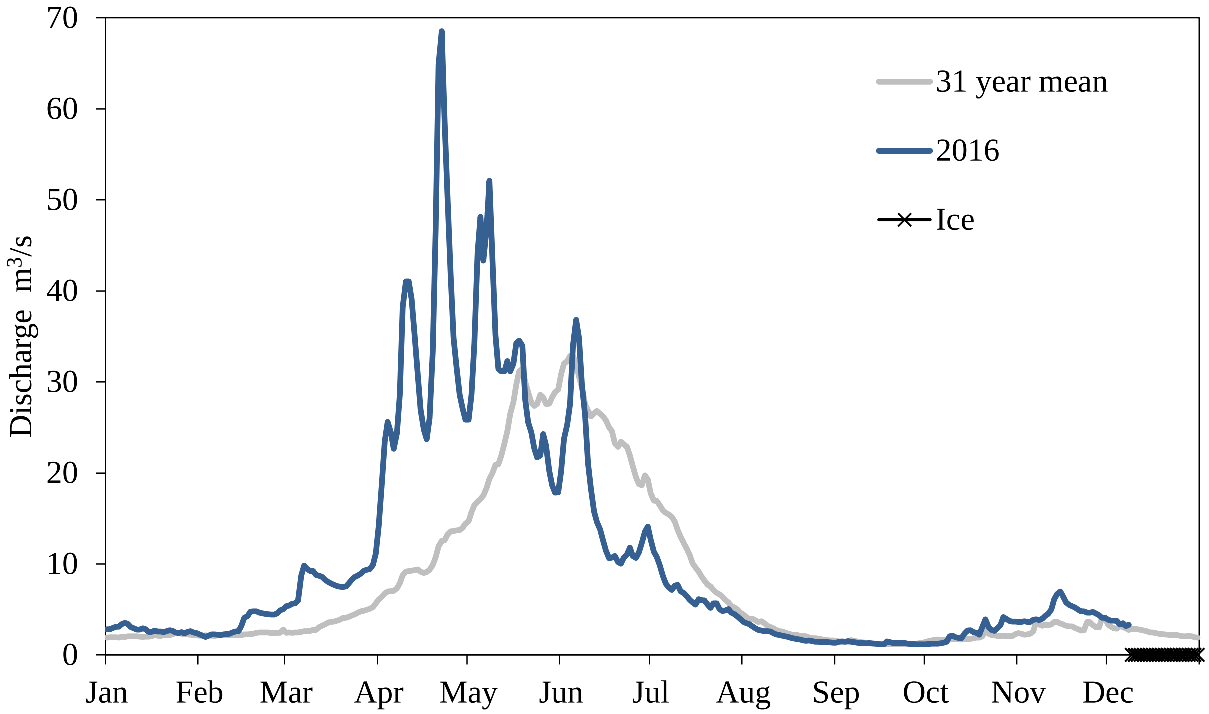

Figure 2. Twisp River 2016 daily discharge and 31-year mean as measured at the USGS gauging station No.12448998 (Twisp River near Twisp, Washington).

Daily Captures and Biological Sampling

2014 Brood Chinook Salmon

A total of 487 wild yearling Chinook salmon emigrants were captured at the Methow site between 19 February and 30 June, with the peak capture (*N* = 56) occurring on 1 April (Figure 3). We inserted PIT tags into 476 of the wild smolts captured, and subsequently released 471 after subtracting three mortalities and two shed tags (Appendix A). Overall mortality of wild yearling Chinook totaled three of the 487 fish captured (0.62%). Instead of PIT tagging hatchery fish, we utilized 65 hatchery spring Chinook salmon that had existing PIT tags to facilitate trap efficiency mark/recapture trials. In addition to the tagged fish, 743 hatchery Chinook were marked with a caudal fin clip and released upstream to aid in efficiency trials. Overall mortality of hatchery Chinook at the Methow site totaled 74 out of 3,339 fish captured (2.2%). Hatchery smolts had a significantly greater mean fork length (128.6 mm) than wild Chinook smolts (99.1 mm) captured at the Methow trap (Mann-Whitney U-test: $P < 0.001$; Table 2).

The Twisp River trap captured 403 wild yearling spring Chinook salmon smolts between 27 February and 30 June. Peak capture occurred on 2 April (*N* = 36; Figure 4). We inserted PIT tags into 397 of the captured wild fish and all were subsequently released (Appendix A). Three of the 403 yearling Chinook captured had existing PIT tags when captured, and three additional fish were in poor condition when captured and were not tagged prior to release. Overall mortality of wild yearling Chinook at the Twisp site totaled one of the 403 fish captured (0.25%). In addition to the 300 hatchery spring Chinook that were caudal clipped, we used 301 hatchery spring Chinook that had existing PIT tags for mark/recapture trials. There was no mortality experienced by any of the 2,177 hatchery Chinook salmon smolts captured at the Twisp trap.

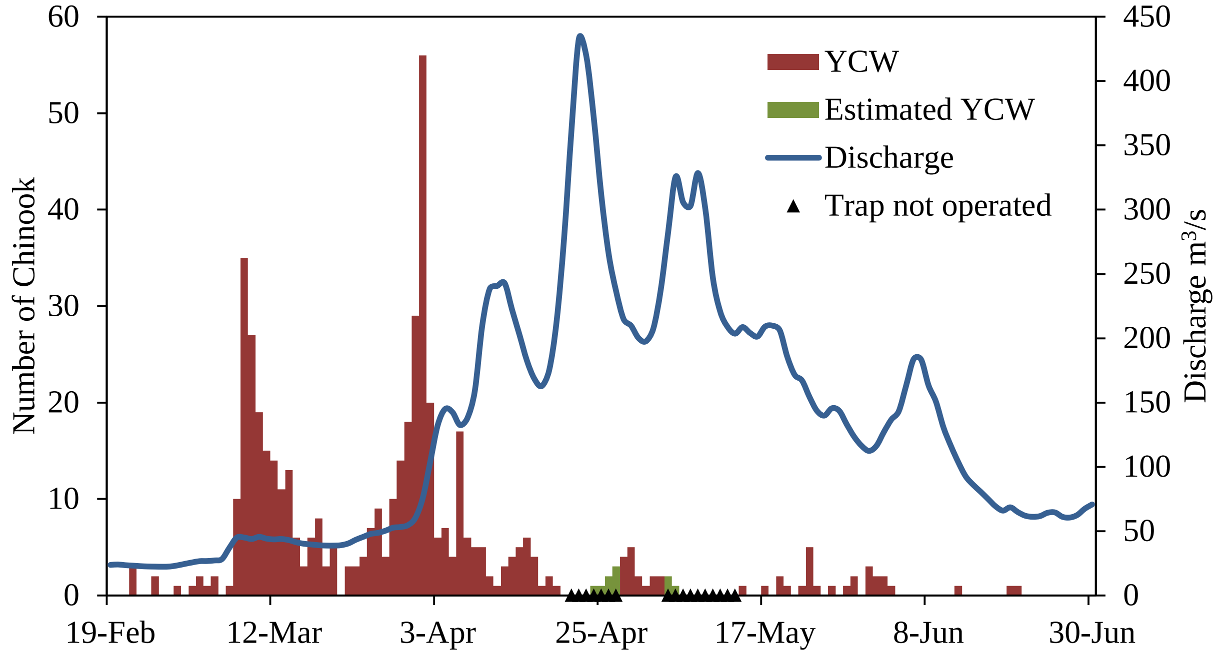

Figure 3. Daily capture of wild Chinook salmon smolts (YCW) at the Methow River smolt trap in 2016.

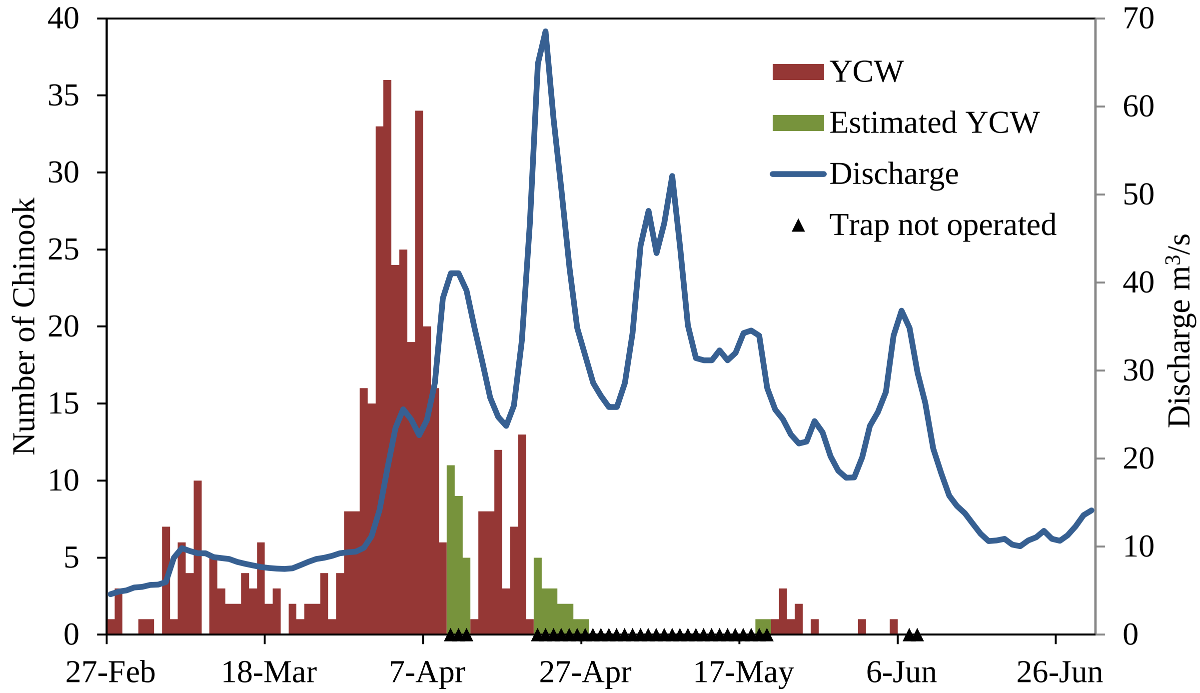

Figure 4. Daily capture of wild spring Chinook salmon smolts (YCW) at the Twisp River smolt trap in 2016.

2015 Brood Chinook Salmon

Subyearling Chinook salmon fry (*N* = 4,581) and parr (*N* = 1,931) captured at the Methow trap between 19 February and 30 September had mean fork lengths of 40.6 mm and 65.3 mm, respectively (Table 2). Mortality during this period totaled 97 fry (2.1%) and 12 parr (0.62%). An additional 179 emigrant Chinook parr were captured during the fall trapping period between 1 October and 5 December. The mean fork length of Chinook parr during this period was 95.6 mm (Table 2), and peak captures occurred on 22 October (*N* = 15). We inserted PIT tags into 174 of the Chinook parr captured and 173 were released after a single mortality occurred prior to being released (0.57%; Appendix A). Six of the parr captured had existing PIT tags from upstream sources. Tissue samples were collected from 174 of the fall-captured parr, and genetic analysis was conducted on 100 of those samples. One of the samples failed to produce a genotype and was excluded from analysis. Of the remaining 99 samples, analysis indicated that 96 (97.0 %) of the sampled parr were spring Chinook, and three (3.0%) were summer Chinook (Appendix B). These results are similar to results from sampling of fall parr in previous years (Table 1).

The Twisp trap captured 1,277 subyearling spring Chinook salmon between 27 February and 5 December, and peak captures occurred on 21 October (*N* = 84; Figure 5). We inserted PIT tags into 612 Chinook parr and 611 were released with tags after one fish shed a tag (Appendix A). There were also five Chinook parr that had existing PIT tags at capture. Overall, four subyearling Chinook mortalities occurred (0.31%). Fall migrant parr had a mean fork length of 88.6 mm (Table 2).

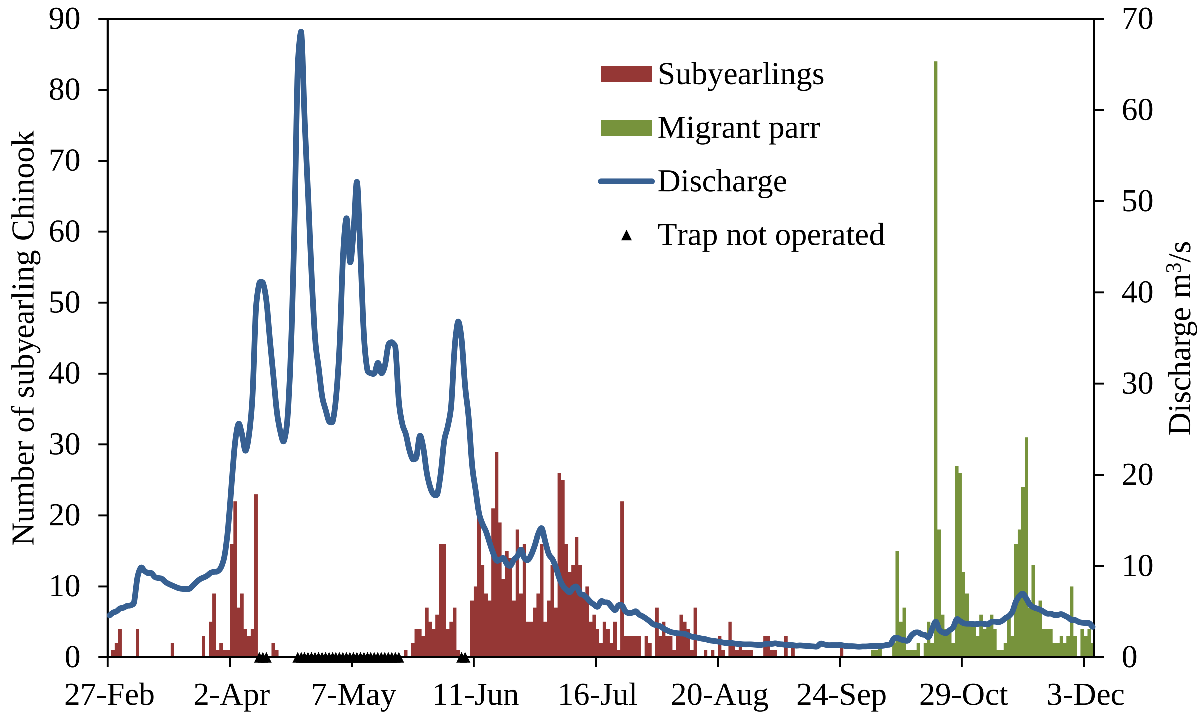

Figure 5. Daily capture of subyearling wild spring Chinook salmon (Feb – Sep) and migrant parr (Oct-Dec) at the Twisp River smolt trap in 2016.

Table 1. Percent of fish that were assigned to the spring Chinook salmon race from DNA analysis conducted on juvenile Chinook salmon captured at the Methow River smolt trap by trapping year and trapping period. During the spring period, samples in 2007 and 2008 were collected from age-1 yearling smolts, but samples from other years were collected from age-0 parr.

Trapping year	Spring (start-30 Jun)	Summer (1 Jul-30 Sep)	Fall (1 Oct-end)
2006	N/A	N/A	95.8
2007	(yearlings) 97.2	N/A	86.7
2008	(yearlings) 98.3	N/A	96.7
2009	5.5	11.8	100.0
2010	5.5	11.1	80.5
2011	18.2	N/A	92.9
2012	N/A	N/A	96.8
2013	N/A	N/A	96.0
2014	N/A	N/A	97.0
2015	N/A	N/A	91.0
2016	N/A	N/A	97.0
Mean	Yearling = 97.8, parr = 9.7	11.5	93.7

Table 2. Summary of length and weight sampling of Chinook salmon captured at Methow Basin smolt traps in 2016.

Brood	Origin/stage	Fork length (mm)			Weight (g)			Mean K-factor
		Mean	*N*	SD	Mean	*N*	SD	
				Methow River trap				
2015	Wild fry	40.6	801	4.4	--	--	--	--
2015	Wild parr (Feb-Sep)	65.3	676	12.7	3.8	645	2.6	1.2
2015	Wild parr (Oct-Dec)	95.6	179	8.8	9.8	179	2.9	1.1
2014	Wild smolt	99.1	486	8.9	10.7	486	2.9	1.1
2014	Hatchery smolt	128.6	816	8.8	25.9	816	5.8	1.2
				Twisp River trap				
2015	Wild fry	40.0	116	5.8	--	--	--	--
2015	Wild parr (Feb-Sep)	63.1	517	11.0	3.3	517	2.0	1.2
2015	Wild parr (Oct-Dec)	88.6	464	7.8	7.8	464	2.1	1.1
2014	Wild smolt	91.1	403	7.2	8.4	403	2.1	1.1
2014	Hatchery smolt	129.4	616	10.7	25.7	616	7.7	1.2

Summer Steelhead

The Methow River trap captured 190 wild summer steelhead emigrants (smolt and transitional) between 19 February and 30 June, with peak capture on 2 April (*N* = 26; Figure 6). We inserted PIT tags into 179 wild steelhead emigrants and all survived to release (Appendix A). Nine additional fish had existing PIT tags when captured; one fish originally tagged in 2014, seven fish tagged in 2015, and one fish tagged at the Twisp trap in 2016. In addition to these, one fish was in poor condition when captured and was not tagged prior to release. Overall mortality of emigrant steelhead totaled one of the 190 fish captured (0.53%). Most wild summer steelhead migrants were age-2 fish (64.7%), which had a mean fork length of 174.2 mm (Table 3). A total of 473 hatchery steelhead juveniles were captured at the Methow River trap. There were no mortalities of hatchery summer steelhead at the Methow trap site.

The Methow River trap captured 23 wild summer steelhead fry and 112 wild parr between 19 February and 5 December. Steelhead parr greater than 65 mm and in good physical condition were PIT tagged (*N* = 104), and 103 were released after subtracting a single mortality (Appendix A). Overall mortality of fry (*N* = 1) and parr (*N* = 1) totaled (1.5%) of the total fry and parr captured. Wild steelhead parr and fry had mean fork lengths of 108.1 mm and 29.7 mm respectively.

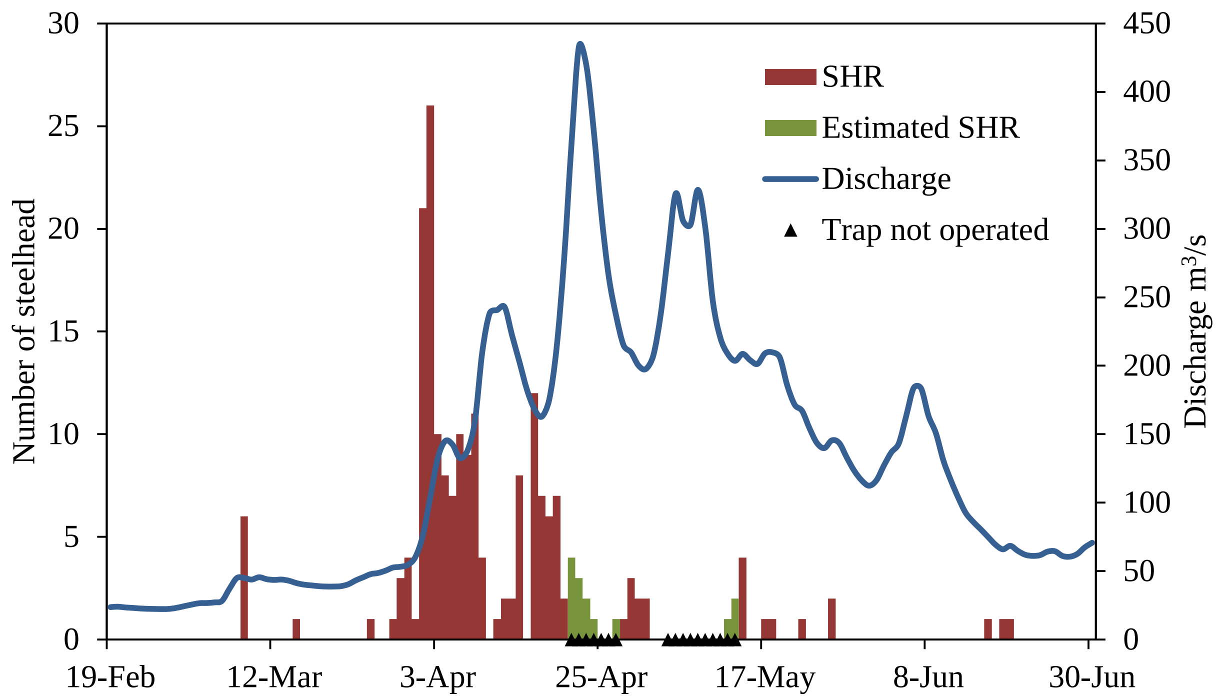

Figure 6. Daily capture of wild steelhead smolt and transitional migrants at the Methow River smolt trap in 2016.

Table 3. Mean length, weight and condition factor by age class of wild transitional and smolt summer steelhead emigrants captured in Methow Basin smolt traps in 2016.

Age	*N* (%)	Fork (mm)			Weight (g)			Mean K-factor
		Mean	*N*	SD	Mean	*N*	SD	
Methow River trap								
1	35 (20.6)	141.1	35	12.6	29.9	35	7.9	1.0
2	110 (64.7)	174.2	110	24.8	55.1	110	23.7	1.0
3	24 (14.1)	185.7	24	23.8	64.1	24	24.6	1.0
4	1 (0.6)	198.0	1	--	67.5	1	--	0.9
Twisp River trap								
1	11 (7.7)	134.2	11	15.2	27.4	11	8.6	1.1
2	105 (73.4)	157.0	105	15.4	39.6	105	12.2	1.0
3	26 (18.2)	178.3	26	18.6	57.5	26	15.5	1.0
4	1 (0.7)	165.0	1	--	44.1	1	--	1.0

A total of 160 wild summer steelhead emigrants (smolt and transitional) were captured at the Twisp trap between 27 February and 30 June, and the peak capture occurred on 2 April (*N* = 21; Figure 7). Wild emigrants (all ages combined) had a mean fork length of 159.4 mm, and were primarily age-2 fish (73.4%; Table 3). We inserted PIT tags into 139 wild steelhead emigrants and all were released alive (Appendix A). Twenty additional fish had existing PIT tags when captured; 17 of these were originally tagged in 2015, and three were originally tagged in 2014. There was only a single trapping mortality experienced by smolt or transitional steelhead out of the 160 captured at the Twisp site (0.63%). A total of 2,100 hatchery summer steelhead juveniles were captured at the Twisp river trap, and no mortalities were experienced (0.0%). We conducted upstream releases of 417 hatchery steelhead for mark/efficiency trials, of which 113 had existing PIT tags, and 301 received caudal clips for identification.

Non-migrant summer steelhead captured at the Twisp trap included 51 wild fry and 276 wild parr captured between 27 February and 5 December (Figure 8). We inserted PIT tags into 242 steelhead parr greater than 65 mm and all survived until release (Appendix A). Overall mortality of fry (*N* = 0) and parr (*N* = 1) represented 0.31% of the total fry and parr captured (*N* = 327). Wild steelhead parr and fry had mean fork lengths of 102.7 mm and 35.8 mm respectively.

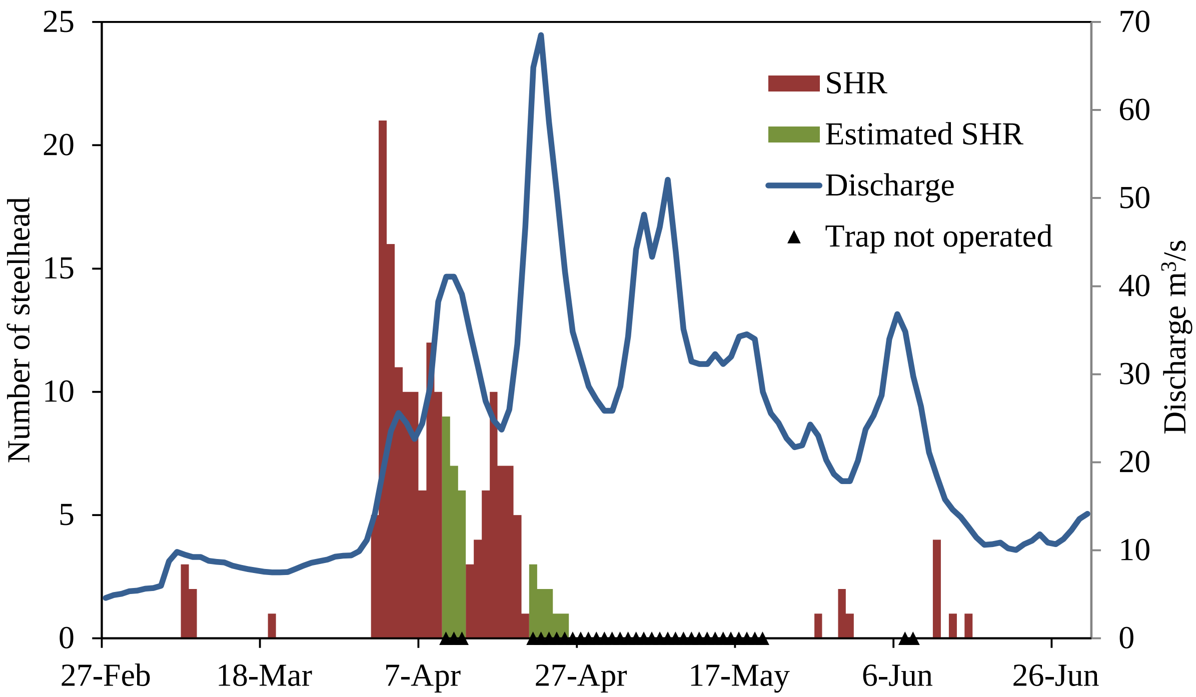

Figure 7. Daily capture of wild steelhead (SHR) smolt and transitional migrants at the Twisp River smolt trap in 2016.

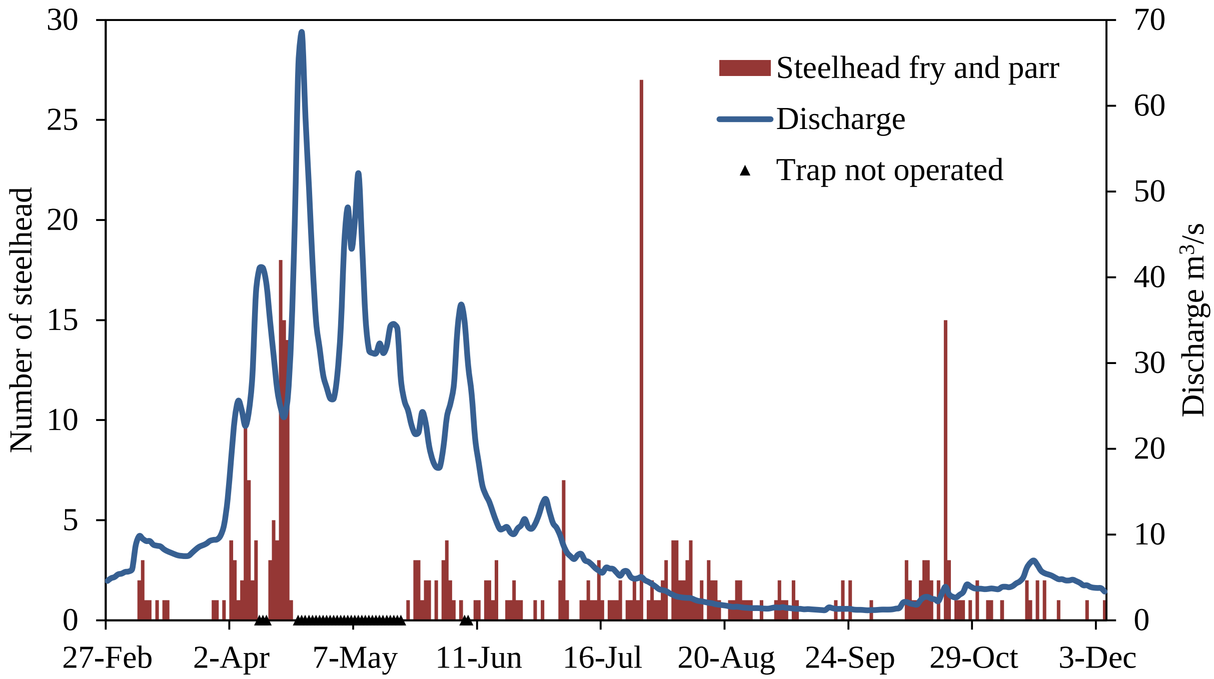

Figure 8. Daily capture of wild steelhead fry and parr at the Twisp River smolt trap in 2016.

<u>*Incidental Species*</u>

Longnose Dace (*Rhinichthys cataractae*) were the most abundant incidental species captured at both the Methow and Twisp River traps. Catch totals and select biological sampling on incidental species in shown in Table 4.

Table 4. Biological sampling conducted on selected incidental species captured at Methow River basin smolt traps in 2016.

Species	Captured	Fork length (mm)			Weight (g)		
		Mean	*N*	SD	Mean	*N*	SD
Methow River trap							
Longnose Dace (*Rhinichthys cataractae*)	1,377	35.7	449	15.1	11.6	22	7.7
Sucker (*Catostomus spp.*)	1,356	52.8	458	27.0	10.5	168	42.5
Pacific Lamprey (*Lampetra tridentata*)	343	153.2	65	30.2	7.2	62	1.9
Sculpin (*Cottus spp.*)	120	40.5	97	15.9	4.0	26	3.6
Wild Coho smolt (*O. kisutch*)	118	104.0	118	11.6	12.6	118	4.1
Hatchery Coho (*O. kisutch*)	98	128.3	17	9.7	23.4	17	4.8
Mountain Whitefish (*Prosopium williamsoni*)	97	35.3	55	6.6	2.4	3	0.9
Redside Shiner (*Richardsonius balteatus*)	48	37.0	32	12.8	6.7	2	7.2
Bridgelip sucker (*Catostomus columbianus*)	20	58.7	14	27.2	7.6	8	14.2
Sockeye fry (*O. nerka*)	18	25.6	18	1.4	--	--	--
Wild Coho parr (*O. kisutch*)	13	80.9	11	10.1	6.8	11	2.2
Bull Trout (*Salvelinus confluentus*)	5	197.0	3	58.3	79.7	3	58.6
Umatilla Dace (*Rhinichthys umatilla*)	2	31.5	2	6.4	--	--	--
Cutthroat Trout (*O. clarki*)	1	149.0	1	--	33.7	1	--
Twisp River trap							
Longnose Dace (*Rhinichthys cataractae*)	942	100.1	632	17.7	14.8	617	6.7
Sculpin (*Cottus spp.*)	128	67.5	121	27.9	10.4	78	10.2
Wild Coho smolt (*O. kisutch*)	49	103.5	49	16.1	13.5	49	7.0
Sucker (*Catostomus spp.*)	26	91.8	23	62.0	33.6	17	80.6
Wild Coho parr (*O. kisutch*)	15	78.1	15	15.7	5.9	15	3.1
Bull Trout (*Salvelinus confluentus*)	15	218.0	4	25.8	110.7	4	32.6
Mountain Whitefish (*Prosopium williamsoni*)	9	53.1	7	46.6	35.8	1	--
Cutthroat Trout (*O. clarki*)	7	195.0	7	26.0	84.1	7	31.8
Wild Coho fry (*O. kisutch*)	3	40.0	3	8.0	--	--	--
Brown Bullhead (*Ictalurus nebulosus*)	3	--	--	--	--	--	--
Bridgelip sucker (*Catostomus columbianus*)	1	316.0	1	--	380.9	1	--

Population Estimates

2014 Brood Spring Chinook Salmon

Mark/recapture efficiency trials for estimating wild spring Chinook salmon smolt production should ideally be conducted with wild Chinook salmon. Due to the low capture numbers for wild fish at the Methow trap, many efficiency trials utilize hatchery Chinook as surrogates. We did not conduct any mark/recapture trials for the low trap position because higher than average river discharge required operation in the upper position for most of the spring trapping season. A significant relationship did exist ($P < 0.01$; $r^2 = 0.52$; Table 5) from trials conducted during previous seasons, and the regression ($y = -2.57E\text{-}05x + 0.161723324$) was used for the low trapping position in 2016. For the upper trapping position, a mark/recapture trial was conducted with wild spring Chinook as well as two trials using hatchery Chinook. These three groups were combined with releases conducted during the previous four years, which resulted in a significant relationship ($P < 0.01$, $r^2 = 0.75$; Table 5) and the regression ($y = -2.52E\text{-}05x + 0.270693602$) was used for the upper position in 2016. Using both these flow models, the estimated number of yearling spring Chinook salmon emigrants was 35,330 (± 5,169, 95% CI). Combining the yearling emigrants with the estimate of parr that emigrated past the trap in the fall of 2015 (34,402 ± 180,061, 95% CI), a total estimated 69,732 (± 180,135, 95% CI) 2014 brood wild spring Chinook migrated from the Methow River basin between 1 October 2015 and 30 June 2016. Emigration peaked during November 2015 when 49.3% of the estimated emigrants migrated past the Methow trap (Figure 9).

Two mark/recapture trials were conducted with hatchery spring Chinook smolts at the Twisp trap in the spring of 2016, but they were conducted at flows that were much higher than any previous releases, and they could not be combined with historical groups to produce a significant relationship. However, a significant efficiency discharge relationship existed from release groups conducted during previous seasons ($P < 0.01$, $r^2 = 0.64$; Table 6). The flow model regression ($y = -0.00056877x + 0.529960351$) was used to estimate that 6,519 (± 1,561, 95% CI) smolts emigrated past the Twisp River trap between 27 February and 30 June 2016. There was one redd identified downstream of the Twisp trap in 2014, so an estimated 48 migrants were added to produce a total of 6,567 (± 1,566, 95% CI) yearling emigrants from the Twisp River in 2016. Snow et al. (2016) estimated that 18,290 (± 4,747, 95% CI) 2014 brood spring Chinook salmon parr emigrated from the Twisp River in the fall of 2015, which included 133 expected emigrants produced from a single redd found downstream of the Twisp trap in 2014. In addition to the smolt trap estimates, mark/detection trials performed at the Twisp PIT tag array (Table 7) were used to estimate that 3,443 (± 1,272, 95% CI) spring Chinook emigrated between 21 November 2015 and 26 February 2016 when the smolt trap was not operating. An additional 25 over-winter migrants were estimated from the single redd located downstream of PIT array in 2014 to total 3,468 (± 1,276, 95% CI) over-winter migrants. Adding all emigrant totals, the complete emigration estimate for the 2014 spring Chinook brood was 28,325 (± 5,167, 95% CI) fish. Emigration peaked during November 2015, when 50.8% of the 2014 brood migrated from the Twisp River (Figure 10).

To corroborate the Chinook estimates calculated from the Twisp River screw trap, we created an estimate from expanding PIT interrogations at the TWR PIT array. We found the 2014 brood Chinook captured between 1 July 2015 and 30 June 2016 to have an existing PIT tag rate of 2.35 percent. The PIT tag rate in conjunction with the flow/efficiency regression created for the TWR PIT antennas ($y = -0.00174870x + 1.336948968$; Table 7) was used to estimate that 27,574 (± 7,151, 95% CI) 2014 brood spring Chinook migrated past the TWR interrogation site. An additional 202 emigrants were added to account for the one redd located downstream of the TWR site to estimate a total of 27,776 (± 7,177, 95% CI) 2014 brood spring Chinook migrating from the Twisp River between 1 July 2015 and 30 June 2016. This estimate accounts for 98.1 % of the estimate created using the screw trap method. There are slight discrepancies between the screw trap and the PIT array estimates within the given trapping periods (Figure 11). The PIT array method estimated more sub-yearling migrants, but less yearling emigrants than the screw trap. For consistency, all production tables include the population estimates created from the screw trap estimation method.

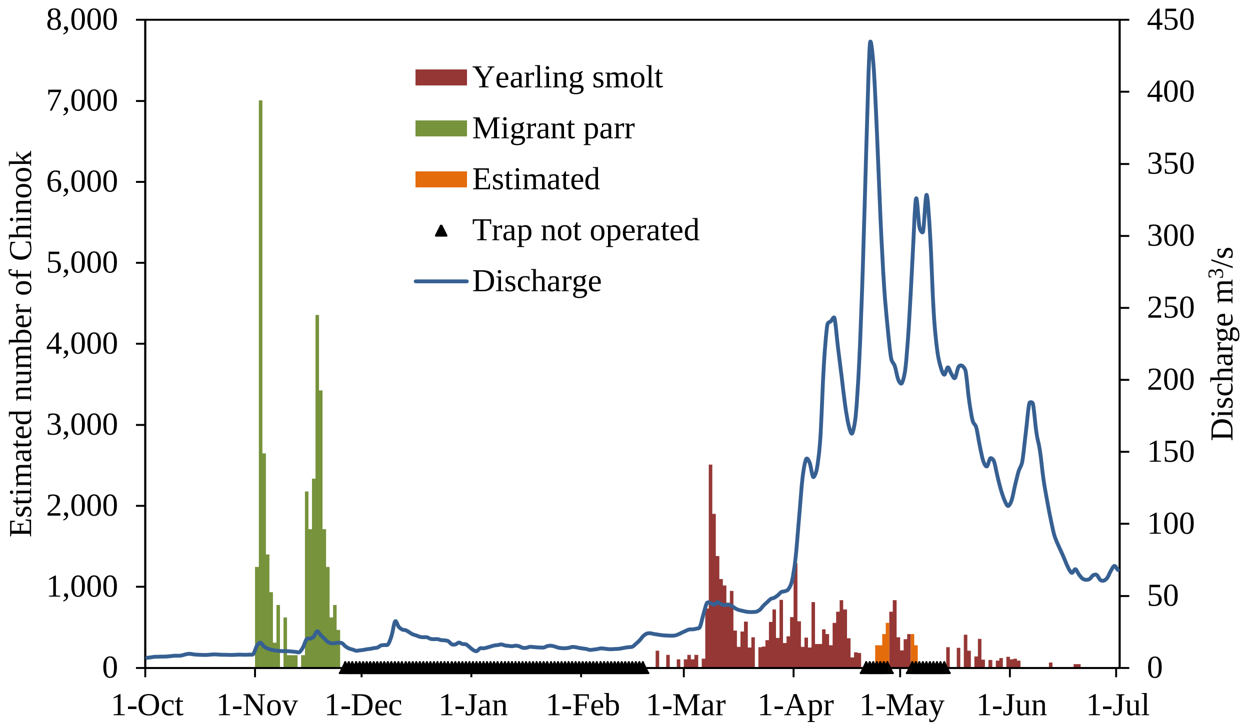

Figure 9. Estimated daily emigration of 2014 brood spring Chinook salmon from the Methow River by life stage.

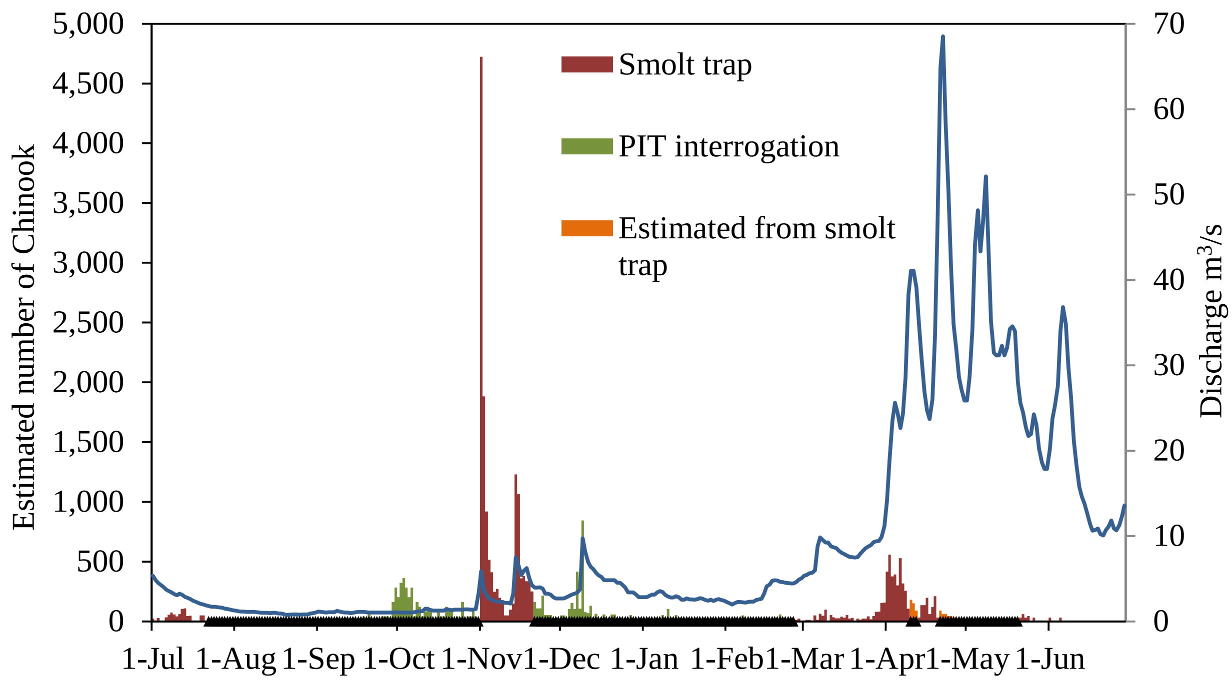

Figure 10. Estimated daily emigration of 2014 brood spring Chinook from the Twisp River by estimation method.

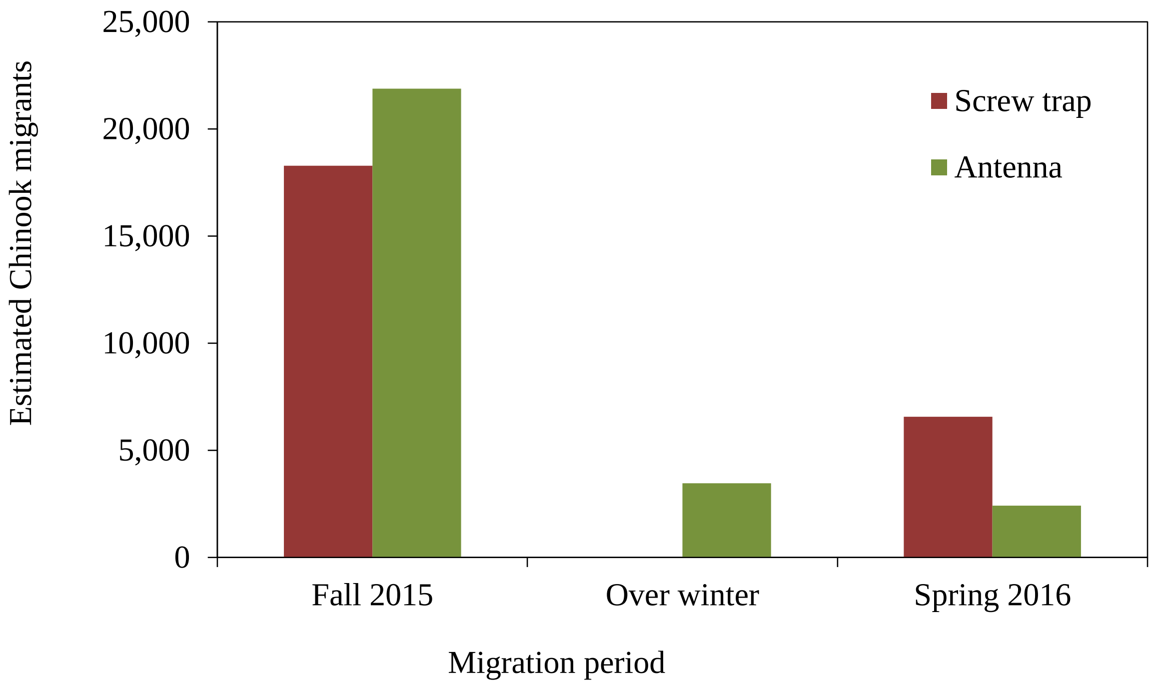

Figure 11. Estimated 2014 brood spring Chinook migration from the Twisp River by migration time and estimation method.

Table 5. Mark/recapture efficiency trials used to estimate emigration of 2014 brood spring Chinook at the Methow trap site (YCH = yearling Chinook-hatchery origin, and YCW = yearling Chinook-wild origin).

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
YCW	17-Apr-08	Low	189	3	1.59	30.4
YCH	20-Apr-08	Low	403	6	1.49	32.3
YCH	22-Apr-08	Low	250	3	1.20	29.7
YCH	03-May-08	Low	281	3	1.07	46.0
YCH	18-Apr-09	Low	221	3	1.36	26.6
YCH	24-Apr-09	Low	423	3	0.71	63.2
YCH	20-Apr-11	Low	521	6	1.15	36.0
YCH	27-Apr-11	Low	493	7	1.42	45.7
YCH	17-Apr-12	Low	500	8	1.60	40.4
YCH	17-Apr-14	Low	394	5	1.27	46.8
	Flow model		3,675	47	1.28	
YCH	20-Apr-12	Upper	399	20	5.01	42.9
YCW	05-Apr-13	Upper	234	11	4.70	79.8
YCW	13-Apr-13	Upper	83	3	3.61	65.2
YCH	15-Apr-13	Upper	353	13	3.68	59.5
YCH	18-Apr-13	Upper	407	28	6.88	51.9
YCH	25-Apr-13	Upper	392	15	3.83	58.1
YCH	19-Apr-14	Upper	415	23	5.54	51.3
YCW	20-Apr-14	Upper	118	5	4.24	49.8
YCW	23-Apr-14	Upper	98	3	3.06	51.3
YCW	29-Apr-14	Upper	85	2	2.35	49.2
YCH	19-Apr-15	Upper	419	17	4.06	66.6
YCH	22-Apr-15	Upper	489	8	1.64	111.4
YCW	03-Apr-16	Upper	81	1	1.23	139.7
YCH	13-Apr-16	Upper	453	5	1.10	208.8
YCH	17-Apr-16	Upper	355	2	0.56	163.3
	Flow model		4,381	156	3.60	

Table 6. Mark/recapture efficiency trials used to estimate emigration of 2014 brood spring Chinook at the Twisp trap site (YCH = yearling Chinook-hatchery origin, and YCW = yearling Chinook-wild origin).

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
YCW	02-Apr-08	Low	118	24	20.3	2.0
YCW	09-Apr-08	Low	118	22	18.6	2.2
YCW	11-Apr-08	Low	117	30	25.6	2.4
YCW	14-Apr-08	Low	375	85	22.7	4.5
YCW	16-Apr-08	Low	260	51	19.6	4.4
YCH, YCW	19-Apr-08	Low	278	40	14.4	4.9
YCW	24-Apr-08	Low	185	23	12.4	4.3
YCW	29-Apr-08	Low	117	23	19.7	5.9
YCW	05-May-08	Low	164	9	5.5	10.6
YCH, YCW	22-Apr-09	Low	334	23	6.9	13.0
YCW	16-Apr-10	Low	150	15	10.0	4.6
YCH, YCW	18-Apr-10	Low	325	63	19.4	7.5
YCH	26-Apr-11	Low	211	22	10.4	9.3
YCW	05-Apr-13	Low	103	10	9.7	13.4
YCH	19-Apr-13	Low	200	27	13.5	8.1
YCH	20-Apr-13	Low	100	12	12.0	8.3
YCH	24-Apr-13	Low	249	27	10.8	7.9
YCW	12-Apr-14	Low	142	17	12.0	7.9
YCH	23-Apr-14	Low	200	18	9.0	8.6
YCH	24-Apr-14	Low	113	11	9.7	9.0
YCH	01-May-14	Low	205	14	6.8	12.6
YCH	19-Apr-15	Low	220	20	9.1	10.0
	Flow model		4,284	586	13.7	

2015 Brood Spring Chinook Salmon

Sufficient numbers of fish could not be obtained at the Methow trap site to develop a flow regression model for the low position in the fall of 2016, and a pooled efficiency was used to estimate fish passage during this time period (Table 8). There were 168 marked Chinook parr released above the trap in the fall of 2016, and five were recaptured providing a pooled trap efficiency of approximately 2.98%. Using this pooled efficiency, an estimated 5,847 (± 16,007, 95% CI) subyearling spring Chinook migrated past the trap in the fall of 2016.

A single mark/recapture trial was conducted at the Twisp trap site in the fall of 2016. Combining this group with trials conducted in 2014 and 2015 showed that trap efficiency was significantly related to discharge ($P < 0.01$, $r^2 = 0.57$; Table 9), and the flow model regression ($y = 0.000908708x + 0.119169681$) was used to estimate that 13,831 (± 3,198, 95% CI) 2015 brood spring Chinook salmon parr emigrated past the Twisp trap between 1 July and 5 December 2016. The trap operated for the entire fall period, so adding estimated migrants using the Twisp PIT tag array was not needed in the fall of 2016. In addition, there were no Chinook redds observed below the Twisp trap site in 2015, so no expansion to account for migrants originating from downstream of the trap was necessary.

Table 7. Mark/detection efficiency trials used to estimate emigration of spring Chinook salmon over the Twisp River PIT tag array (TWR) during non-trapping periods.

Species	Date	Released	Detected at RRJ	Detected at RRJ and TWR	Efficiency (%)	Discharge (m^3/s)
YCW	23-Mar-10	37	4	3	75.0	2.66
YCW	04-Apr-10	23	8	7	87.5	3.14
YCW	05-Apr-10	63	12	9	75.0	3.28
YCW	08-Apr-10	61	8	6	75.0	3.11
YCW	09-Apr-10	27	7	4	57.1	3.09
YCW	11-Apr-10	45	5	4	80.0	2.97
YCW	13-Apr-10	26	6	4	66.7	3.17
YCW	16-Apr-10	150	31	17	54.8	4.59
YCW	18-Apr-10	157	37	13	35.1	7.48
YCW	20-Apr-10	95	24	7	29.2	13.20
YCW	02 Apr-11	57	5	2	40.0	10.62
YCW	27-Apr-11	59	5	3	60.0	9.63
YCW	12-Apr-12	213	9	6	66.7	5.41
YCW	14-Apr-12	78	8	6	75.0	6.03
YCW	21-Apr-12	61	6	1	16.7	9.09
	Flow model	1,152	175	92	52.6	

Table 8. Mark/recapture efficiency trials used to estimate emigration of 2015 brood subyearling spring Chinook salmon (SBC) at the Methow River smolt trap in 2016.

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
SBC	14-Oct-16	Low	2	0	0.00	15.7
SBC	18-Oct-16	Low	2	0	0.00	18.0
SBC	21-Oct-16	Low	7	0	0.00	24.7
SBC	24-Oct-16	Low	18	1	5.56	20.4
SBC	27-Oct-16	Low	2	0	0.00	30.1
SBC	30-Oct-16	Low	22	0	0.00	29.2
SBC	02-Nov-16	Low	13	0	0.00	28.3
SBC	05-Nov-16	Low	13	0	0.00	28.7
SBC	08-Nov-16	Low	9	0	0.00	30.2
SBC	11-Nov-16	Low	10	1	10.0	32.4
SBC	16-Nov-16	Low	21	2	9.52	41.5
SBC	19-Nov-16	Low	18	0	0.00	37.3
SBC	22-Nov-16	Low	8	0	0.00	33.8
SBC	25-Nov-16	Low	7	0	0.00	32.5
SBC	29-Nov-16	Low	5	1	20.0	29.1
SBC	02-Dec-16	Low	8	0	0.00	26.9
SBC	04-Dec-16	Low	3	0	3.57	26.2
	Pooled		168	5	2.98	

Table 9. Mark/recapture efficiency trials used to estimate emigration of 2015 brood subyearling Chinook salmon (SBC) at the Twisp River smolt trap.

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m3/s)
SBC	01-Nov-14	Low	117	9	7.69	4.73
SBC	07-Nov-14	Low	107	12	11.2	7.39
SBC	11-Nov-14	Low	82	2	2.44	4.81
SBC	21-Nov-14	Low	106	3	2.83	3.77
SBC	01-Nov-15	Low	200	7	3.50	4.25
SBC	02-Nov-15	Low	200	16	8.00	3.23
SBC	04-Nov-15	Low	248	8	3.23	2.55
SBC	14-Nov-15	Low	111	13	11.7	6.82
SBC	15-Nov-15	Low	117	10	8.55	5.92
SBC	22-Oct-16	Low	99	3	3.03	2.80
	Flow model		1,387	83	5.98	

Summer Steelhead

Due to low capture numbers of migratory steelhead, no mark/recapture trials were conducted with steelhead in 2016 at the Methow trap. No significant regression model exists for steelhead at the Methow River trap, so the yearling Chinook flow/efficiency models were used to estimate steelhead production for each position (see Table 5). Combining numbers from both trapping positions, an estimated 16,943 (± 4,393, 95% CI) summer steelhead emigrated past the Methow River trap in 2016. An additional 696 migrants were estimated from redds located downstream of the trap in 2012 through 2015, which provides a total estimated migration of 17,639 (± 4,482, 95% CI) summer steelhead from the Methow River basin in 2016. Most 2016 migrants were age-2 fish (65.6%) from the 2014 brood (Table 10). The entire 2012 brood migration was estimated to be 25,726 (± 4,629, 95% CI) fish, including 392 migrants that were expected from redds (N = 9) located downstream of the Methow trap in 2012 (Table 14).

Numerous mark/recapture trials were conducted with wild summer steelhead at the Twisp site in 2016, but none contained more than 35 fish. A flow efficiency relationship from previous years' release groups was used to estimate steelhead emigration at the Twisp site in 2016 (Table 11). The flow model regression ($y = -0.00029758x + 0.410040455$; $P < 0.01$, $r^2 = 0.52$) was used to estimate that 5,132 (± 1,733, 95% CI) wild summer steelhead migrated past the Twisp River trap between 27 February and 30 June 2016. An additional 594 migrants were estimated from redds located downstream of the trap in 2012 through 2015, which provides a total estimated migration of 5,726 (± 1,831, 95% CI) summer steelhead from the Twisp River in 2016. Most 2016 migrants were age-2 fish (74.6%) from the 2014 brood (Table 10). Combining numbers from the last four years, the entire 2012 brood migration was estimated to be 5,882 (± 1,514, 95% CI) fish, which included 446 expected migrants produced from redds (N = 10) downstream of the Twisp trap in 2012 (Table 14).

Table 10. Estimated number of steelhead emigrants from the Methow River basin in 2016 by age and brood.

Age	Brood	Percent of emigrants	Number
		Methow River trap	
1	2015	19.8	3,495
2	2014	65.6	11,569
3	2013	14.0	2,474
4	2012	0.6	101
Total		100.0	17,639
		Twisp River trap	
1	2015	7.4	424
2	2014	74.6	4,273
3	2013	17.3	990
4	2012	0.7	39
Total		100.0	5,726

Table 11. Mark/recapture efficiency trials used to estimate emigration of wild summer steelhead (SHR) migrants from the Twisp River.

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
SHR	15-Apr-08	Low	92	14	15.22	4.45
SHR	05-May-08	Low	173	10	5.78	10.62
SHR	22-Apr-09	Low	267	15	5.62	13.03
SHR	25-Apr-09	Low	129	11	8.53	10.87
SHR	18-Apr-10	Low	180	17	9.44	7.48
SHR	02-Apr-11	Low	63	7	11.11	10.62
SHR	06-May-11	Low	58	3	5.17	13.51
SHR	09-May-11	Low	56	3	5.36	15.32
SHR	12-Apr-14	Low	85	8	9.41	7.90
SHR	02-May-14	Low	81	4	4.94	19.77
	Flow model		1,184	92	7.77	

<u>*2015 Brood Summer Chinook Salmon*</u>

Four mark/recapture trials were conducted at the Methow trap with subyearling Chinook for the low position in the spring of 2016, but no significant relationship was found between flow and efficiency. We therefore used a pooled efficiency of approximately 0.25 percent to estimate Chinook emigration during that period (Table 12). Three mark/recapture trails were conducted with subyearling Chinook for the upper trapping position in 2016. These groups, combined with trials from previous seasons, were used to create a flow efficiency model to estimate emigrants during the upper trapping period (Table 12). The flow model regression (y = -0.000029349949x + 0.2529416; $P < 0.01$, $r^2 = 0.80$), was used in addition to the pooled efficiency to estimate that 761,769 (± 4,082,084, 95% CI) wild summer Chinook migrated past the Methow trap in 2016. There were 462 summer Chinook redds located downstream of the Methow trap in 2015, so an estimated 457,656 (± 3,164,024 95% CI) fish migrated from redds located below the trap, thus bringing the total to 1,219,425 (± 5,164,732, 95% CI) wild 2015 brood summer Chinook migrants from the Methow River in 2016.

<u>*2014 Brood Coho Salmon*</u>

A total of 129 wild juvenile Coho migrants were captured at the Twisp site and 143 were captured at the Methow site between 1 July 2015 and 30 June 2016. Utilizing the same mark/recapture efficiency trial data used for spring Chinook at each site (Tables 5-9), an estimated 3,172 (± 653, 95% CI) and 15,421 (± 15,032, 95% CI) wild 2014 brood Coho emigrated past the Twisp and Methow River traps, respectively.

Table 12. Mark/recapture efficiency trials used to estimate emigration of 2015 brood summer Chinook salmon (SBC) at the Methow River smolt trap in 2016.

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
SBC	02-Mar-16	Low	63	0	0.00	26.5
SBC	10-Mar-16	Low	100	0	0.00	44.8
SBC	18-Mar-16	Low	152	1	0.66	38.7
SBC	22-Mar-16	Low	89	0	0.00	41.6
	Pooled		404	1	0.25	
SBC	30-Apr-07	Upper	493	5	1.01	123.0
SBC	26-May-07	Upper	600	5	0.83	171.0
SBC	28-May-07	Upper	600	1	0.17	172.8
SBC	11-Jun-07	Upper	760	7	0.92	132.1
SBC	14-Jun-07	Upper	620	12	1.94	106.8
SBC	18-Jun-07	Upper	1,000	32	3.20	95.2
SBC	25-Jun-07	Upper	1,000	25	2.50	75.7
SBC	28-Jun-07	Upper	833	21	2.52	71.6
SBC	03-Jul-07	Upper	340	12	3.53	64.6
SBC	11-Jun-08	Upper	503	8	1.59	112.9
SBC	23-Jun-08	Upper	170	2	1.18	112.0
SBC	03-Aug-11	Upper	50	2	4.00	59.4
SBC	31-May-16	Upper	400	6	1.50	114.0
SBC	13-Jun-16	Upper	320	7	2.19	87.4
SBC	21-Jun-16	Upper	180	7	3.89	60.9
	Flow model		7,869	152	1.93	

Juvenile Survival

2014 Brood Spring Chinook Salmon

Yearling emigrants accounted for 23.2% of all 2014 brood spring Chinook salmon migrating from the Twisp River, and 50.7% of the overall emigrants from the Methow River basin (Table 13). The 2014 brood had more emigrants per redd than average for both the Twisp and Methow rivers.

Summer Steelhead

Since juvenile steelhead may emigrate as age-4 fish, completed emigration estimates have only been calculated for broods prior to 2013 (Table 14). The 2012 brood produced an estimated 45 and 44 emigrants from each redd in the Methow and Twisp river basins, respectively.

Table 13. Estimated emigrants-per-redd (EPR) and egg-to-emigrant survival for Methow Basin spring Chinook. Methow Basin and Twisp River estimates are for redds deposited upstream and downstream of the respective trap sites, and include redds that dewatered. Rows identified with a * include an estimate of over-winter emigration derived from a PIT tag array and added to the total number of emigrants estimated from smolt trapping activities. DNOT = Did not operate trap.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants			Egg to emigrant (%)	EPR
				Age-0	Age-1	Total		
Twisp	2003	18	81,395	DNOT	900	900	1.1	50
Twisp	2004	139	510,220	1,219	5,224	6,443	1.3	46
Twisp	2005	55	237,729	3,245	3,329	6,574	2.8	120
Twisp	2006	87	298,074	1,531	16,415	17,946	6	206
Twisp	2007	30	128,182	4,181	5,547	9,728	7.6	324
Twisp	2008	79	268,771	7,139	4,793	11,932	4.4	151
Twisp	2009	24	100,694	3,282	1,842	5,124	5.1	214
Twisp*	2010	145	568,266	4,874	3,917	9,682	1.7	67
Twisp*	2011	63	269,855	6,431	3,617	12,759	4.7	203
Twisp*	2012	139	466,182	3,953	6,043	13,690	2.9	98
Twisp*	2013	85	281,719	16,314	6,373	26,025	9.2	306
Twisp*	2014	138	490,824	18,290	6,567	28,325	5.8	205
Twisp	2015	119	524,425	13,831	--	13,831	--	--
Twisp	Mean 2003-2014	84	308,493	6,405	5,381	12,427	4.4	166
Methow	2002	1,192	4,578,109	DNOT	28,099	28,099	0.6	24
Methow	2003	474	2,215,494	8,170	15,306	23,476	1.1	50
Methow	2004	543	1,926,603	DNOT	15,869	15,869	0.8	29
Methow	2005	566	2,060,259	17,490	33,710	51,200	2.5	90
Methow	2006	929	3,375,219	2,913	28,857	31,770	0.9	34
Methow	2007	308	1,240,129	4,083	5,163	9,246	0.7	30
Methow	2008	477	1,724,592	2,948	9,302	12,250	0.7	26
Methow	2009	490	1,944,428	1,602	29,610	31,212	1.6	64
Methow	2010	1,366	5,284,533	8,979	51,325	60,304	1.1	44
Methow	2011	760	3,032,862	8,422	27,637	36,059	1.2	47
Methow	2012	895	3,065,992	9,575	38,648	48,223	1.6	54
Methow	2013	592	2,076,279	20,493	15,749	36,242	1.7	61
Methow	2014	1,140	4,211,530	34,402	35,330	69,732	1.7	61
Methow	2015	979	3,867,031	5,847	--	5,847	--	--
Methow	Mean 2003-2014	749	2,825,848	10,825	25,739	34,899	1.2	47

Table 14. Estimated emigrants-per-redd (EPR) and egg-to-emigrant survival of Methow Basin summer steelhead. Methow Basin and Twisp River estimates are for redds deposited upstream and downstream of the respective trap sites. Emigrant-per-redd and egg-to-emigrant values were not calculated for incomplete brood years. DNOT = Did not operate trap.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants					Egg to emigrant (%)	EPR
				Age-1	Age-2	Age-3	Age-4	Total		
Twisp	2003	696	4,420,992	DNOT	2,284	1,497	65	3,846	0.09	6
Twisp	2004	256	1,176,064	183	3,200	504	202	4,089	0.35	16
Twisp	2005	484	3,004,672	344	2,870	2,254	127	5,595	0.19	12
Twisp	2006	389	2,484,932	82	4,788	2,256	341	7,467	0.30	19
Twisp	2007	82	418,774	41	10,338	2,845	445	13,669	3.26	167
Twisp	2008	182	1,078,350	73	2,363	795	33	3,264	0.30	18
Twisp	2009	352	2,147,200	59	4,766	1,084	38	5,947	0.28	17
Twisp	2010	332	1,934,564	22	2,675	2,488	21	5,206	0.27	16
Twisp	2011	190	1,187,880	0	5,759	608	0	6,367	0.54	34
Twisp	2012	132	759,924	41	4,839	963	39	5,882	0.77	45
Twisp	2013	140	835,660	183	4,542	990	--	5,715	--	--
Twisp	2014	144	759,456	288	4,273	--	--	4,561	--	--
Twisp	2015	161	938,469	424	--	--	--	424	--	--
Twisp	Mean 03-12	301	1,861,335	94	4,388	1,529	131	6,133	0.64	35
Methow	2003	2,019	12,824,688	1,602	4,895	2,471	109	9,077	0.07	4
Methow	2004	997	4,580,218	1,989	9,592	1,319	365	13,265	0.29	13
Methow	2005	1,784	11,075,072	2,144	13,413	913	1,136	17,606	0.16	10
Methow	2006	808	5,161,504	644	6,503	3,932	328	11,407	0.22	14
Methow	2007	740	3,779,180	3,255	25,588	4,774	122	33,739	0.89	46
Methow	2008	867	5,136,975	1,430	13,229	1,884	131	16,674	0.32	19
Methow	2009	1,030	6,283,000	3,425	13,133	1,858	660	19,076	0.30	19
Methow	2010	1,720	10,022,440	1,214	7,243	8,641	116	17,214	0.17	10
Methow	2011	854	5,339,208	303	10,162	1,761	275	12,501	0.23	15
Methow	2012	591	3,402,387	402	21,827	3,396	101	25,726	0.76	44
Methow	2013	810	4,834,890	1,649	15,155	2,474	--	19,278	--	--
Methow	2014	878	4,630,572	1,008	11,569	--	--	12,577	--	--
Methow	2015	991	5,776,539	3,495	--	--	--	3,495	--	--
Methow	Mean 03-12	1,141	6,760,467	1,641	12,559	3,095	334	17,629	0.34	19

<u>*Smolt to Adult Returns*</u>

The PTAGIS website (http://www.ptagis.org) was used to determine adult PIT tag detections at Columbia River adult fish ladder detection sites for wild Chinook (Table 15) and at Wells Dam for wild steelhead (Table 16). Unique adult detections were summed and divided by the number of juvenile salmonids tagged and released at the Methow and Twisp smolt traps by species to determine smolt to adult survival rates.

Table 15. Smolt to adult return (SAR) from release to Columbia River return by release year for PIT tagged wild yearling Chinook smolts encountered at the Twisp and Methow smolt traps.

Brood	Release year	Release *N*	Age at return (*N*) to Columbia River			Total	SAR %
			Age-3	Age-4	Age-5		
			Twisp trap				
2003	2005	110	0	0	0	0	0.00
2004	2006	818	0	1	0	1	0.12
2005	2007	271	0	1	0	1	0.37
2006	2008	2,494	5	18	8	31	1.24
2007	2009	630	0	9	0	9	1.43
2008	2010	953	1	4	1	6	0.63
2009	2011	304	0	1	0	1	0.33
2010	2012	606	1	1	1	3	0.50
2011	2013	435	0	1	0	1	0.23
2012	2014	664	0	2	--	2	0.30
2013	2015	434	0	--	--	0	0.00
2003-2011 brood mean							0.54
Pooled 2003-2011 brood		6,621	7	36	10	53	0.80
			Methow trap				
2003	2005	301	0	1	0	1	0.33
2004	2006	489	1	2	0	3	0.61
2005	2007	379	0	4	0	4	1.06
2006	2008	633	2	7	2	11	1.74
2007	2009	111	0	2	0	2	1.80
2008	2010	208	0	0	0	0	0.00
2009	2011	338	0	0	0	0	0.00
2010	2012	674	1	1	0	2	0.30
2011	2013	763	1	1	0	2	0.26
2012	2014	883	0	2	--	2	0.23
2013	2015	441	0	--	--	0	0.00
2003-2011 brood mean							0.68
Pooled 2003-2011 brood		3,896	5	18	2	25	0.64

Table 16. Smolt to adult returns (SAR) from release to Wells Dam by release year for PIT tagged wild steelhead encountered at the Twisp and Methow smolt traps.

Release year	Released	Age at return (*N*) to Wells Dam		Total	SAR %
		1-Salt	2-Salt		
		Twisp trap			
2006	486	0	0	0	0.00
2007	332	2	5	7	2.11
2008	642	7	5	12	1.87
2009	640	3	5	8	1.25
2010	454	2	2	4	0.88
2011	321	1	0	1	0.31
2012	135	1	2	3	2.22
2013	243	2	2	4	1.65
2014	328	1	0	1	0.30
2015	271	1	--	1	0.37
2006-2014 mean					1.18
Pooled 2006-2014	3,581	19	21	40	1.12
		Methow trap			
2006	319	0	0	0	0.00
2007	166	0	1	1	0.60
2008	108	2	2	4	3.70
2009	395	0	0	0	0.00
2010	319	0	1	1	0.31
2011	175	0	0	0	0.00
2012	178	4	2	6	3.37
2013	432	1	4	5	1.16
2014	591	2	1	3	0.51
2015	442	1	--	1	0.23
2006-2014 mean					1.07
Pooled 2006-2014	2,683	9	11	20	0.75

Discussion

River conditions at both the Methow and Twisp sites were generally favorable for trapping activities during the 2016 season. The Methow trap was not operated for 17 days between 21 April and 13 May because of high river discharge. The Twisp trap was not operated for 35 days between 10 April and 8 June, with 30 of those days spanning from 21 April through 20 May. Operating the traps during this time would make the traps susceptible to damage due to debris, potentially cause excessive fish mortality, and escalate safety concerns for employees working on the traps. Conversely, the Twisp trap did not experience the downtime due to low river discharge during the summer months like it has during many previous trapping seasons.

River turbidity was abnormally high for much of the spring trapping period due to the additional sediment input from recent wildfires in both the Methow and Twisp basins. This may have had an influence on the diel migration patterns of juvenile salmonids in the basin. In past seasons, trap captures and observations suggest that the majority of juvenile salmonid migration occurs during dark periods. The capture of the hatchery Chinook at the Methow trap was much lower than expected during the spring of 2016. A hypothesis for this occurrence is that a significant number of fish migrated past the trap during daylight hours (the trap was not operating during the day due to permit obligations). There was some data collected to support this hypothesis at the Twisp site, where the trap operates during all hours of the day. During a ten day period between 1 and 15 April, a significant number of fish were captured during daylight hours. These daytime captures accounted for over half of the wild spring Chinook and over one third of the total migrant steelhead captures during the same period. If fish were similarly passing the Methow trap during daylight hours, the spring portion of both the spring Chinook and steelhead estimates likely underestimate the actual number of emigrants.

River discharge was higher earlier in the season than usual, and we were forced to pull the traps from operation earlier than we have since the project started. This was problematic because many of the hatchery fish scheduled to be released upstream of the traps had not been released before the traps were pulled for high discharge. Since these hatchery fish are commonly used as surrogates for wild fish in mark/recapture trials, we were unable to conduct as many trap efficiency trials as desired at the higher river discharge levels experienced for much of the spring trapping period. With the mark/recapture trials that were conducted, the model discharge upper limit was extended for estimating yearling Chinook in the upper position at the Methow site. This should help reduce the variance in future estimate calculations. At the Twisp site, only two trials were performed in 2016 and more data points will be needed to produce a significant regression for high discharge periods. The trials that were conducted suggest that the efficiency of the traps stay fairly consistent once a certain discharge is reached.

Production estimates and associated variance estimates for the 2016 trapping season were made using the statistical methodology described in Murdoch et al. (2012). This methodology has minimal effect on the production estimate but corrects for the extremely high variances estimated by the former methodology. Once this methodology has been peer reviewed, all estimates from past years will be recalculated and reported.

Tissue samples (i.e., fin clips) were taken from subyearling Chinook captured at the Methow River trap in 2016 to determine the proportion of subyearling fish that were spring Chinook salmon. Spring Chinook salmon accounted for 97.0% of the Chinook sampled during the fall trapping period. Emigration estimates were produced for spring Chinook salmon during the fall trapping period at the Methow River trap site and the proportion of fish identified as summer Chinook salmon were removed. Emigration estimates are not produced for spring Chinook salmon that may emigrate before the fall period as subyearling fish. Therefore, spring Chinook production estimates for the Methow Basin, including Twisp River estimates, underestimate production by the portion of spring Chinook salmon emigrating as subyearling fish in the spring and summer, assuming that those fish do not move back upstream of the trap after initial capture.

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Appendix A. Number of fish released with PIT tags from the Methow and Twisp River smolt traps. YCW = wild yearling spring Chinook; YCH = hatchery yearling Chinook; SBC = wild subyearling Chinook; SHR = wild steelhead; SHH = hatchery steelhead.

Year	Trap site	Number of fish released with PIT tags					
		YCW smolts	YCH smolts	SBC parr	SHR migrants	SHH migrants	SHR parr
2005	Twisp	110	0	251	0	0	0
2006	Twisp	818	966	562	466	1,410	689
2007	Twisp	271	1,096	251	324	1,292	126
2008	Twisp	2,502	1,081	511	641	1,594	440
2009	Twisp	627	201	741	637	205	231
2010	Twisp	952	325	291	441	585	450
2011	Twisp	304	211	485	302	752	136
2012	Twisp	599	4	914	127	0	323
2013	Twisp	432	2	325	214	518	392
2014	Twisp	651	205	824	297	410	240
2015	Twisp	431	0	1,099	239	1	383
2016	Twisp	397	0	611	139	0	242
2005	Methow	301	324	0	0	0	0
2006	Methow	479	1,000	165	318	1,493	57
2007	Methow	378	1,248	60	162	993	16
2008	Methow	619	1,619	90	154	1,300	51
2009	Methow	109	645	66	386	3	39
2010	Methow	199	1,078	57	303	0	92
2011	Methow	325	1,566	500	165	4	47
2012	Methow	654	899	229	168	0	53
2013	Methow	714	1,153	230	414	1	234
2014	Methow	844	811	265	574	405	93
2015	Methow	426	2	246	426	1	54
2016	Methow	471	0	173	179	1	103

Appendix B. Genetic assignments of migrant subyearling Chinook at the Methow River smolt trap.

2016 Methow Chinook salmon juvenile assignments

Maureen P. Small and Cherril Bowman
Conservation Biology Unit, Molecular Genetics Lab, WDFW
Report, January 2017

Summary

In fall 2016, emigrating natural-origin sub-yearling Chinook salmon were collected in the Methow River smolt trap. Because two genetically distinct types of Chinook salmon, a spring-run and summer-run, spawn in the Methow River, the juveniles could be from either or both run types, and the different run type juveniles may emigrate at different times. Further, the spring Chinook salmon population in the Twisp River, a tributary upstream of the smolt trap in the Methow River, is genetically distinct from Methow/Chewuch spring Chinook salmon population (Small et al. 2007) and some juveniles may have originated in the Twisp spring Chinook salmon population. We investigated the genetic identity of the juvenile Chinook salmon through comparisons to adult spring and summer Chinook salmon collections from the Methow River and an adult spring Chinook salmon from the Twisp River. We found that most of the juveniles were spring type and that about 25% of the spring type originated in the Twisp population.

Methods

We genotyped 100 juvenile Chinook salmon (WDFW collection code 16FT, Table 1) at the 13 standardized GAPS loci as described in Small et al. (2007, 2009, 2010) and compared them to Twisp River spring Chinook salmon, and Methow River spring and summer Chinook salmon genotyped at the same loci.

Juvenile identities were examined from two perspectives. The first analysis examined individual ancestry using a Bayesian analysis implemented in STRUCTURE (Pritchard et al. 2000). In this analysis, we hypothesized that there were two groups in the data set, spring and summer Chinook salmon, and estimated individual ancestry in two groups. Without knowledge of the origin or identity of individuals the program sorts the data set in order to achieve Hardy-Weinberg equilibrium and minimize linkage disequilibrium in each hypothesized group. To further identify juvenile origins, we used assignment tests implemented in GENECLASS (Piry et al. 2004) with the Rannala and Mountain algorithm (Rannala and Mountain 1997) to calculate the likelihood that the juvenile came from the Methow spring or summer Chinook salmon collection or the Twisp spring Chinook salmon collection based on the genotype of the individual and the allele frequencies of the baseline collections. The analysis was run with 50,000 burn-in runs and 200,000 iterations: the burn-in runs move the analysis away from starting conditions to prevent them from influencing the analysis.

Results and discussion

One individual, 16FT0156, failed to produce a genotype and was excluded from analysis. The STRUCTURE analysis divided the adult spring and summer Chinook salmon into two distinct clusters

(Figure 1). Ninety three juveniles had 90% or greater ancestry in the spring Chinook salmon cluster and two juveniles had 90% or greater ancestry in the summer Chinook salmon cluster (Table 2). Note: we included only Methow River spring and summer collections in the STRUCTURE analysis to decrease the complexity of the analysis because genetic variance between Twisp and Methow spring Chinook salmon populations is below the resolving power of STRUCTURE.

Results from GENECLASS paralleled the STRUCTURE analyses and provided further resolution (Figure 2 and Table 3). We plotted the negative log likelihood assignment values for the juveniles and for the adult spring and summer Chinook salmon collections (Figure 2). The plot shows that the adult spring and summer Chinook salmon assigned well to their respective groups. The distinction indicated high power for distinguishing genetically between run groups. The plot also shows that three juveniles assigned to the summer collection (labeled in Figure 2). Nineteen juveniles assigned with less than 90% likelihood to a spring-run baseline collection. The second most likely assignment for each was the other spring-run collection indicating that the smolts were spring-run, and these were labeled “Spring” in Table 3. For instance, 16FT0014 assigned with 83% likelihood to Methow spring and with 17% likelihood to Twisp spring. It likely originated in the Methow spring-run population but had one or more alleles that were common in the Twisp spring-run population.

In summary, three smolts assigned with high likelihood to the Methow summer Chinook salmon collection and 96 smolts assigned to Methow or Twisp spring Chinook salmon collections.

Acknowledgments

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Figure 1. Ancestry values for individual fish calculated in STRUCTURE. Each fish is represented by a bar of color with red corresponding to summer Chinook salmon ancestry and green corresponding to spring Chinook salmon ancestry. Individuals with "pure" ancestry have a single color in their bar and individuals with "mixed" ancestry have two colors in their bar. Individuals are in order of the collection code number so juveniles with spring ancestry can be compared with STRUCTURE ancestry values in Table 2 and GENECLASS assignments in Table 3**.**

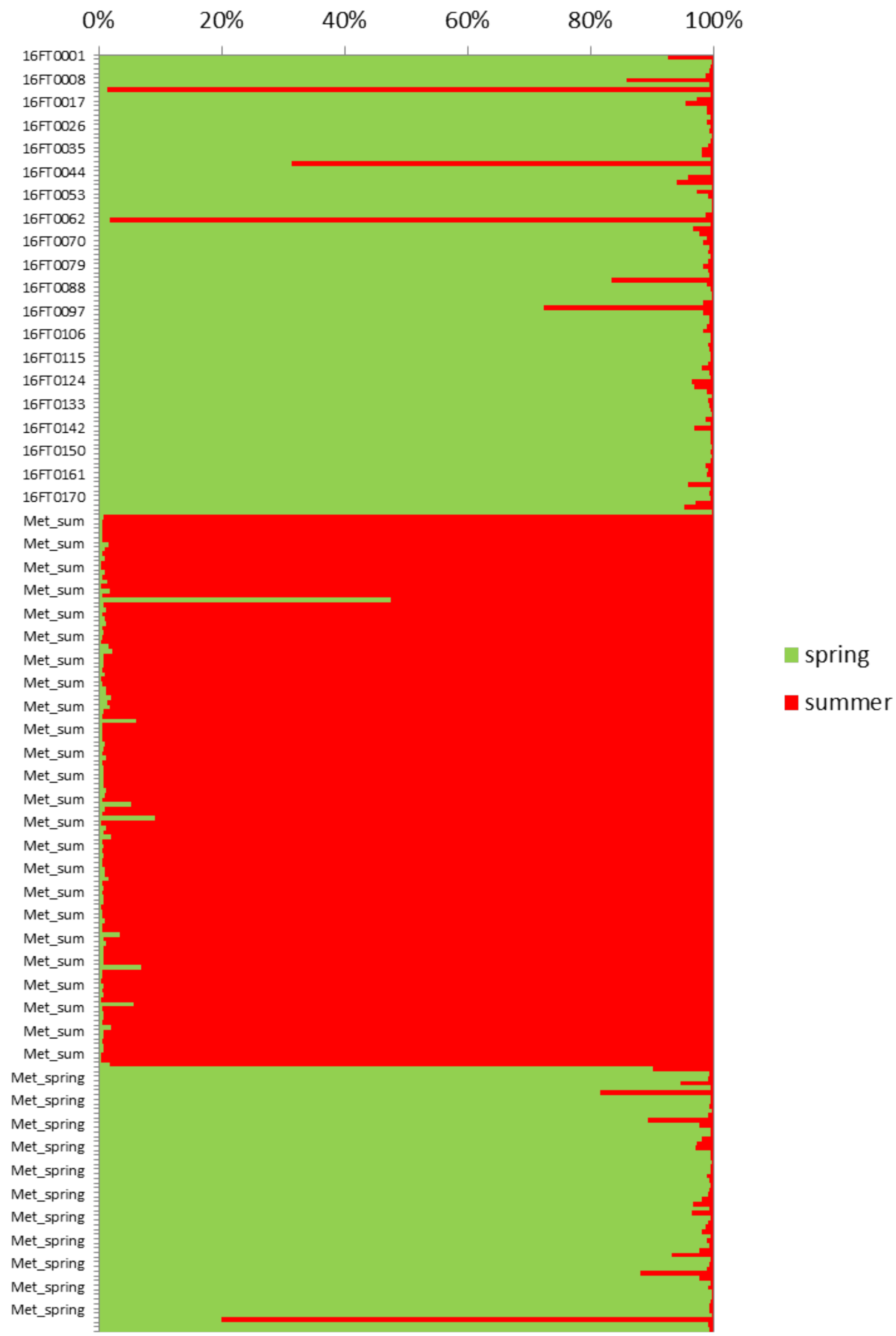

Figure 2. Graph of negative log likelihood assignment scores from GENECLASS. Methow juveniles (blue diamonds) are abbreviated Juv. Highest likelihood values assigned 96 juveniles to spring and 3 to summer.

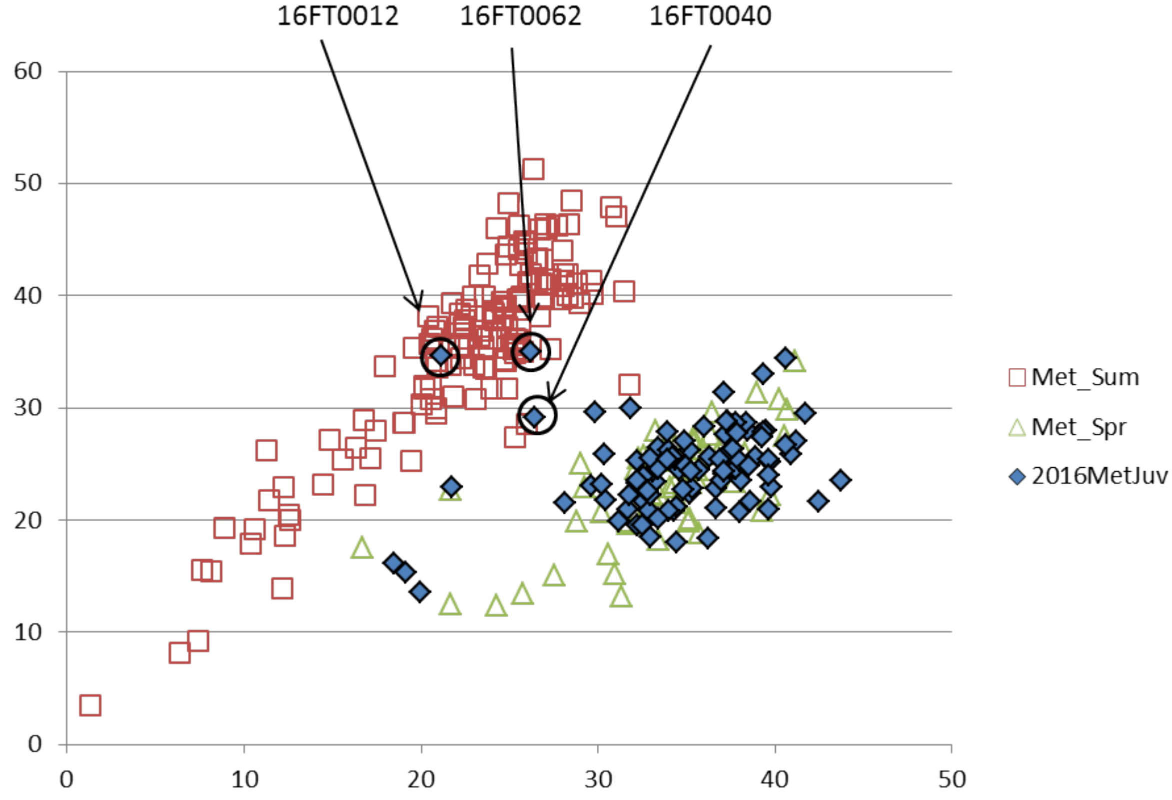

Table 1. List of samples used in the Methow Chinook salmon juvenile assignment tests.

Code	Name	N
16FT	Methow juveniles - 2016	100
05HW	Methow spring	42
05HX	Twisp spring	42
93EC	GAPS Methow summer	143

Table 2. Juvenile collection date, ancestry values and assignments from GENECLASS and STRUCTURE. See Figure 1 for graphic STRUCTURE data – percentage of ancestry in the two clusters (here summer and spring) is shown as percentage of colors in color bar in Figure 1. Samples labeled as "Spring" under GeneClass assignments assigned to one spring collection with less than 90% likelihood and the next most likely assignment was to the other spring collection.

			STRUCTURE clusters	
sample	Highest	%	spring	summer
16FT0001	TwispSpr	96.80	0.926	0.074
16FT0002	MetSpr	100.00	0.997	0.003
16FT0003	TwispSpr	100.00	0.995	0.005
16FT0005	TwispSpr	99.05	0.993	0.007
16FT0006	MetSpr	100.00	0.987	0.013
16FT0008	TwispSpr	98.41	0.859	0.141
16FT0010	MetSpr	99.29	0.993	0.007
16FT0012	MethowSum	100.00	0.014	0.986
16FT0014	Spring	83.05	0.996	0.004
16FT0015	MetSpr	99.92	0.972	0.028
16FT0017	TwispSpr	99.96	0.955	0.045
16FT0019	MetSpr	99.84	0.990	0.010
16FT0021	Spring	52.55	0.989	0.011
16FT0022	MetSpr	99.79	0.995	0.005
16FT0024	MetSpr	98.81	0.990	0.010
16FT0026	TwispSpr	99.66	0.995	0.005
16FT0028	MetSpr	100.00	0.994	0.006
16FT0030	MetSpr	100.00	0.997	0.003
16FT0031	TwispSpr	95.67	0.995	0.005
16FT0033	MetSpr	100.00	0.991	0.009
16FT0035	MetSpr	100.00	0.981	0.019
16FT0037	MetSpr	99.94	0.980	0.020
16FT0038	TwispSpr	100.00	0.996	0.004
16FT0040	MethowSum	99.79	0.314	0.686
16FT0042	MetSpr	99.48	0.995	0.005
16FT0044	MetSpr	97.37	0.995	0.005
16FT0046	MetSpr	100.00	0.959	0.041
16FT0047	MetSpr	99.95	0.940	0.060
16FT0049	MetSpr	93.54	0.997	0.003
16FT0051	MetSpr	100.00	0.973	0.027
16FT0053	Spring	61.02	0.991	0.009
16FT0054	Spring	88.42	0.997	0.003
16FT0056	TwispSpr	95.59	0.997	0.003
16FT0058	Spring	62.06	0.997	0.003
16FT0060	Spring	79.12	0.986	0.014
16FT0062	MethowSum	100.00	0.018	0.982
16FT0063	MetSpr	100.00	0.996	0.004
16FT0065	MetSpr	100.00	0.967	0.033
16FT0067	MetSpr	99.93	0.977	0.023
16FT0069	Spring	64.48	0.990	0.010
16FT0070	MetSpr	100.00	0.983	0.017
16FT0072	Spring	88.52	0.994	0.006
16FT0074	TwispSpr	99.30	0.991	0.009
16FT0076	Spring	85.18	0.995	0.005
16FT0078	TwispSpr	96.14	0.991	0.009
16FT0079	MetSpr	100.00	0.982	0.018

			STRUCTURE clusters	
sample	Highest	%	spring	summer
16FT0081	MetSpr	99.50	0.992	0.008
16FT0083	MetSpr	100.00	0.994	0.006
16FT0085	TwispSpr	99.42	0.833	0.167
16FT0086	MetSpr	100.00	0.990	0.010
16FT0088	TwispSpr	98.75	0.996	0.004
16FT0090	MetSpr	100.00	0.997	0.003
16FT0092	MetSpr	99.22	0.997	0.003
16FT0094	MetSpr	99.49	0.982	0.018
16FT0095	TwispSpr	94.19	0.723	0.277
16FT0097	MetSpr	99.08	0.983	0.017
16FT0099	Spring	77.13	0.994	0.006
16FT0101	MetSpr	99.35	0.994	0.006
16FT0102	TwispSpr	98.24	0.990	0.010
16FT0104	MetSpr	100.00	0.983	0.017
16FT0106	MetSpr	98.53	0.996	0.004
16FT0108	TwispSpr	98.96	0.996	0.004
16FT0110	TwispSpr	99.77	0.992	0.008
16FT0111	Spring	78.90	0.993	0.007
16FT0113	MetSpr	96.67	0.996	0.004
16FT0115	MetSpr	100.00	0.995	0.005
16FT0117	Spring	82.54	0.991	0.009
16FT0118	MetSpr	99.93	0.981	0.019
16FT0120	TwispSpr	99.99	0.993	0.007
16FT0122	TwispSpr	100.00	0.996	0.004
16FT0124	MetSpr	100.00	0.965	0.035
16FT0126	Spring	84.91	0.968	0.032
16FT0127	MetSpr	99.13	0.988	0.012
16FT0129	MetSpr	99.46	0.997	0.003
16FT0131	Spring	66.21	0.991	0.009
16FT0133	TwispSpr	100.00	0.993	0.007
16FT0134	MetSpr	99.94	0.996	0.004
16FT0136	MetSpr	100.00	0.997	0.003
16FT0138	MetSpr	100.00	0.987	0.013
16FT0140	MetSpr	97.12	0.996	0.004
16FT0142	Spring	65.33	0.968	0.032
16FT0143	MetSpr	100.00	0.996	0.004
16FT0145	MetSpr	99.98	0.995	0.005
16FT0147	MetSpr	99.96	0.995	0.005
16FT0149	Spring	73.14	0.998	0.002
16FT0150	TwispSpr	99.01	0.996	0.004
16FT0152	TwispSpr	99.88	0.997	0.003
16FT0154	Spring	77.28	0.995	0.005
16FT0158	MetSpr	99.91	0.987	0.013
16FT0159	TwispSpr	95.95	0.992	0.008
16FT0161	Spring	69.43	0.988	0.012
16FT0163	TwispSpr	98.06	0.995	0.005
16FT0165	MetSpr	100.00	0.958	0.042
16FT0166	MetSpr	100.00	0.995	0.005
16FT0168	MetSpr	98.69	0.994	0.006
16FT0170	Spring	61.39	0.995	0.005
16FT0172	MetSpr	100.00	0.970	0.030
16FT0173	MetSpr	99.60	0.952	0.048
16FT0174	MetSpr	82.77	0.997	0.003

Attachment B. In-stream PIT tagging of juvenile spring Chinook and steelhead in the Methow River basin in 2016.

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
FISH PROGRAM-SCIENCE DIVISION
METHOW RESEARCH TEAM
20268 HWY 20, Twisp, WA 98856
Voice (509) 997-0048 FAX (509) 997-0072

7 March 2017

To: Charlie Snow

From: Matt Young and Ben Goodman

Subject: 2016 in-stream PIT tagging in the Methow River basin.

Productivity of Methow River basin spring Chinook Salmon *Oncorhynchus tshawytscha* and summer steelhead *O. mykiss* is low due, at least in part, to the poor survival of natural-origin fish (Murdoch et al. 2012). However, it is unknown whether the diminished survival occurs at a particular life stage, or if survival is poor across all life stages. Murdoch et al. (2012) recommended that PIT-tag based assessment of survival could be useful in investigating limiting life stages for spring Chinook Salmon and summer steelhead. Instream PIT tagging of juvenile Chinook Salmon and steelhead parr has been conducted in the Methow Basin over the last several years to estimate parr-to-smolt survival, identify stream of origin for returning adults, evaluate life-history differences among specific stocks (e.g., emigration timing), or as part of an ongoing relative reproductive success study. In 2016, we conducted in-stream PIT tagging in the Twisp, Chewuch, and Methow basins with the objective of refining methodologies to estimate the population size of natural-origin juvenile spring Chinook Salmon and steelhead, while meeting sampling requirements of the relative reproductive success study of steelhead in the Twisp basin (i.e., 2,500 total parr assuming that 1,500 will be age-1 parr). This memo summarizes the methods and results of our in-stream PIT tagging in 2016.

Methods

We used a combination of angling and electrofishing to collect spring Chinook Salmon and steelhead parr in 2016. Angling was conducted following equipment rules for selective fisheries (i.e., unscented artificial flies or lures with a single, barbless hook) defined in annual sport fishing rule pamphlets for Washington State. Backpack electrofishing was conducted using a Halltech HT-2000 pulsed DC battery powered backpack electrofisher with a telescoping anode pole and stainless steel cable cathode. Boat electrofishing was conducted in a 13-ft shocking raft using a Smith Root model 1.5kVA electrofisher powered by a 2000-Watt generator with a bowmounted anode, and paired cathode skirts on each raft side. The raft allowed the rower to position the raft in the current while another person netted fish from a secure standing platform above the anode. Electrofisher voltage and frequency were altered by date and location to maximize capture efficiency and minimize fish injury. Sampling efficiency using these techniques varied throughout the sampling period in relation to river flows and staff availability. Start time, stop time, and the number of samplers (i.e., effort) were recorded for each angling event. Electrofishing effort was measured as the number of seconds the unit was operating (i.e., wand time). The number of crew members was also recorded for each electrofishing event.

In the Twisp River basin, angling and electrofishing were conducted at various locations in the Twisp River mainstem (mouth to rkm 46.9), Little Bridge Creek (mouth to rkm 7.8), and Buttermilk Creek (mouth to rkm 4.1). Angling effort occurred from 29 June to 7 September to target age-1 and age-2 steelhead parr. This time period was selected because water temperature and fish activity levels made them relatively susceptible to angling. Angling effort varied by location. The primary spawning reaches for summer steelhead sampled at the Twisp Weir were fished completely (i.e., a single angling pass was conducted along the entire length of each reach); this area consisted of the Twisp River mainstem from Upper Poorman Creek Bridge (rkm 7.8) to the middle of T7 (rkm 32.2), and the lower 2.4 km of Little Bridge Creek (LBC1). Outside of the primary spawning reaches, angling effort was reduced because the likelihood of capturing the progeny of adults sampled at the Twisp Weir declines in these areas. To reduce spatial bias in the sampling within these areas, 21 sites were randomly selected and each was subjected to 3 hrs of angling effort. These areas consisted of the remainder of the Twisp River mainstem from the Methow River confluence upstream to Roads End Campground (rkm 46.4), the upstream sections of Little Bridge Creek (bottom of LBC2 [rkm 2.4] to the top of LBC3 [rkm 7.8]), and Buttermilk Creek (mouth to top of BM2 [rkm 4.1]). Electrofishing in the Twisp River basin occurred after 20 September when most juvenile Chinook captured would be large enough for PIT tagging (i.e., ≥ 55 mm fork length) and prior to seasonal movements of fish out of the basin. Individual sampling sites for electrofishing in the Twisp River basin were selected by Douglas PUD staff using a Generalized Random Tessellation Stratified (GRTS) design. In the Twisp Basin, sampling effort was divided into three spatial strata; 20% (N = 10) were downstream of the weir, 52% (N = 26) were upstream of the weir, and 28% (N = 14) were in tributaries.

The GRTS design allows random site selection while ensuring that the sampling design is spatially balanced. Sampling sites were selected from within the known redd distribution of spring Chinook Salmon and steelhead from previous years. Mainstem sites were 100 m long and tributary sites were 50 m long. Two types of electrofishing sampling methods were used at these sites; three-pass depletion sampling and single-pass sampling. In three-pass depletion samples, each electrofishing pass occurred in an upstream direction and all wetted area within the site that could be accessed was sampled with approximately equal effort per pass. Single-pass sites were conducted in the same manner, but with only a single pass at each site.

To assess the feasibility of GRTS sampling on larger rivers, electrofishing also occurred in the Chewuch River basin and the Methow River mainstem. Electrofishing in the Chewuch River basin was conducted from 6 to 19 October. Within the Chewuch River mainstem, one electrofishing site was randomly selected within each of the 13 established stream sections from the mouth to the falls above Thirtymile Bridge (rkm 54.4). In addition, one electrofishing event occurred in each of the following Chewuch River tributaries: Boulder Creek, Eightmile Creek, Twentymile Creek, and Lake Creek. Tributary sites were randomly selected from within the first river kilometer of each tributary. Electrofishing in the Methow River mainstem was conducted from 5 to 28 October. Two shocking sites were selected within the Methow River mainstem that contained habitat suitable for rearing juvenile Chinook Salmon and steelhead parr within reach M4 (rkm 67.3–74.5). Both sites were sampled using a backpack electrofishing unit where safe wading was possible along the margins of the river. For deeper water inaccessible to backpack electrofishing, boat electrofishing was used. The rower of the raft allowed the current to carry the raft downstream while adjusting its orientation to facilitate netting of immobilized fish. Each site required multiple passes; each pass was as wide as the observed effective shocking range of the raft. After each pass, the raft was moved back upstream and the adjacent area was shocked until the entire area in the 100-m long site had been covered completely. Each of the two sites was sampled completely on 5 October and a recapture pass was conducted on the upstream most site on 28 October. Electrofishing was also conducted in the Silver Side Channel, a perennial, spring-fed side channel of the Methow River, in support of an ongoing habitat restoration project. In order to assess fish assemblage and density, most of the channel was electrofished on two occasions; a spring pass (17 March) and a fall pass (20 October). Prior to the initiation of restoration work, electrofishing was also used to remove fish from the lower 0.7 rkm of the Silver Side Channel on 27–28 June.

Regardless of capture method, parr were held in 19-L plastic buckets filled with aerated river water until the sampling event was completed. Captured fish were anesthetized in a solution of tricaine methanesulfonate (i.e., MS-222) at a concentration of 40−60 mg/L, scanned for presence of a PIT tag, measured for fork length to the nearest mm, and weighed to the nearest 0.1 g. All unmarked wild parr ≥ 55 mm were PIT tagged to prevent double sampling of individuals, and to estimate survival to other life-history stages (e.g., smolt to adult) or locations (e.g., in-stream PIT tag antenna arrays or Columbia River hydropower detection facilities). Parr with fork lengths from 55 to 64 mm were tagged with 9-mm PIT tags, while parr with fork lengths ≥ 65 mm were tagged with 12-mm PIT tags. All hatchery origin fish captured during angling and electrofishing (i.e., fish that failed to emigrate) were euthanized to reduce the proportion of hatchery residuals in natal rearing areas. Sampling locations were geo-referenced using a hand-held GPS device. Fish were allowed to fully recover in a bucket of river water prior to release in a calm part of the river near the sampling location. Tagging data was uploaded following standard protocols to the regional PIT tag database (PTAGIS) maintained by the Pacific States Marine Fisheries Commission.

Results

In the Twisp River basin, we captured a total of 2,360 wild steelhead parr, 142 residual hatchery-origin steelhead parr, and 576 wild Chinook Salmon parr during angling and electrofishing. Most wild Chinook Salmon and summer steelhead were tagged (Table 1) unless they were too small or other fish health concerns existed. Angling and electrofishing effort in 2016 was similar to the previous two years (i.e., since GRTS sampling was initiated); however, total catch of target species was lower than in these previous years (Table 2). Wild steelhead fork length in the Twisp Basin was greater for those captured by angling (mean = 148 mm) than by electrofishing (mean = 94 mm) in 2016 (Figure 1; $P < 0.001$; Kolmogorov-Smirnov test).

In the Chewuch River basin, 638 steelhead parr and 180 Chinook Salmon parr were captured with 11.7 wand hrs of electrofishing effort, and most were PIT tagged (Table 3). In the Methow River basin, 175 steelhead and 604 Chinook Salmon parr were captured with 7.2 wand hrs of electrofishing effort and most were PIT tagged (Table 3). During the recapture pass in the upstream-most Methow River mainstem site, 25% of the 20 target fish captured were recaptures from the original sample, despite three weeks between sampling events.

Table 1. Numbers of spring Chinook and summer steelhead parr PIT tagged by reach and capture method in the Twisp River basin in 2016. Section descriptions can be found in Section 2, Table 2.5 of this annual report.

Section	Angling			Electrofishing		
	Effort (hrs)	Chinook tagged	Steelhead tagged	Effort (hrs)	Chinook tagged	Steelhead tagged
T10	6.3	0	10	1.9	0	9
T9	6.0	0	17	0.9	0	23
T8	4.5	0	19	0.9	7	9
T7	19.0	0	58	3.2	77	45
T6	26.3	0	119	2.4	108	71
T5	18.5	0	52	3.7	135	137
T4	35.5	0	279	2.0	43	87
T3	24.5	0	74	3.9	35	170
T2	12.0	1	21	7.0	75	276
T1	9.0	0	31	2.2	31	122
LBC3	6.0	0	30	0.2	0	53
LBC2	6.0	0	46	0.1	0	29
LBC1	18.5	0	180	0.7	0	124
BM2	3.0	0	38	1.0	0	55
BM1	3.0	0	42	0.3	3	4
EA1	0.0	0	0	1.1	2	8
WR1	0.0	0	0	0.2	2	4
WR2	0.0	0	0	0.4	0	7
SO1	0.0	0	0	0.2	0	0
Total	198.1	1	1,016	32.3	518	1,233

Table 2. Numbers of spring Chinook and summer steelhead parr PIT tagged by year and capture method (angling and electrofishing only) in the Twisp River basin. Effort is listed as “n/a” for years when documentation of effort was inconsistent.

Year	Angling			Electrofishing		
	Effort (hrs)	Chinook tagged	Steelhead tagged	Effort (hrs)	Chinook tagged	Steelhead tagged
2010	n/a	51	1,144	n/a	58	351
2011	n/a	170	1,002	n/a	875	707
2012	209.5	87	959	n/a	895	1,474
2013	345.5	203	1,525	11.8	900	566
2014	256.6	0	1,354	50.4	926	1,607
2015	273.5	1	1,399	44.0	1,115	2,478
2016	198.1	1	1,016	32.3	518	1,233

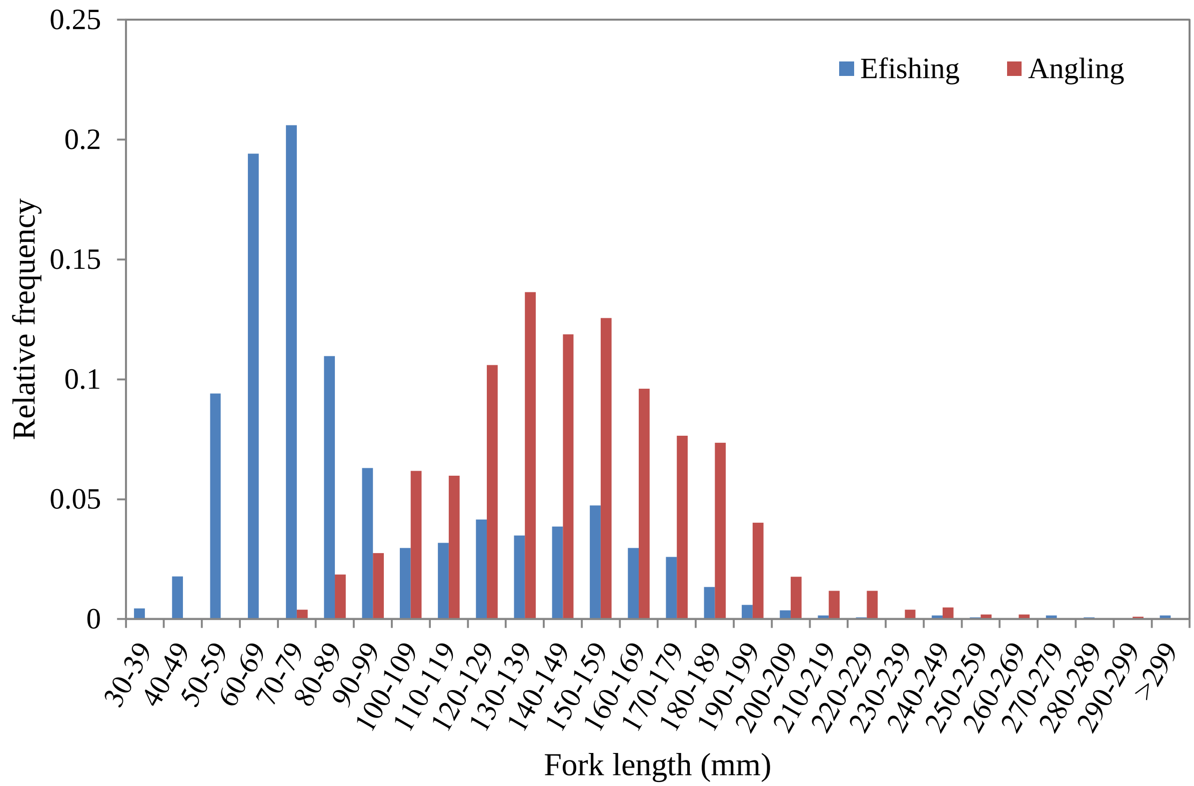

Figure 1. Relative frequency distribution of wild steelhead by fork length and capture method in the Twisp River basin.

Table 3. Numbers of Chinook Salmon and summer steelhead parr PIT tagged by subbasin and year.

Year	Methow River		Chewuch River		Twisp River	
	Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead
2010	24	320	5	514	141	1,501
2011	560	518	517	1,068	1,060	1,728
2012	638	1,062	771	2,059	982	2,433
2013	1,717	1,871	1,610	2,353	1,103	2,091
2014	62	24	3,040	0	926	2,961
2015	51	110	0	0	1,120	3,877
2016	400	175	178	608	519	2,249

References

Murdoch, A., C. Snow, C. Frady, A. Repp, M. Small, S. Blankenship, T. Hillman, M. Miller, G. Mackey, and T. Kahler. 2012. Evaluation of the hatchery programs funded by Douglas County PUD, 5-Year Report, 2006- 2010. Report to the Wells HCP Hatchery Committee, East Wenatchee, WA.

Attachment C. Summary of spring Chinook spawning ground surveys conducted in the Methow River basin in 2016.

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
METHOW FIELD OFFICE
20268 HWY 20, Twisp WA, 98856
Voice (509) 997-0048 FAX (509) 997-0072

From: Charles Frady

To: Charlie Snow

Date: 26 May 2016

Subject: Results of 2016 spring Chinook salmon spawning ground surveys and escapement estimates in the Methow River Basin.

Spring Chinook salmon are propagated at Methow Hatchery (MH) and used to supplement the natural spawning populations in the Methow River Basin. Hatchery origin adults (HORs) from supplementation programs are managed to have migration timing, spawn timing, and redd distribution similar to those of natural origin adults (NORs). Deviations from these life-history traits may have deleterious effects on the overall reproductive success of supplemented populations. The number of spawners, derived from estimates of redd abundance, provides critical information not only for survival and spawner-recruit analyses, but also for assessing freshwater smolt production. Knowledge of both the productivity of the population (i.e., recruits per spawner), as related to the total abundance of spawners, and the proportion of HOR fish on the spawning grounds should provide valuable insight regarding the factors limiting the number of NOR adults. In addition to spawner abundance, the proportion of stray HOR fish on the spawning grounds may also assist in understanding the productivity of the population (i.e., stray fish may be maladapted to the Methow Basin). Spring Chinook salmon spawning ground surveys and associated activities (i.e., broodstock collection and management) were used to evaluate spawn timing, distribution, and tributary-specific escapement levels within the Methow River basin.

Methods

Run Escapement

Adult spring Chinook salmon were trapped and sampled at Wells Dam to assess migration timing, origin composition, and to collect broodstock for MH (Tonseth 2016). All trapped fish were sampled for marks (fin-clips) and tags (CWT). Scale samples, sex, and fork length data were collected from all potential NOR fish, and NOR fish retained for broodstock were also tissue sampled for DNA analysis to determine genetic origin (i.e., Methow basin origin and Twisp or non-Twisp). All HOR fish were sampled for scales, sex, and length, and passive integrated transponder (PIT) tags were inserted in the pelvic girdle of all released fish (HOR and NOR) to assess sex ratio of the 2016 brood. All ad-clipped adults were assumed to be returns from Winthrop NFH production. Ad-clipped jacks were assigned to either Winthrop NFH production, or CCT production (Okanogan Basin and Chief Joseph Hatchery) according to proportional returns of PIT-tagged fish. Gender was determined using ultrasound. All trapped fish were either held pending DNA and scale analyses and subsequently transported to MH as broodstock or placed back in the fish ladders upstream of the traps.

Digital video records of fish passage at Wells Dam between 22 May and 2 July for both ladders were reviewed to exclude summer Chinook salmon from the spring Chinook salmon count and vice versa. The number of fish that were double counted (i.e., re-ascensions) or fell back (i.e., fell below without re-ascending) were estimated based on PIT-tag detections at in-stream interrogation sites and mainstem Columbia and Snake River dams. No estimates of predation, pre-spawn mortality or illegal removal (i.e., poaching) were made.

Spawning Ground Surveys

Spring Chinook salmon redds were individually georeferenced with hand-held global positioning system (GPS) devices for subsequent mapping and analyses and all pertinent data were collected for each redd. Most reaches were surveyed every six to eight days during the spawning season (August and September). Female carcass locations (river kilometers [rkm]) were used as surrogates for spatial redd distribution of hatchery and natural origin spawning.

Spawner Composition, Demographics, and Egg Deposition

Spawning population characteristics were derived from biological data collected from carcasses recovered during surveys. Location, origin, sex, fork length, post-orbital-to-hypural-plate (POH) length, egg retention (females), and scale samples were collected from each carcass when possible. Tissue samples were collected from NOR fish, and a small number of HOR fish for genetic analyses; most DNA samples from HOR fish were collected at Methow Hatchery during spawning activities. Carcass locations were recorded using hand-held GPS devices and all carcasses were sampled for CWTs using hand-held electronic detection wands. Spring Chinook salmon released from Methow Hatchery are tagged with a CWT but no external mark (to avoid removal in mark-selective fisheries), thus requiring the use of electronic detectors. Most other HOR fish released in the Upper Columbia are externally marked with an adipose fin-clip in addition to the CWT to designate hatchery origin. Snouts were sent to the WDFW CWT Lab for tag extraction and decoding. Scales were sent to the WDFW Ageing Lab for age determination.

Fish age was determined either through CWT or scale analysis. Scale analysis was also used to confirm origin for fish with no detectable hatchery mark or tag (i.e., NOR).

Egg retention was determined for female carcasses with an intact abdomen by counting the number of eggs present. The percentage of eggs retained was determined by dividing the number of eggs counted by the mean fecundity for the fish's specific age and origin derived from 2016 MH broodstock (WDFW, unpublished data). Female carcasses with intact abdominal cavities, a large number of eggs, and no external signs of spawning (i.e., eroded caudal fin) were categorized as pre-spawn mortalities. Estimated egg deposition was calculated using mean fecundities from MH broodstock (i.e., MetComp stock for Methow and Chewuch subbasins, Twisp stock for Twisp subbasin) and adjusted for mean egg-retention rates.

Natural Replacement Rate

The natural replacement rate (NRR) for each brood was calculated by adding the number of recruits (r) from successive return years that originated from the same brood year (i), and dividing the sum by the number of spawners (S) for that brood year calculated from expanded spawning ground surveys, as follows:

$$\mathrm{NRR} = (r_{i+1} + r_{i+2} + r_{i+3} + \ldots)/S$$

Estimated spawning escapement was derived from redd counts expanded by fish-per-redd values. Prior to 2006, fish-per-redd values were calculated from Wells Dam counts and adjusted for the proportion of jacks (age-3 fish) in the run (Meekin 1967). Since 2006, fish-per-redd values have been calculated using the male-to-female sex ratio from run-at-large sampling at Wells Dam. In 2016, fish-per-redd values were calculated on the population remaining after broodstock collection and removal of surplus hatchery-origin fish. Recruits were expanded to account for non-selective fishery harvest and indirect mortality attributed to selective fisheries.

Stray Rates

The composition of HOR fish on spawning grounds, and associated stray rates were determined by expanding all CWT recoveries by the code-specific tag-retention rates and stream-specific sampling rates from spawning ground surveys. HOR fish were considered strays depending on their release and recovery locations. All MH fish recovered in a stream within the Methow River watershed from which they were not released were considered within-basin strays. Out-of-basin strays included all fish recovered in streams other than their stream of release. When fish are retained for broodstock, it is unknown whether they would have eventually migrated to their natal (or release) streams or to "non-target" areas. Therefore, fish retained for broodstock were excluded from stray rates calculations. Further, all CWT recoveries of the 1992 and 1994 broods were within broodstock collections, thus stray rates were not calculated for these broods, and no

Twisp or Chewuch fish were released from the 1995 brood year. The Methow and Chewuch programs were maintained and released as an aggregate stock (Methow Composite) in the 1998 and 2000 brood years; stray rates could not be determined for the individual release sites.

Results

Migration Timing and Run Composition

The 2016 spring Chinook salmon migration to Wells Dam was monitored between 3 May and 24 June. Overall, wild fish migrated to Wells Dam two days earlier than hatchery fish (Table 1). Based on PIT tag detections at Wells Dam fish ladders, an estimated two fish were double counted and 97 fish fell below Wells Dam after being counted and did not re-ascend; excluding these totals, the estimated spring Chinook salmon to Wells Dam (including broodstock) was 5,211 fish. The run was composed primarily of hatchery fish (87.3%), 76% of which were adipose fin-clipped. After correcting for sex determination errors and accounting for fish retained for broodstock (N = 559), fish destined for the Okanogan Basin (N = 372), and fish removed as surplus (N = 3,080) the remaining estimated escapement in the Methow River was 1,200 fish.

Table 1. Mean migration date of hatchery (H) and wild (W) spring Chinook to Wells Dam of the overall return for the 2006-2016 broods.

Year	Origin	Percentile					Mean	*N*
		10	25	50	75	90		
2006	H	26-May	2-Jun	7-Jun	11-Jun	19-Jun	6-Jun	593
2006	W	22-May	26-May	30-May	2-Jun	27-Jun	1-Jun	24
2007	H	19-May	22-May	28-May	9-Jun	15-Jun	31-May	212
2007	W	10-May	19-May	22-May	3-Jun	9-Jun	23-May	23
2008	H	19-May	28-May	3-Jun	6-Jun	21-Jun	3-Jun	377
2008	W	16-May	19-May	31-May	6-Jun	12-Jun	29-May	51
2009	H	19-May	26-May	28-May	3-Jun	16-Jun	31-May	811
2009	W	18-May	19-May	26-May	2-Jun	9-Jun	27-May	123
2010	H	12-May	17-May	19-May	26-May	9-June	22-May	1,193
2010	W	11-May	17-May	19-May	25-May	2-June	21-May	182
2011	H	24-May	31-May	6-Jun	15-Jun	27-Jun	8-Jun	868
2011	W	18-May	25-May	2-Jun	14-Jun	27-Jun	4-Jun	112
2012	H	21-May	22-May	29-May	4-Jun	12-Jun	29-May	820
2012	W	16-May	22-May	29-May	30-May	12-Jun	28-May	115
2013	H	14-May	20-May	22-May	3-Jun	11-Jun	26-May	875
2013	W	14-May	15-May	22-May	3-Jun	12-Jun	25-May	83
2014	H	13-May	19-May	21-May	29-May	9-Jun	24-May	1,557
2014	W	12-May	19-May	20-May	28-May	3-Jun	22-May	160
2015	H	6-May	11-May	13-May	20-May	28-May	16-May	1,461

Table 1. Continued.

Year	Origin	Percentile					Mean	*N*
		10	25	50	75	90		
2015	W	6-May	6-May	12-May	19-May	27-May	14-May	139
2016	H	8-May	12-May	16-May	19-May	21-May	23-May	670
2016	W	10-May	12-May	15-May	18-May	20-May	22-May	90

Redd Distribution, Spawn Timing, and Spawner Demographics

Spawning ground surveys were performed on foot between 1 August and 29 September. A total of 361 spring Chinook redds were constructed in the Methow basin in 2016 (Tables 2-4); the majority of redds were found in the Methow River subbasin (64.0%; *N* = 231; Table 2). The greatest number of redds within that subbasin were found in the 9 km reach downstream of Weeman Bridge (*N* = 75). On average, Methow Hatchery females and wild females spawned at the same time in both the Methow and Twisp subbasins, but in the Chewuch subbasin, Methow Hatchery females spawned four days earlier than wild females (Tables 5-7). On average, wild females spawned between six and 15 km further upstream than Methow Hatchery females, depending on subbasin (Tables 5-7).

Based on expanded redd counts, there were an estimated 697 spawners in the Methow River basin in 2016, of which 320 (45.9%) were estimated to be wild (NOR) fish (see Tables 2-4). Estimated spawning escapement does not include hatchery or wild fish collected for broodstock. Wild fish comprised 67.4%, 62.3%, and 35.7% of the estimated spawning escapement in the Twisp, Chewuch, and Methow subbasins, respectively (see Tables 2-4).

A total of 169 Methow Hatchery and wild fish carcasses were recovered for which age, origin, gender, and length were measurable (Table 8). Comparisons of hatchery and wild fish show similar mean lengths within age groups for both MetComp and Twisp stocks (Table 8).

Egg retention was estimated for 133 of the 174 female carcasses examined. Using mean fecundities from MH broodstock (MetComp and Twisp), adjusting for mean egg-retention rates, and accounting for the proportion of hatchery and wild females by age class on the spawning grounds, an estimated total of 1,426,641 eggs were deposited in the Methow River basin in 2016 (Table 9).

Table 2. 2016 spring Chinook salmon redd distribution, estimated spawning escapement, and carcass recoveries in the Methow River subbasin.

Reach	Redds		Estimated spawning escapement	Carcasses				
				Recoveries			Expanded count	
	Count	Subbasin Prop. (%)		H	W	Total	H	W
			Methow River mainstem					
M15	2	0.9	4	0	2	2	0	4
M14	16	6.9	31	6	11	17	11	20
M13	5	2.2	10	0	8	9[a]	0	10
M12	5	2.2	10	4	1	5	8	2
M11	17	7.3	33	3	3	6	17	16
M10	25	10.8	48	7	3	10	34	14
M9	75	32.4	144	18	13	31	86	58
M8	2	0.9	4	3	0	4[a]	4	0
M7	16	6.9	31	10	3	13	24	7
M6	15	6.5	29	12	4	16	22	7
M5,4	1	0.4	2	1	1	2	1	1
Total	179	77.4	346	64	49	115[a]	207	139
			Lost River					
L2	8	3.5	15	0	2	2	0	15
L1	1	0.4	2	0	1	1	0	2
Total	9	3.9	17	0	3	3	0	17
			Early Winters Creek					
EW5,4	0	0.0	0	0	0	0	0	0
EW3	4	1.8	8	3	0	3	8	0
EW2,1	1	0.4	2	0	1	1	0	2
Total	5	2.2	10	3	1	4	8	2
			Methow River tributaries					
HA2	0	0.0	0	0	0	0	0	0
HA1	1	0.4	2	0	0	0	1[b]	1[b]
MH1	2	0.9	4	2	0	2	4	0
Lsusp1	0	0.0	0	0	0	0	0	0
Susp1	6	2.6	11	2	0	2	11	0
W3	0	0.0	0	0	0	0	0	0
W2	0	0.0	0	0	0	0	0	0
W1	0	0.0	0	0	0	0	0	0
WN1	29	12.6	56	16	0	16	56	0
Total	38	16.5	73	20	0	20	72	1
Grand total	231	100.0	446	87	53	142[a]	287	159

[a] Includes carcasses of unknown origin.
[b] Expanded count based on H and W proportions from M9upper.

Table 3. 2016 spring Chinook salmon redd distribution, estimated spawning escapement, and carcass recoveries in the Chewuch River subbasin.

Reach	Redds		Estimated spawning escapement	Carcasses				
	Count	Subbasin Prop. (%)		Recoveries			Expanded count	
				H	W	Total	H	W
			Chewuch River mainstem					
C13	0	0.0	0	0	0	0	0	0
C12	5	6.0	10	1	3	4	2	8
C11	1	1.2	2	0	0	0	1	1
C10	3	3.6	6	1	1	2	3	3
C9	0	0.0	0	0	0	0	0	0
C8	6	7.1	12	0	4	5[a]	0	12
C7	9	10.7	17	1	4	5	3	14
C6	14	16.6	27	6	11	17	10	17
C5	9	10.7	17	5	9	14	6	11
C4	12	14.3	23	1	10	12[a]	2	25
C3	2	2.4	4	0	0	1[a]		
C2	22	26.2	42	8	1	10	34	8
C1	1	1.2	2	0	1	1	0	2
Total	84	100.0	162	23	45	71[a]	61	101

[a] Includes carcasses of unknown origin.

Table 4. 2016 spring Chinook salmon redd distribution, estimated spawning escapement, and carcass recoveries in the Twisp River subbasin.

Reach	Redds		Estimated spawning escapement	Carcasses				
	Count	Subbasin Prop. (%)		Recoveries			Expanded count	
				H	W	Total	H	W
T10	0	0.0	0	0	0	0	0	0
T9	0	0.0	0	0	0	0	0	0
T8	0	0.0	0	0	0	0	0	0
T7	15	32.6	29	0	5	6[a]	0	29
T6	14	30.4	27	6	8	14	12	15
T5	14	30.4	27	7	6	14[a]	13	14
T4	0	0.0	0	0	1	1		
T3	3	6.6	6	2	1	3	4	2
T2	0	0.0	0	0	0	0	0	0
T1	0	0.0	0	0	0	0	0	0
Total	46	100.0	89	15	21	38	29	60

[a] Includes carcasses of unknown origin.

Table 5. Mean recovery location (rkm) and spawn timing (day of year) of Methow Composite females and their wild (NOR) counterparts in the Chewuch River subbasin in 2016.

Year	Origin	Recovery location (rkm) of female Chinook			Spawn timing (day of year) of female Chinook	
		Mean	SD	*N*	Mean	SD
2006	H	102	12	40	251	5
2006	W	107	10	26	251	7
2007	H	110	11	5	249	6
2007	W	110	10	8	251	8
2008	H	105	8	22	254	3
2008	W	111	10	21	254	5
2009	H	103	13	20	252	6
2009	W	108	14	37	250	5
2010	H	101	10	75	249	6
2010	W	116	13	39	250	7
2011	H	104	10	46	246	6
2011	W	117	15	37	240	9
2012	H	105	10	85	252	8
2012	W	115	12	34	251	7
2013	H	105	13	47	250	6
2013	W	122	14	23	249	7
2014	H	107	11	52	251	6
2014	W	114	13	35	251	4
2015	H	101	13	59	256	4
2015	W	112	14	53	255	4
2016	H	106	7	5	249	9
2016	W	112	12	30	253	8
Mean	H	104	11	41	251	6
Mean	W	113	12	31	250	6

Table 6. Mean recovery location (rkm) and spawn timing (day of year) of Methow Composite on-station-release female Chinook and their wild (NOR) counterparts in the Methow River subbasin in 2016.

Year	Origin	Recovery location (rkm) of females in the Methow subbasin			Spawn timing (day of year) of females in the Methow subbasin	
		Mean	SD	*N*	Mean	SD
2006	H	89	7	164	251	7
2006	W	112	13	18	249	7
2007	H	94	7	10	252	10
2007	W	110	9	15	250	12
2008	H	93	10	40	252	7
2008	W	103	10	35	254	6
2009	H	98	13	31	251	9
2009	W	102	10	31	249	7
2010	H	92	8	254	249	9
2010	W	103	10	71	246	9
2011	H	93	12	93	249	8
2011	W	104	12	49	245	8
2012	H	90	7	262	252	7
2012	W	105	11	24	249	5
2013	H	99	16	73	250	6
2013	W	107	13	21	247	6
2014	H	98	11	157	248	6
2014	W	109	11	45	249	7
2015	H	96	9	182	251	5
2015	W	102	12	55	250	7
2016	H	95	11	24	250	8
2016	W	110	13	33	250	9
Mean	H	94	10	117	250	7
Mean	W	106	11	36	249	8

Table 7. Mean recovery location (rkm) and spawn timing (day of year) of Twisp female Chinook and their wild (NOR) counterparts in the Twisp River subbasin.

Year	Origin	Recovery location (rkm) of females in the Twisp subbasin			Spawn timing (day of year) of females in the Twisp subbasin	
		Mean	SD	*N*	Mean	SD
2006	H	86	9	13	254	8
2006	W	97	4	9	250	12
2007	H	87	8	3	247	1
2007	W	89	2	2	248	1
2008	H	87	7	29	251	6
2008	W	90	6	10	249	7
2009	H	82	3	3	250	4
2009	W	86	1	2	249	5
2010	H	86	5	14	249	10
2010	W	91	6	20	247	6
2011	H	90	1	2	253	13
2011	W	94	7	15	243	9
2012	H	90	5	33	245	8
2012	W	96	9	11	243	8
2013	H	91	6	15	245	10
2013	W	98	8	4	244	11
2014	H	92	7	31	247	6
2014	W	90	8	21	246	10
2015	H	86	3	19	249	5
2015	W	93	5	40	248	6
2016	H	84	5	7	247	11
2016	W	93	6	14	248	7
Mean	H	88	5	15	249	7
Mean	W	92	6	13	247	8

Table 8. Mean POH length (*N*; SD) by age and sex of spring Chinook salmon carcasses recovered during Methow Basin spawning ground surveys in 2016. These data include all measureable and aged Methow Hatchery fish regardless of their recovery location.

Stock	Origin	Mean length (POH; cm) of adult returns (*N*; SD)					
		Male			Female		
		Age-3 (2013 BY)	Age-4 (2012 BY)	Age-5 (2011 BY)	Age-3 (2013 BY)	Age-4 (2012 BY)	Age-5 (2011 BY)
MetComp	H	- -	61 (*5*; 5)	67 (*1*; - -)	- -	61 (*21*; 3)	68 (*10*; 3)
Methow / Chewuch	W	43 (*1*; - -)	61 (*28*; 2)	73 (*5*; 5)	- -	60 (*54*; 4)	69 (*8*; 3)
Twisp	H	38 (*3*; 3)	61 (*4*; 4)	- -	- -	58 (*6*; 4)	70 (*2*; 6)
Twisp	W	43 (*3*; 2)	60 (*4*; 5)	- -	- -	59 (*11*; 3)	72 (*3*; 1)

Table 9. Estimated egg deposition for spring Chinook salmon in the Methow Basin. Mean fecundities were derived from Methow Hatchery broodstock (MetComp or Twisp) and adjusted according to hatchery and wild proportions by age class in each subbasin. Estimated egg deposition includes eggs from dewatered redds.

Year	Females with egg retention estimated	Mean fecundity	Mean egg retention (%)	Redds	Estimated egg deposition
			Chewuch River subbasin		
2007	19	4,355	0.20	79	343,357
2008	70	3,739	0.30	120	447,334
2009	73	3,965	0.30	143	565,294
2010	134	3,903	0.50	286	1,110,677
2011	104	4,089	0.40	225	916,345
2012	142	3,627	1.70	236	841,420
2013	71	3,616	1.50	171	609,061
2014	104	3,836	1.00	239	907,636
2015	109	4,020	1.10	206	819,011
2016	36	4,221	0.90	84	351,373
			Methow River subbasin		
2007	68	3,870	0.20	198	764,727
2008	148	3,668	1.10	278	1,008,487
2009	153	3,998	1.00	323	1,278,440
2010	518	3,911	1.40	935	3,605,590
2011	243	3,940	0.70	472	1,846,662
2012	353	3,440	1.70	520	1,758,390
2013	117	3,582	1.50	336	1,185,499
2014	333	3,743	1.50	763	2,813,070
2015	288	3,882	0.60	654	2,523,595
2016	84	3,764	0.40	231	866,006

Table 9. Continued.

Year	Females with egg retention estimated	Mean fecundity	Mean egg retention (%)	Redds	Estimated egg deposition
			Twisp River subbasin		
2007	10	4,277	0.10	30	128,182
2008	48	3,461	1.70	79	268,771
2009	7	4,204	0.20	24	100,694
2010	38	3,923	0.10	145	568,266
2011	16	4,292	0.20	63	269,855
2012	48	3,398	1.30	139	466,182
2013	23	3,358	1.30	85	281,719
2014	57	3,589	0.90	138	490,824
2015	58	4,438	0.70	119	524,425
2016	13	4,551	0.04	46	209,262

Natural Replacement Rates

Natural replacement rates (NRR) for the latest complete brood (2010) were less than 1.0 in all subbasins (Chewuch = 0.43; Methow = 0.20; Twisp = 0.57; Appendices A-C). Though all NRR values were below replacement, 2010 rates were two to three times greater than those in 2009. HRR values from the 2010 brood were between nine and 32 times greater than corresponding NRR values within subbasins (Appendices A-C).

Stray Rates by Brood Year

Based on total expanded CWT recoveries, an estimated 37.1% of the 2010 brood Chewuch spring Chinook salmon was recovered on spawning grounds of other recipient spawning areas (Appendix D). Excluding broods with no usable spawning ground recovery information (1992, 1994-1995, 1998, 2000), the recovery rate of Chewuch River fish in stray areas (mean = 32.7%) was greater than the 5% target. Based on total expanded CWT recoveries, an estimated 8.6% of the 2010 brood Methow spring Chinook salmon was recovered on spawning grounds of other recipient spawning areas (Appendix E). Excluding broods with no usable spawning ground recovery information (1992, 1994, 1998, 2000), the recovery rate of Methow River fish in stray areas (mean = 3.5%) was less than the 5% target. Based on total expanded CWT recoveries, an estimated 24.3% of the 2010 brood Twisp spring Chinook salmon carcasses were recovered on spawning grounds of non-target areas (Appendix F). Excluding broods with no spawning ground recoveries (1992, 1994-1995), the recovery rate of Twisp River fish in stray areas (mean = 22.6%) was greater than the 5% target.

Stray Rates within the Methow Basin

A total of 104 coded wire tags (CWTs) were successfully decoded from the adult spring Chinook salmon collected during spawning ground surveys in the Methow River basin in 2016. These fish were expanded by tag-specific retention rates and stream-specific sample rates to account for 334 fish (Appendix G). As a percent of the spawning escapement, most within-basin strays were recovered in the Chewuch subbasin (Table 10-12; 8.6% Methow and Twisp releases combined). Out-of-basin stray fish were found in the Chewuch and Methow subbasins (Table 10 and 11; Appendix G).

Stray Rates outside the Methow Basin

A total of 77 fish from Methow Hatchery were estimated to have strayed to recipient populations outside the Methow River basin from all broods examined (Table 13). Of these, 58 fish strayed into other spring Chinook salmon populations (e.g., Chiwawa and Entiat Rivers; Table 13). Stray Methow Hatchery fish have comprised less than 5.0% of the overall estimated spawning escapement to the Entiat River (Table 13) and did not exceed 5% in any other population.

Table 10. Spawning escapement (%) of hatchery release groups in the Chewuch subbasin. Percent of spawning escapement comprised by wild fish is not included.

Run year	Estimated spawning			Hatchery stock (% of spawning escapement)					
	H	W	Total	Chewuch	Methow	Twisp	Winthrop	MetComp	Out-of basin
2000	52	31	83	8.4	8.4	0.0	8.7	- -	18.5
2001	1,761	732	2,493	33.8	2.0	0.2	10.4	2.1	0.2
2002	588	78	666	3.6	0.0	0.0	7.9	69.7	0.0
2003	465	25	490	0.0	1.5	0.0	2.6	78.5	0.5
2004	289	46	335	5.1	1.1	0.0	3.0	70.7	0.0
2005	289	219	508	41.9	3.6	0.4	2.1	4.0	3.8
2006	378	135	513	28.8	3.2	0.9	5.5	- -	7.4
2007	203	74	277	20.0	8.4	0.0	8.9	- -	19.4
2008	166	86	252	26.7	4.5	0.0	17.3	- -	10.4
2009	500	271	771	30.8	9.9	1.5	16.0	- -	1.5
2010	341	155	496	39.0	6.7	0.4	14.7	- -	2.5
2011	499	370	869	39.2	4.1	0.0	7.6	- -	13.0
2012	261	81	342	51.8	3.2	2.3	2.3	- -	5.0
2013	226	89	315	51.4	5.4	2.7	3.4	- -	1.3
2014	267	166	433	28.9	17.3	1.5	8.1	- -	0.0
2015	152	134	286	31.1	6.5	0.5	4.5	- -	8.4
2016	61	101	162	7.2	5.7	2.9	5.8	- -	18.3

Table 11. Spawning escapement (%) of hatchery release groups in the Methow subbasin. Percent of spawning escapement comprised by wild fish is not included.

Run year	Estimated spawning			Hatchery stock (% of spawning escapement)					
	H	W	Total	Chewuch	Methow	Twisp	Winthrop	MetComp	Out-of basin
2000	574	65	639	2.5	38.0	2.9	25.5	- -	0.0
2001	6,994	594	7,588	7.9	27.8	0.4	45.6	1.8	0.4
2002	1,644	86	1,730	0.6	4.6	1.1	28.3	47.1	0.0
2003	597	8	605	0.0	5.1	4.0	26.3	43.3	0.6
2004	622	199	821	3.6	4.5	4.4	16.9	35.6	0.0
2005	526	221	747	32.2	16.2	1.6	11.7	1.2	1.7
2006	942	128	1,070	22.8	25.2	4.6	19.1	- -	7.0
2007	545	152	697	12.3	6.8	7.2	36.6	- -	6.9
2008	412	172	584	12.9	17.7	0.4	42.6	- -	3.4
2009	1,480	261	1,741	10.9	27.2	2.3	36.8	- -	3.4
2010	1,331	290	1,621	10.8	34.9	0.8	29.2	- -	0.4
2011	1,391	432	1,823	28.1	21.4	3.9	23.2	- -	5.1
2012	691	63	754	28.0	40.2	8.1	7.8	- -	2.5
2013	505	113	618	20.2	38.0	8.4	5.3	- -	0.8
2014	1,131	250	1,381	7.3	48.6	1.9	16.6	- -	0.9
2015	749	154	903	11.3	36.4	0.2	19.8	- -	0.8
2016	287	159	446	1.4	22.3	0.0	26.0	- -	3.4

Table 12. Spawning escapement (%) of hatchery release groups in the Twisp subbasin. Percent of spawning escapement comprised by wild fish is not included.

Run year	Estimated spawning			Hatchery stock (% of spawning escapement)					
	H	W	Total	Chewuch	Methow	Twisp	Winthrop	MetComp	Out-of basin
2000	235	21	256	0.0	0.0	72.6	2.2	- -	0.0
2001	384	506	890	1.5	0.8	19.6	0.8	0.0	0.0
2002	60	181	241	0.0	0.0	9.1	12.1	3.1	0.0
2003	18	25	43	0.0	0.0	30.2	0.0	0.0	0.0
2004	98	243	341	0.0	0.0	19.7	1.2	1.3	4.4
2005	34	87	121	2.6	0.0	15.8	0.0	0.0	0.0
2006	100	65	165	0.0	2.5	40.0	2.8	- -	0.0
2007	65	40	105	0.0	0.0	55.2	0.0	- -	0.0
2008	126	40	166	2.7	0.0	60.1	0.0	- -	4.0
2009	97	32	129	0.0	0.0	55.6	3.4	- -	3.4
2010	96	156	252	1.4	0.0	30.1	2.8	- -	1.4
2011	85	159	244	2.5	0.0	17.4	0.0	- -	32.
2012	146	56	202	2.2	1.1	62.4	1.1	- -	1.1
2013	117	39	156	1.7	3.4	56.2	0.0	- -	3.3
2014	157	92	249	1.8	3.6	52.1	0.9	- -	0.0
2015	54	110	164	1.0	5.0	21.4	1.9	- -	0.0
2016	29	60	89	0.0	2.7	34.9	0.0	- -	0.0

Table 13. Methow Hatchery program strays by run year and recovery location.

Run year	Recovery location	CWT	Stock	Expanded recoveries	Estimated escapement	% of population
2006	Chiwawa River	631976	MetComp	2	528	0.38
2010	Chiwawa River	633884	MetComp	6	1,094	0.55
1997	Entiat River	635551	Methow	1[a]	89	- -
2000	Entiat River	630130	Methow	6	175	3.43
2001	Entiat River	630613	Methow	3	485	0.62
2002	Entiat River	631024	MetComp	5	370	1.35
2003	Entiat River	631024	MetComp	6	259	2.32
2006	Entiat River	631976	MetComp	4	257	1.56
2007	Entiat River	632564	Twisp	6	245	2.45
2010	Entiat River	633866	MetComp	6	490	1.22
2010	Entiat River	633884	MetComp	6	490	1.22
2013	Entiat River	635664	MetComp	4[b]	238	- -
2015	Entiat River	635664	MetComp	3	509	0.59
2000	Similkameen River	630130	Methow	3	- -	- -
2001	Similkameen River	630614	Chewuch	5	- -	- -
2001	Similkameen River	631024	MetComp	5	- -	- -
2002	Similkameen River	631024	MetComp	5	- -	- -
2003	Similkameen River	631024	MetComp	1	- -	- -

[a] Fish was recovered during WDFW genetic study trapping and was not included in spawning escapement estimate.
[b] Recovery was an age-1 juvenile non-migrant and not included in the estimated spawning escapement.

Discussion

2016 marked the first year since 2003 that four-year old hatchery fish would not be returning to a location they were released from in the Methow Basin. Hatchery fish were not planted in the Chewuch River in 2014 from the 2012 brood, and in 2016 there were no four-year old Chewuch hatchery origin returns. Additionally, Chewuch River releases decreased to below 100,000 fish starting with the 2010 brood, and are currently set at about 60,516 fish annually. The lower release numbers in general, and the absence of hatchery returns from the 2012 brood specifically, reduced pHOS in the Chewuch River in 2016. Although pHOS in 2016 was lower than the 2003-2015 mean pHOS values in each subbasin (Methow, Twisp, and Chewuch) the Chewuch subbasin had the greatest reduction overall. The 2016 pHOS value of 0.38 was the first time the Chewuch subbasin had a pHOS value under 0.50 in the WDFW survey era (2003-present).

Hatchery releases resumed in the Chewuch subbasin with the 2013 brood, released in 2015, and four-year old hatchery fish will be returning in 2017. Proposed projects in the Chewuch subbasin include planting additional hatchery-origin adults in the Chewuch prior to spawning to increase spawner abundance. Low sampling rates of natural-origin fish at Wells Dam, PIT array efficiencies, and the absence of an instream weir are some of factors that increase the uncertainty surrounding how many natural-origin and hatchery-origin spawners are destined for the

Chewuch in any given year, and therefore how many extra fish should be planted. Managers should evaluate the benefits and consequences of increasing pHOS closely to determine how these actions might affect the population of natural-origin spring Chinook in the Chewuch subbasin and the Methow River Basin as a whole.

References

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Appendix A. Natural Replacement Rates (NRR) in the Chewuch subbasin for brood years 1992 to 2010 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
1992	421.75	0	25	14	41.25	0.10	1.50
1993	184.34	2	69	21	95.53	0.52	1.01
1994	62.85	0	15	3	18.95	0.30	0.17
1995	6.09	1	12	19	33.69	5.54	- -
1996	8.00	0	13	86	102.02	12.75	0.39
1997	123.30	1	662	55	921.30	7.47	4.34
1998	7.00	11	23	19	62.69	8.96	12.71
1999	21.08	0	2	0	2.14	0.10	- -
2000	82.84	6	47	13	69.97	0.84	3.34
2001	2,493.22	0	205	49	264.42	0.11	3.95
2002	665.76	2	91	61	169.01	0.25	4.34
2003	489.60	0	15	33	53.14	0.11	0.65
2004	334.62	4	63	11	92.27	0.28	1.18
2005	507.78	5	282	8	312.76	0.62	1.81
2006	513.24	25	191	218	565.85	1.10	4.84
2007	276.50	8	178	36	285.47	1.03	8.28
2008	252.00	22	81	16	152.38	0.60	7.92
2009	770.77	3	89	6	107.10	0.14	4.20
2010	498.78	2	187	25	214.41	0.43	4.44

Appendix B. Natural Replacement Rates (NRR) in the Methow subbasin for brood years 1992 to 2010 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
1992	924.26	0	44	43	92.38	0.10	- -
1993	759.56	5	79	32	119.66	0.16	1.94
1994	172.27	0	23	7	30.46	0.18	0.50
1995	27.39	1	54	18	77.30	2.82	8.71
1996	15.00	1	30	230	268.34	17.89	3.33
1997	152.45	21	348	50	537.66	3.53	3.09
1998	23.00	16	34	2	60.75	2.64	12.71
1999	70.27	3	2	0	4.32	0.06	0.80
2000	639.39	5	197	39	256.60	0.40	3.34
2001	7,587.84	3	183	36	230.70	0.03	5.40
2002	1,729.65	0	96	93	209.12	0.12	5.21
2003	604.80	0	59	27	95.12	0.16	1.21
2004	820.82	13	163	35	248.46	0.30	3.90
2005	746.76	11	239	3	268.70	0.36	2.69
2006	1,069.72	33	363	199	775.03	0.72	9.42
2007	696.50	9	269	39	406.89	0.58	5.72
2008	583.80	16	85	19	155.23	0.27	8.80
2009	1,740.97	0	103	18	131.27	0.08	4.20
2010	1,617.55	13	281	29	326.48	0.20	5.44

Appendix C. Natural Replacement Rates (NRR) in the Twisp subbasin for brood years 1992 to 2010 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
1992	316.31	0	54	37	96.00	0.30	0.84
1993	426.42	5	27	17	50.48	0.12	0.60
1994	74.49	0	13	9	22.94	0.31	1.00
1995	12.17	0	26	12	39.30	3.23	- -
1996	8.00	0	11	56	69.10	8.64	5.39
1997	71.74	0	460	109	729.31	10.17	3.60
1998	11.00	24	72	21	138.15	12.56	2.00
1999	24.60	0	7	0	7.36	0.30	1.53
2000	256.27	37	264	17	339.31	1.32	2.51
2001	889.58	27	77	20	128.96	0.14	1.22
2002	241.09	0	47	35	90.85	0.38	8.00
2003	43.20	0	1	0	1.11	0.03	1.36
2004	340.55	8	48	9	75.82	0.22	2.42
2005	121.00	4	28	5	39.16	0.32	1.92
2006	165.00	19	179	61	337.90	2.05	8.93
2007	105.00	5	105	9	151.91	1.45	0.93
2008	165.90	10	63	4	98.82	0.60	10.37
2009	129.36	5	25	3	36.06	0.28	3.00
2010	250.85	17	105	20	143.35	0.57	5.09

Appendix D. Chewuch River spring Chinook expanded CWT recoveries. Both Methow and WNFH Hatchery are considered target broodstock locations for Chewuch releases. Stray rate is the percent of spawning ground recoveries collected on non-target spawning grounds. T = target, NT = non-target, W = Wells Dam, Com. = commercial, Sp. = sport, Trbl. = tribal. 1998 and 2000 MetComp broods share one CWT for both release rivers and are not included.

Brood	Broodstock			Spawning grounds		Ocean fishery			Freshwater fishery			Total	Stray rate	
	T	NT	W	T	NT	Com.	Sp.	Trbl.	Com.	Sp.	Trbl.		W/ harvest	No harvest
Chewuch spring Chinook salmon														
1992	0	1	38	0	0	0	0	0	0	0	0	39	- -	- -
1993	0	19	79	8	3	5	0	0	0	0	1	115	2.6%	2.8%
1994	0	0	3	0	0	0	0	0	0	0	0	3	- -	- -
1996	- -	15	15	0	4	0	0	0	2	0	1	37	10.8%	11.8%
1997	26	39	22	4	27	0	0	0	22	141	49	330	8.2%	22.9%
2001	61	0	2	317	321	0	0	0	0	0	2	703	45.7%	45.8%
2002	94	1	58	174	299	0	0	0	1	3	1	631	47.4%	47.8%
2003	17	0	9	7	22	0	0	0	0	0	0	55	40.0%	40.0%
2004	35	0	4	76	70	0	0	0	0	0	9	194	36.1%	37.8%
2005	37	0	1	117	148	0	0	0	4	0	0	307	48.2%	48.8%
2006	43	1	3	340	262	0	0	0	0	0	81	730	35.9%	40.4%
2007	176	1	5	273	338	0	0	0	1	3	14	811	41.8%	42.7%
2008	162	0	0	243	409	2	0	0	20	162	70	1,068	38.3%	50.3%
2009	76	2	0	144	116	0	0	0	5	4	10	357	33.1%	34.9%
2010	60	6	0	121	112	0	0	0	0	1	2	302	37.1%	37.5%

Appendix E. Methow River spring Chinook expanded CWT recoveries. Both Methow and WNFH Hatchery are considered target broodstock locations for Methow releases.

Brood	Broodstock			Spawning grounds		Ocean fishery			Freshwater fishery			Total	Stray rate	
	T	NT	W	T	NT	Com.	Sp.	Trbl.	Com.	Sp.	Trbl.		W/ harvest	No harvest
Methow spring Chinook salmon														
1993	43	0	134	6	1	0	0	0	0	4	3	191	0.5%	0.5%
1994	0	0	1	0	0	0	0	0	0	0	0	1	- -	- -
1995	3	0	114	3	0	2	0	0	0	0	0	122	0.0%	0.0%
1996	200	0	58	221	8	0	0	0	2	0	12	501	1.6%	1.6%
1997	297	0	3	16	1	0	0	0	83	205	111	716	0.1%	0.3%
1998	- -	- -	- -	- -	- -	3	0	0	144	424	353	924	- -	- -
1999	93	0	- -	35	7	0	0	0	3	6	0	144	4.9%	5.2%
2000	- -	- -	- -	- -	- -	5	0	0	0	6	21	32	- -	- -
2001	289	0	5	182	23	4	0	0	0	0	0	503	4.6%	4.6%
2002	245	2	37	287	26	4	0	0	0	0	2	603	4.3%	4.4%
2003	43	0	5	4	0	0	0	0	0	0	0	52	0.0%	0.0%
2004	133	0	5	110	33	0	0	0	0	0	23	304	10.9%	11.7%
2005	162	1	5	148	10	0	0	0	0	0	0	326	3.1%	3.1%
2006	469	1	18	925	106	0	0	0	3	3	182	1,707	6.2%	7.0%
2007	281	0	7	214	10	0	0	0	1	2	0	515	1.9%	2.0%
2008	427	0	4	451	39	0	0	0	23	183	79	1,206	3.2%	4.2%
2009	508	2	0	226	13	0	0	0	2	7	3	761	2.0%	2.0%
2010	565	35	0	657	81	1	0	2	1	3	8	1,353	8.6%	8.7%

Appendix F. Twisp River spring Chinook expanded CWT recoveries.

Brood	Broodstock			Spawning grounds		Ocean fishery			Freshwater fishery			Total	Stray rate	
	T	NT	W	T	NT	Com.	Sp.	Trbl.	Com.	Sp.	Trbl.		W/ harvest	No harvest
1992	0	0	21	0	0	0	0	0	0	0	0	21	- -	- -
1993	0	3	18	1	1	0	0	0	0	4	0	27	3.7%	4.3%
1994	0	0	5	0	0	0	0	0	0	0	0	5	- -	- -
1996	2	33	65	151	17	0	0	0	0	0	6	274	6.2%	6.3%
1997	10	6	- -	14	0	0	0	0	2	9	13	54	0.0%	0.0%
1998	1	8	- -	0	2	0	0	0	4	0	6	21	9.5%	18.2%
1999	3	25	- -	8	20	0	0	0	4	0	0	60	33.3%	35.7%
2000	22	12	0	67	37	0	0	0	0	0	7	145	25.5%	26.8%
2001	2	0	1	33	7	0	0	0	0	0	0	43	16.3%	16.3%
2002	7	59	6	70	66	0	0	0	0	0	3	211	31.3%	31.7%
2003	2	2	6	21	13	0	0	0	0	0	0	44	29.5%	29.5%
2004	23	7	5	97	27	0	0	0	2	0	19	180	15.0%	17.0%
2005	10	1	0	25	9	0	0	0	0	0	0	45	20.0%	20.0%
2006	15	27	0	122	59	0	0	0	0	0	25	248	23.8%	26.5%
2007	9	9	0	12	7	0	0	0	0	0	0	37	43.2%	43.2%
2008	15	39	2	156	129	0	0	0	8	68	29	446	37.7%	49.3%
2009	11	29	0	58	24	0	0	0	0	1	1	124	42.7%	43.4%
2010	1	58	0	156	70	0	0	0	0	1	2	288	24.3%	24.6%

Appendix G. Expanded coded wire tag (CWT) recoveries in 2016 by recovery location. Recoveries were expanded by tag-specific mark rates and stream sample rates.

Recovery location	BY	CWT	Release river	Stray status	Estimated escapement
Chewuch River	2011	635664	Chewuch	Homed	12
Chewuch River	2012	54567	Methow	Within-Basin	5
Chewuch River	2012	54671	Methow	Winthrop	2
Chewuch River	2012	55087	Clearwater	Out-of-Basin	25
Chewuch River	2012	55653	Methow	Winthrop	2
Chewuch River	2012	55655	Methow	Winthrop	2
Chewuch River	2012	55659	Methow	Winthrop	2
Chewuch River	2012	636284	Methow	Within-Basin	5
Chewuch River	2012	636464	Twisp River	Within-Basin	5
Chewuch River	2012	636485	Chiwawa	Out-of-Basin	5
Early Winters Creek	2012	54567	Methow	Winthrop	3
Early Winters Creek	2012	55490	Icicle	Out-of-Basin	15
Early Winters Creek	2012	55653	Methow	Winthrop	3
Methow Hatchery outfall	2012	636284	Methow	Homed	2
Methow River	2011	51599	Methow	Winthrop	3
Methow River	2011	54789	Methow	Winthrop	6
Methow River	2011	635664	Chewuch	Within-Basin	6
Methow River	2011	636409	Methow	Homed	3
Methow River	2011	636410	Methow	Homed	3
Methow River	2011	636413	Methow	Homed	6
Methow River	2012	54567	Methow	Winthrop	12
Methow River	2012	54671	Methow	Winthrop	12
Methow River	2012	55654	Methow	Winthrop	3
Methow River	2012	55655	Methow	Winthrop	3
Methow River	2012	55659	Methow	Winthrop	33
Methow River	2012	636284	Methow	Homed	70
Methow River	2013	55718	Methow	Winthrop	3
Methow River	2013	55720	Methow	Winthrop	6
Twisp River	2011	636179	Twisp	Homed	5
Twisp River	2012	636284	Methow	Within-Basin	2
Twisp River	2012	636464	Twisp	Homed	19
Twisp River	2013	636613	Twisp	Homed	7
Winthrop Hatchery outfall	2011	54789	Methow	Winthrop	4
Winthrop Hatchery outfall	2012	55653	Methow	Winthrop	4
Winthrop Hatchery outfall	2012	55654	Methow	Winthrop	4
Winthrop Hatchery outfall	2012	55659	Methow	Winthrop	28
Winthrop Hatchery outfall	2013	55720	Methow	Winthrop	4

Appendix H. Methow River subbasin spring Chinook salmon redd counts by section and survey year. Ns = not surveyed.

Section description	Reach code	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ballard C.G. - Lost River	M15	0	0	0	6	4	1	0	8	3	1	4	5	1	2
Lost River - Gate Creek	M14	4	9	7	17	12	17	11	32	23	20	31	27	6	16
Gate Creek - Early Winters Creek	M13	0	14	0	5	3	13	1	34	9	13	15	25	2	5
Early Winters Creek - Mazama Bridge	M12	6	9	10	20	13	9	10	14	15	6	10	12	13	5
Mazama Bridge - Suspension Bridge	M11	7	10	12	24	15	17	14	50	22	21	17	24	10	17
Suspension Bridge - Weeman Bridge	M10	34	51	45	36	19	31	44	63	26	24	21	62	84	25
Weeman Bridge - Along Highway 20	M9	105	104	136	173	84	94	138	332	156	161	97	200	294	75
Along Highway 20 - Wolf Creek	M8	2	3	5	9	2	4	11	8	0	7	0	5	14	2
Wolf Creek - Foghorn Dam	M7	20	16	19	59	10	13	11	67	37	48	26	66	68	16
Foghorn Dam - Winthrop Bridge	M6	19	17	18	46	12	20	12	71	54	74	26	67	19	15
Winthrop Bridge – MVID diversion	M5	5	0	7	0	Ns	2	3	9	3	2	0	1	10	1
MVID diversion – Twisp Bridge	M4	Ns	0	0	0	Ns	1	Ns	1[a]	0	1	0	1	3	0
Twisp Bridge – Upper Burma Bridge	M3,2	Ns	Ns	Ns	Ns	Ns	Ns	Ns	4[a]	Ns	Ns	Ns	Ns	Ns	Ns
Eureka Creek - Lost River Bridge	L2	1	10	12	26	11	10	9	12	11	10	24	23	29	8
Lost River Bridge - Confluence	L1	0	5	1	2	0	2	4	5	4	3	4	3	1	1
Klipchuck C,G. - Early Winters Bridge	EW5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Early Winters Bridge - Highway 20 Bridge	EW4	0	0	0	0	0	0	3	4	0	0	1	0	0	0
Highway 20 Bridge - Diversion dam	EW3	3	10	0	9	3	2	7	26	3	5	3	7	5	4
Diversion dam - Highway 20 Bridge	EW2	1	0	0	1	0	0	0	1	0	0	0	0	0	0
Highway 20 Bridge - Confluence	EW1	0	0	2	4	0	0	0	0	0	0	0	0	1	1
Various reaches of Gold Creek + Foggy	GDN4-1,FD1	Ns	Ns	0	0	1	0	0	5	1	Ns	Ns	Ns	Ns	Ns
Suspension Creek (Entire length)	Susp1	19	12	7	36	0	7	9	31	16	17	11	37	25	6
Little Suspension Creek (Entire length)	Lsusp1	Ns	Ns	Ns	Ns	Ns	Ns	Ns	0	5	2	0	7	0	0
Methow Hatchery Outfall (Entire length)	MH1	13	9	8	75	7	10	14	50	38	55	33	79	19	2
Winthrop NFH Outfall(Entire length)	WN1	11	8	5	21	3	25	17	55	44	33	10	81	39	29
Hancock Cr. (Kumm Rd. to Wolf Cr. Rd.)	HA2	Ns	Ns	Ns	Ns	Ns	Ns	Ns	19	2	9	1	12	0	0
Hancock Cr. (Wolf Cr. Rd. to Confluence)	HA1	Ns	Ns	Ns	Ns	Ns	Ns	Ns	1	0	1	1	3	4	1
Wolf Creek (Rd 5505 access - footbridge)	W3,2	0	Ns	Ns	Ns	Ns	Ns	5	30	0	4	1	14	0	0
Wolf Creek (footbridge - Confluence)	W1	2	0	0	0	0	0	0	3	0	3	0	2	3	0
Upper Methow River subbasin total		252	287	294	569	199	278	323	935	472	520	336	763	654	231

[a] Data provided by BioAnalysts.

Appendix I. Chewuch River subbasin spring Chinook salmon redd counts by section and survey year. Ns = not surveyed.

Section description	Reach code	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Chewuch Falls - 30 Mile Bridge	C13	Ns	Ns	0	Ns	0	2	2	2	8	4	3	5	2	0
30 Mile Bridge - Road Side Camp	C12	0	0	3	1	5	4	10	32	35	12	20	24	12	5
Road Side Camp - Andrews Creek	C11	0	0	1	1	1	3	4	9	8	8	3	6	1	1
Andrews Creek - Lake Creek	C10	0	0	7	9	0	7	4	10	14	7	13	18	6	3
Lake Creek - Buck Creek	C9	2	0	0	0	0	1	0	0	0	1	1	2	0	0
Buck Creek - Camp 4 C.G.	C8	14	10	5	10	7	7	7	8	18	14	6	14	10	6
Camp 4 C.G. - Chewuch Campground	C7	25	2	16	32	9	16	11	24	17	22	14	17	17	9
Chewuch C.G. - Falls Creek C.G.	C6	16	19	33	54	23	21	30	37	25	42	29	51	33	14
Falls Creek C.G. - Eightmile Creek	C5	18	27	32	22	8	12	14	15	23	18	17	23	21	9
Eightmile Creek - Boulder Creek	C4	49	20	44	63	9	19	26	82	45	66	34	44	36	12
Boulder Creek - Chewuch Bridge	C3	3	0	10	5	0	0	0	5	0	0	0	0	0	2
Chewuch Bridge - WDFW Land	C2	51	29	55	51	13	21	29	52	27	41	30	31	61	22
WDFW Land - Confluence	C1	26	10	11	25	4	7	6	9	5	1	1	4	7	1
Eightmile Creek Bridge - Confluence	EM1	0	Ns	0	Ns	Ns	0	0	0	0	0	0	Ns	Ns	Ns
Black Lake - Confluence	LK2,1	0	0	Ns	Ns	Ns	Ns	Ns	1[a]	Ns	Ns	Ns	Ns	Ns	Ns
Chewuch River subbasin total		204	117	217	273	79	120	143	286	225	236	171	239	206	84

Partial survey in LK2.

Appendix J. Twisp River subbasin spring Chinook salmon redd counts by section and survey year. Ns = not surveyed.

Section description	Reach code	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Road’s End C.G. - South Creek Bridge	T10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Creek Bridge - Poplar Flats C.G.	T9	0	0	0	0	0	0	0	1	1	0	1	1	0	0
Poplar Flats C.G. - Mystery Bridge	T8	0	1	0	3	0	0	0	11	3	6	3	5	5	0
Mystery Bridge - War Creek Bridge	T7	1	24	5	19	7	18	5	21	7	19	20	25	17	15
War Creek Bridge - Buttermilk Bridge	T6	8	62	24	39	14	24	11	54	40	74	46	66	56	14
Buttermilk Bridge - Little Bridge Cr.	T5	7	26	10	15	9	26	3	35	8	24	7	27	30	14
Little Bridge Creek - Twisp Weir	T4	1	9	3	3	0	7	3	9	0	6	2	3	4	0
Twisp Weir - Upper Poorman Bridge	T3	1	5	8	2	0	2	1	9	1	4	4	7	5	3
Up. Poorman Br. - Lower Poorman Br.	T2	0	8	4	2	0	2	1	5	3	3	0	3	2	0
Lower Poorman Bridge - Confluence	T1	0	4	1	4	0	0	0	0	0	3	2	1	0	0
Twisp River subbasin total		18	139	55	87	30	79	24	145	63	139	85	138	119	46

Appendix K. HOR and NOR spawner composition in the Chewuch subbasin by release group (Methow Hatchery, Winthrop Hatchery, etc.) and total age. All out-of-basin strays are grouped. Adult spawner PNOB and PNI account for genetic crosses of parent broods; all broods from Winthrop NFH and out-of-basin hatcheries are assumed to have PNOB values of zero.

Year	HOR spawners (proportion)															HOR Total	NOR spawners (proportion)			NOR Total	Adult spawner PNOB	PNI
	MC-Che			MC-Met			Twisp			Winthrop NFH			Out-of-basin									
	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5		3	4	5			
2003	0.069	0.000	0.878	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.007	0.000	465	0.167	0.083	0.750	25	0.568	0.374
2004	0.063	0.870	0.015	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.000	0.000	0.000	0.000	289	0.000	1.000	0.000	46	0.039	0.043
2005	0.007	0.749	0.071	0.014	0.050	0.000	0.000	0.007	0.000	0.000	0.035	0.000	0.053	0.014	0.000	289	0.010	0.933	0.057	219	0.339	0.373
2006	0.000	0.510	0.096	0.000	0.067	0.000	0.000	0.025	0.000	0.013	0.088	0.017	0.109	0.071	0.004	378	0.000	0.648	0.352	135	0.040	0.052
2007	0.063	0.056	0.273	0.091	0.000	0.000	0.000	0.000	0.000	0.098	0.000	0.042	0.091	0.286	0.000	203	0.059	0.176	0.765	74	0.002	0.003
2008	0.014	0.438	0.014	0.014	0.062	0.000	0.000	0.000	0.000	0.090	0.146	0.042	0.000	0.062	0.118	166	0.051	0.590	0.359	86	0.003	0.005
2009	0.258	0.247	0.009	0.150	0.015	0.000	0.026	0.000	0.000	0.176	0.075	0.018	0.026	0.000	0.000	500	0.065	0.919	0.016	271	0.017	0.025
2010	0.006	0.612	0.000	0.006	0.099	0.000	0.000	0.006	0.000	0.000	0.233	0.000	0.000	0.038	0.000	341	0.045	0.910	0.045	155	0.026	0.036
2011	0.134	0.437	0.042	0.049	0.014	0.000	0.000	0.000	0.000	0.021	0.076	0.023	0.070	0.134	0.000	499	0.052	0.390	0.558	370	0.102	0.151
2012	0.009	0.670	0.118	0.009	0.041	0.000	0.009	0.027	0.000	0.000	0.036	0.000	0.000	0.081	0.000	243	0.036	0.696	0.268	94	0.205	0.221
2013	0.020	0.702	0.096	0.041	0.041	0.000	0.020	0.020	0.000	0.030	0.020	0.000	0.000	0.010	0.000	226	0.024	0.833	0.143	89	0.369	0.339
2014	0.046	0.472	0.000	0.056	0.253	0.000	0.000	0.000	0.028	0.019	0.126	0.000	0.000	0.000	0.000	267	0.059	0.912	0.029	166	0.428	0.410
2015	0.000	0.620	0.007	0.000	0.092	0.028	0.000	0.000	0.007	0.000	0.092	0.000	0.140	0.014	0.000	152	0.000	0.859	0.141	134	0.251	0.321
2016	0.000	0.000	0.250	0.000	0.083	0.000	0.000	0.083	0.000	0.042	0.375	0.000	0.000	0.167	0.000	61	0.000	0.800	0.200	101	0.174	0.316

Appendix L. HOR and NOR spawner composition in the Methow subbasin by release group (Methow Hatchery, Winthrop Hatchery, etc.) and total age. All out-of-basin strays are grouped. Adult spawner PNOB and PNI account for genetic crosses of parent broods; all broods from Winthrop NFH and out-of-basin hatcheries are assumed to have PNOB values of zero.

Year	HOR spawners (proportion)															HOR Total	NOR spawners (proportion)			NOR Total	Adult spawner PNOB	PNI
	MC-Che			MC-Met			Twisp			Winthrop NFH			Out-of-basin									
	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5		3	4	5			
2003	0.000	0.000	0.000	0.008	0.060	0.541	0.004	0.042	0.004	0.004	0.010	0.319	0.000	0.008	0.000	597	0.600	0.200	0.200	8	0.393	0.285
2004	0.056	0.000	0.000	0.059	0.544	0.011	0.000	0.065	0.000	0.056	0.203	0.006	0.000	0.000	0.000	622	0.015	0.985	0.000	199	0.061	0.074
2005	0.025	0.474	0.000	0.025	0.225	0.019	0.019	0.006	0.000	0.027	0.139	0.012	0.000	0.019	0.010	526	0.000	0.824	0.176	221	0.296	0.296
2006	0.000	0.290	0.004	0.000	0.321	0.013	0.003	0.058	0.000	0.007	0.274	0.012	0.000	0.013	0.005	942	0.000	0.730	0.270	128	0.009	0.010
2007	0.067	0.040	0.076	0.040	0.011	0.022	0.058	0.033	0.009	0.200	0.204	0.100	0.000	0.140	0.000	545	0.080	0.360	0.560	152	0.058	0.069
2008	0.087	0.092	0.009	0.061	0.164	0.000	0.000	0.004	0.000	0.109	0.433	0.000	0.000	0.041	0.000	412	0.060	0.800	0.140	172	0.006	0.008
2009	0.060	0.073	0.002	0.248	0.086	0.001	0.022	0.006	0.002	0.273	0.160	0.024	0.009	0.034	0.000	1,480	0.097	0.790	0.113	261	0.017	0.019
2010	0.018	0.120	0.002	0.019	0.439	0.000	0.001	0.010	0.000	0.009	0.374	0.000	0.000	0.006	0.002	1,331	0.024	0.968	0.008	290	0.024	0.028
2011	0.130	0.204	0.007	0.123	0.122	0.017	0.041	0.004	0.002	0.080	0.170	0.038	0.006	0.056	0.000	1,391	0.030	0.536	0.434	432	0.112	0.128
2012	0.012	0.297	0.014	0.054	0.403	0.011	0.005	0.089	0.000	0.006	0.077	0.006	0.000	0.015	0.011	641	0.000	0.703	0.297	103	0.220	0.203
2013	0.052	0.211	0.011	0.125	0.392	0.007	0.078	0.029	0.007	0.043	0.016	0.015	0.007	0.007	0.000	505	0.114	0.743	0.143	113	0.399	0.328
2014	0.012	0.073	0.005	0.097	0.550	0.002	0.005	0.018	0.000	0.040	0.185	0.002	0.000	0.011	0.000	1,131	0.029	0.905	0.067	250	0.377	0.315
2015	0.000	0.165	0.000	0.008	0.480	0.041	0.003	0.000	0.000	0.011	0.256	0.025	0.008	0.003	0.000	749	0.089	0.767	0.144	154	0.235	0.221
2016	0.000	0.000	0.023	0.000	0.368	0.046	0.000	0.000	0.000	0.046	0.460	0.046	0.000	0.011	0.000	287	0.019	0.906	0.075	159	0.206	0.243

Appendix M. HOR and NOR spawner composition in the Twisp subbasin by release group (Methow Hatchery, Winthrop Hatchery, etc.) and total age. All out-of-basin strays are grouped. Adult spawner PNOB and PNI account for genetic crosses of parent broods; all broods from Winthrop NFH and out-of-basin hatcheries are assumed to have PNOB values of zero.

Year	HOR spawners (proportion)															HOR Total	NOR spawners (proportion)			NOR Total	Adult spawner PNOB	PNI
	MC-Che			MC-Met			Twisp			Winthrop NFH			Out-of-basin									
	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5		3	4	5			
2003	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.667	0.000	0.000	0.000	0.000	0.000	0.000	0.000	18	0.333	0.167	0.500	25	0.374	0.472
2004	0.000	0.045	0.000	0.000	0.000	0.000	0.045	0.708	0.000	0.000	0.045	0.000	0.045	0.112	0.000	98	0.098	0.902	0.000	243	0.112	0.280
2005	0.000	0.136	0.000	0.000	0.000	0.000	0.000	0.864	0.000	0.000	0.000	0.000	0.000	0.000	0.000	34	0.000	0.828	0.172	87	0.547	0.660
2006	0.000	0.000	0.000	0.000	0.048	0.000	0.000	0.936	0.000	0.000	0.016	0.000	0.000	0.000	0.000	100	0.000	0.692	0.308	65	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.304	0.566	0.130	0.000	0.000	0.000	0.000	0.000	0.000	65	0.167	0.000	0.833	40	0.509	0.451
2008	0.018	0.018	0.000	0.000	0.000	0.000	0.064	0.827	0.018	0.000	0.000	0.000	0.018	0.037	0.000	126	0.105	0.895	0.000	40	0.589	0.437
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.619	0.165	0.114	0.051	0.000	0.000	0.051	0.000	0.000	97	0.250	0.500	0.250	32	0.163	0.178
2010	0.000	0.045	0.000	0.000	0.090	0.000	0.000	0.820	0.045	0.000	0.000	0.000	0.000	0.000	0.000	96	0.024	0.952	0.024	156	0.029	0.070
2011	0.047	0.000	0.000	0.000	0.000	0.000	0.236	0.095	0.000	0.000	0.000	0.000	0.575	0.047	0.000	85	0.036	0.607	0.357	159	0.070	0.167
2012	0.000	0.036	0.000	0.000	0.015	0.000	0.029	0.890	0.000	0.000	0.015	0.000	0.000	0.015	0.000	135	0.083	0.792	0.125	64	0.214	0.239
2013	0.000	0.031	0.000	0.000	0.061	0.000	0.346	0.500	0.031	0.000	0.000	0.000	0.031	0.000	0.000	117	0.438	0.500	0.063	39	0.534	0.416
2014	0.000	0.030	0.000	0.016	0.045	0.000	0.061	0.818	0.015	0.000	0.015	0.000	0.000	0.000	0.000	157	0.100	0.875	0.025	92	0.621	0.496
2015	0.000	0.041	0.000	0.000	0.184	0.000	0.000	0.653	0.061	0.000	0.061	0.000	0.000	0.000	0.000	54	0.015	0.809	0.176	110	0.633	0.658
2016	0.000	0.000	0.000	0.000	0.067	0.000	0.200	0.533	0.133	0.067	0.000	0.000	0.000	0.000	0.000	29	0.143	0.714	0.143	60	0.527	0.618

Attachment D. Summary of summer steelhead spawning ground surveys and escapement estimates conducted in the Methow River basin in 2016.

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
METHOW FIELD OFFICE
20268 HWY 20, Twisp WA, 98856
Voice (509) 997-0066 FAX (509) 997-0072

From: Charles Frady

To: Charlie Snow

Date: 25 April 2017

Subject: Results of 2016 brood steelhead spawning ground surveys and escapement estimates in the Methow River Basin.

Summer steelhead are propagated at Wells Hatchery and used to supplement the natural spawning populations in the Methow and Okanogan rivers. Hatchery origin adults (HORs) from conservation programs should have migration timing, spawn timing, and redd distribution similar to those of natural origin adults (NORs). Deviations from these life-history traits may have deleterious effects on the overall reproductive success of supplemented populations. The number of spawners, derived from a combination of redd counts, surveyor efficiency modeling, and PIT tag array expansions, provides critical information not only for survival and spawner-recruit analyses, but also for assessing freshwater smolt production. Knowledge of both the productivity of the population (i.e., recruits per spawner), as related to the total abundance of spawners, and the proportion of HOR fish on the spawning grounds should provide valuable insight on the factors limiting the number of NOR adults. In addition to spawner abundance, the proportion of stray HOR fish on the spawning grounds may also assist in understanding the productivity of the population (i.e., stray fish may be maladapted to the Methow Basin). Steelhead spawning ground surveys, hatchery broodstock trapping, creel surveys, and PIT tag arrays were used to evaluate spawn timing, distribution, and tributary-specific escapement levels within the Methow River basin. While steelhead from Wells Hatchery were released in both the Methow and Okanogan populations, this report focuses on the Methow population. Monitoring and evaluation activities are conducted in the Okanogan Basin by the Colville Confederated Tribes (CCT) and those activities are reported separately (Miller et al. 2017) unless specifically relevant to Methow Basin activities.

Methods

Run Composition

Broodstock were collected at Wells Dam from a composite of both the Methow and Okanogan populations. Adult fish were trapped a maximum of three days per week and were retained for broodstock as necessary to achieve collection goals for HOR and NOR fish (Tonseth 2016). All trapped steelhead were sampled for hatchery marks, and scale samples were collected from all fish to determine age and origin (i.e., HOR or NOR). In 2016, trapping was conducted on both Wells Dam fish ladders.

PIT tag records were reviewed to determine if fish migrated through fish ladders more than once; these events cause overestimation of the total count at Wells Dam. Dam fallback and double counting of fish at Wells Dam were estimated using data from PIT tag detections at Columbia River hydroelectric facilities or within tributaries. The total number of double counted HOR and NOR fish was expanded to the run-at-large HOR and NOR totals. Fish that were detected at dams or within tributaries downstream of Wells Dam after their last detection at Wells Dam, before or during the presumed spawning period were considered fallbacks; fish were not considered fallbacks if downstream detection (e.g., Rocky Reach juvenile bypass [RRJ]) was consistent with likely kelt migration timing. Total fallback was calculated by expanding the estimated fallback proportion of HOR and NOR fish to the run-at-large HOR and NOR totals at Wells Dam.

Steelhead passing Wells Dam were subjected to local selective fisheries, and creel surveys were used to estimate the number of steelhead removed from the Methow, Columbia, Okanogan, and Similkameen river basins (Maitland et al. 2016). Estimates of tribal fisheries conducted by the CCT at Chief Joseph Dam, the mouth of the Okanogan River, and in the Okanogan Basin were provided by CCT staff (Mike Rayton, personal communication). Run escapement estimates were calculated for the Methow and Okanogan rivers by applying the proportion of fish that migrated to each basin based on results of local radio-telemetry studies (English et al. 2001, 2003) to the estimated number of HOR and NOR steelhead passing Wells Dam. Basin-specific fishery removal and indirect mortality (5%) estimates, along with local broodstock collections were subtracted from the estimated escapement to each basin to determine the number of steelhead available for natural spawning. No estimates were made of pre-spawn mortality or illegal removal (i.e., poaching).

Spawn Timing and Redd Distribution

An evaluation of spawn timing and redd distribution in the natural environment was conducted in the Twisp River (Goodman et al. 2017). Adult steelhead on their upstream spawning migration were trapped at the Twisp weir and sampled for hatchery marks, sex, and origin. All NOR fish were sampled, tagged and released upstream from the weir except for fish retained for broodstock. HOR fish were also sampled, tagged, and released upstream of the weir consistent with escapement goals and objectives of an on-going steelhead relative reproductive success study (RRS) in the Twisp River. These objectives targeted a spawning population upstream of the Twisp River weir comprised of equal populations of NOR and HOR fish. All excess HOR steelhead were lethally removed from the spawning population. All steelhead released upstream of the weir received uniquely colored anchor tags that represented their origin and sex (green = NOR male, pink = HOR male, blue = HOR female, red = NOR female). The assignment of colored anchor tags rotates each year to avoid any spawning success bias that could be associated with the presence of anchor tags. Visual observation of these tags was used to assess the spawn timing and location of HOR and NOR fish. Observations of anchor tagged fish on redds were used for spawn timing analyses and to determine redd distribution.

Historically, the Methow River basin was divided into four geographic subbasins; the upper Methow, lower Methow, Chewuch, and Twisp, and index areas of annual spawning activity were established within each subbasin and index areas were surveyed weekly. In 2016, a combination of methods was implemented to estimate spawning escapement and total redds. In the Twisp subbasin, comprehensive surveys served as the primary methodology to estimate total redds (Goodman et al. 2017). Escapement estimates in Methow River subbasins and lower Methow River tributaries were estimated via PIT tag detections at lower Methow River and subbasin antenna arrays (WDFW, unpublished data); redd totals were back-calculated using the run-at-large fish-per-redd value. Redd surveys were performed weekly in lower Methow River index reaches as conditions permitted; one-time redd surveys were performed around peak spawning in non-index reaches. The application of the surveyor efficiency model previously developed was not applied to redd counts in 2016 therefore redd totals in lower Methow River reaches should be considered minimum values. Both hatchery outfall channels were surveyed weekly. Winthrop NFH outfall survey data was provided by USFWS. Steelhead redds were individually flagged with date, redd number, and location recorded on each flag. Each redd was also recorded with hand-held global positioning system (GPS) devices for subsequent mapping.

Natural Replacement Rate (NRR) and Stray Rates

To estimate run escapement (parent broods) to the Methow Basin, steelhead returning to Wells Dam were apportioned to the Methow Basin based on radio-telemetry data (English et al. 2001, 2003). The NRR for each brood was calculated by adding the number of recruits (r) to Wells Dam, based on total age determined from scales, from successive return years (i) that originated from the same parent brood. The total number of recruits was divided by the number of spawners (S) for that brood year:

$$\mathrm{NRR} = (r_{i+1} + r_{i+2} + r_{i+3} + \ldots)/S$$

Estimated run escapement of parent broods (S) are apportioned to the Methow and Okanogan basins based on radio telemetry data applied to run-at-large sampling totals at Wells Dam. Fish collected for broodstock and incidental mortality as a result of the local fishery were excluded from escapement totals. Recently, PIT tags have provided the ability to estimate fallback and the total number of double counted fish at Wells Dam fish ladders.

Recently, PIT tag antenna arrays have also been deployed at or near the mouth of many spawning tributaries on the upper Columbia River. This technology allows the escapement of Wells Hatchery steelhead to tributaries downstream of Wells Dam to be estimated. Stray rates to the Wenatchee and Entiat populations can be estimated using PIT tag rates from run-at-large sampling at Priest Rapids Dam. Since all returning Wells Hatchery steelhead were from a single stock (MEOK), evaluating within-basin straying is not relevant from a genetic risk perspective. Homing fidelity was assessed via PIT tags that were inserted into a portion of the 2012 and 2013 brood fish and the release location of tagged fish was recorded during release monitoring.

None of the 2012 or 2013 brood releases from the Wenatchee Basin were given unique external marks to distinguish them from Wells Hatchery, Methow Hatchery, or WNFH releases. Only fish released from Ringold Hatchery were identified as strays. The number of stray HOR steelhead reported should be considered a minimum value. Unmarked HOR fish (identified through scale analysis) were apportioned to local or stray populations based on proportions of externally-marked fish in the weekly collections. Since stray HOR fish are largely no longer distinguishable from local HOR fish, all comparisons of HOR and NOR fish include all hatchery-origin fish.

Results

Run Composition

Stock assessment and collection of the 2016 brood Wells Hatchery steelhead broodstock occurred at Wells Dam between 3 August and 27 October 2015. During that time, a total of 8,358 steelhead passed Wells Dam. Of those fish, 442 (5.3%) were sampled to determine origin through hatchery marks and scale samples. Of the sampled fish, 211 HOR steelhead were retained for broodstock purposes. All remaining steelhead were released into the west or east ladders upstream of the traps.

After removing the Wells Hatchery broodstock, the number of fish estimated to have been double-counted at Wells Dam, and the number of fish estimated to have fallen back below Wells Dam that did not re-ascend, the net run escapement upstream of Wells Dam for the 2016 brood was 8,422 fish (Table 1). Analysis of scale samples and observations of hatchery marks indicate that NOR fish comprised 22.7% of the steelhead run to Wells Dam (77.3% HOR). Based on biological sampling of steelhead during broodstock collection, identification of hatchery marks, and coded-wire tags from fish retained for broodstock, only 3.3% of total escapement was composed of out-of-basin stray hatchery fish from the Wenatchee Basin, Ringold Hatchery, and Idaho. The abundance and relative proportion of NOR steelhead in the 2016 brood return was great enough to allow a selective sport fishery in the Methow, Okanogan, and Similkameen rivers, as well as the mainstem Columbia River. Creel censuses conducted during these fisheries estimated 1,384 adipose fin-clipped steelhead were retained (total HOR fish mortality = 1,404; Table 2; Maitland et al. 2016, with unpublished corrections). Indirect mortality of steelhead captured and released during the fisheries was assumed to be 5% and resulted in estimated mortality of 37 NOR steelhead (Table 2). Remaining steelhead were assigned to the Okanogan and Methow Basins based on results of radio-telemetry studies (see Table 1; English et al. 2001, 2003). An estimated 323 and 1,046 wild fish were available for natural spawning in the Okanogan and Methow River basins, respectively (see Table 1). Historic steelhead passage, mortality, and escapement data are presented in Appendix A.

Based on radio-telemetry data (English et al. 2001, 2003), an estimated 58.0% of the hatchery fish passing Wells Dam were destined for the Methow Basin. After broodstock and fishery removal, an estimated 2,468 HOR and 1,046 NOR steelhead were available for natural spawning in the Methow River basin (see Table 1), resulting in a basin pHOS estimate of 0.70 prior to spawning.

Table 1. Escapement and disposition of the 2016 brood summer steelhead passing Wells Dam. HOR (*N* = 211) fish removed for broodstock at Wells Dam are not included in the escapement estimate above Wells Dam. Methow and Okanogan River escapements are based on radio-telemetry data (English et al. 2001, 2003), which account for 90.4% and 91.6% of the hatchery and wild escapement, respectively. Dam count includes passage from 15 June 2015 through 14 June 2016.

Area	Description (Variable)		Number
Wells Dam	Wells Dam fish count (DCPUD raw data)	(A)	9,968
	Wells Dam HOR total (based on trapping)	(A_{HOR})	7,704
	Wells Dam NOR total (based on trapping)	(A_{NOR})	2,264
	Estimated double counted fish (HOR)	(B)	732
	Estimated fallback fish (HOR)	(C)	274
	Adjusted Wells Dam HOR total	($D = A_{HOR}$-B-C)	6,698
	Estimated double counted fish (NOR)	(E)	170
	Estimated fallback fish (NOR)	(F)	370
	Adjusted Wells Dam NOR total	($G = A_{NOR}$-E-F)	1,724
Above Wells Dam	Local HOR fish	(H)	6,478
	Stray HOR fish	(I)	220
	Hatchery fish removed in WDFW fishery	(J)	517
	HOR fish removed in CCT fisheries	(J_{CCT})	105
	Above Wells HOR run estimate	($K = (H+I)-J-J_{CCT}$)	6,076
	NOR fish	(L = G)	1,724
	NOR fish removed in WDFW fishery	(M)	9
	NOR fish removed in CCT fisheries	(M_{CCT})	69
	Above Wells NOR run estimate	($N = L-M-M_{CCT}$)	1,646
Okanogan Basin	HOR run escapement estimate	(O = K * 0.324)	1,969
	HOR fish removed in WDFW fishery	(P)	152
	HOR fish collected for broodstock	(Q)	42
	NOR run escapement estimate	(R = N * 0.208)	342
	NOR fish removed in WDFW fishery	(S)	3
	NOR fish collected for broodstock	(T)	16
	Maximum spawning escapement estimate	(O-P-Q+R-S-T)	2,098
Methow Basin	HOR run escapement estimate	(U = K * 0.580)	3,524
	HOR fish removed in WDFW fishery	(V)	736
	HOR fish collected for broodstock	(W)	110
	HOR fish removed as excess	(Wexcess)	210
	NOR run escapement estimate	(X = N * 0.708)	1,165
	NOR fish removed in WDFW fishery	(Y)	25
	NOR fish collected for broodstock	(Z)	94
	Maximum spawning escapement estimate	(U-V-W+X-Y-Z)	3,514

Table 2. Estimated number of steelhead caught, retained, released, and mortalities from expanded creel census above Wells Dam during the 2015-2016 fishery. Similkameen and Okanogan data and creel were combined in reporting.

Origin/disposition	Columbia	Methow	Okanogan	Similkameen	Total
Est. total steelhead caught	801	1,498	241	N/A	2,540
Est. HOR steelhead retained (ad -)	512	723	150	N/A	1,384
Est. HOR steelhead released (ad -)	2	9	0	N/A	11
Est. HOR steelhead released (ad +)	100	268	32	N/A	400
Est. NOR steelhead released	187	499	59	N/A	745
Est. HOR steelhead hook mortality	5	13	2	N/A	20
Est. NOR steelhead hook mortality	9	25	3	N/A	37

Twisp River Migration Timing, Spawn Timing, and Redd / Spawner Distribution

PIT-tagged steelhead were detected between 27 February and 4 June as they ascended the Twisp River to spawn. Based on recaptures of PIT-tagged fish above the Twisp River array, detection efficiency for adult steelhead was 97.5%. Thirteen NOR steelhead were retained for broodstock. A total of 23 HOR steelhead were removed as surplus at the weir and 48 HOR steelhead were retained for broodstock. Few observations were made of anchor-tagged steelhead in 2016, so comparisons of spawn timing and spawner distributions of hatchery and wild fish were not made.

Redd surveys in the Twisp River basin were conducted from 10 March to 3 June. Redd surveys in the mainstem Methow River from the MRW array upstream of Winthrop downstream to Pateros were conducted from 4 March to 2 June. Early, prolonged high flow precluded surveyors ability to effectively document steelhead redds in 2016, so all subbasin redd totals should be considered minimum values. Based on PIT-based escapement estimates (Truscott et al. 2017), removal of fishery harvest, and comprehensive Twisp River redd counts (Goodman et al. 2017), an estimated 682 steelhead redds were created in the Methow River basin in 2016 (Tables 3-5). Historic redd counts for each of the subbasins are listed in Appendices B1-B4.

Based on biological sampling during 2016 run evaluation at Wells Dam, the age distribution of HOR steelhead was skewed towards 1-salt fish (72.6%); NOR steelhead were also skewed towards 1-salt fish (61.4%). Based on scale analysis, 29.6% (N = 42) of the steelhead sampled at the Twisp River weir were NOR (Table 6). Using expanded redd counts by tributary, and the mean fecundity from Wells Hatchery broodstock by salt age and origin, an estimated 3,504,116 were deposited in the Methow Basin (Table 7). This estimate may be biased towards hatchery (ad-clipped) fish and not representative of actual spawners since the majority of fish used to estimate mean fecundity were from Wells Hatchery broodstock.

Table 3. Twisp River mainstem and tributary census redd counts by section number and survey year. Ns = not surveyed. Data from Goodman et al. 2017.

Stream reach	Code	Length (km)	2010	2011	2012	2013	2014	2015	2016
			Twisp River mainstem						
Road's End C.G. - South Creek Bridge	T10	4.6	0	Ns	Ns	Ns	Ns	Ns	Ns
South Creek Bridge - Poplar Flats C.G.	T9	3.2	3	0	0	0	0	2	0
Poplar Flats C.G. - Mystery Bridge	T8	3.2	4	0	0	1	1	2	1
Mystery Bridge - War Creek Bridge	T7	6.9	18	8	5	8	4	9	2
War Creek Bridge - Buttermilk Bridge	T6	7.4	97	43	43	21	36	30	3
Buttermilk Bridge - Little Bridge Creek	T5	5.9	62	33	26	18	25	10	4
Little Bridge Creek - Twisp weir	T4	3.8	27	13	5	7	3	10	1
Twisp weir - Upper Poorman Bridge	T3	3.5	70	46	20	46	30	44	7
Up. Poorman Br. - Lower Poorman Br.	T2	5.0	35	30	12	23	23	18	1
Lower Poorman Bridge - Confluence	T1	2.9	13	4	11	7	12	11	2
Twisp River mainstem total		46.4	329	177	122	131	134	136	21
			Twisp River tributaries						
Little Br. Cr. (Road's End - Vetch Cr.)	LBC4	1.3	0	Ns	Ns	Ns	Ns	Ns	Ns
Little Br. Cr. (Vetch Cr. - 2nd Culvert)	LBC3	3.0	1	0	3	0	0	0	1
Little Br. Cr. (2nd Culvert - 1st Culvert)	LBC2	2.4	3	0	0	1	0	0	0
Little Br. Cr. (1st Culvert - Confluence)	LBC1	2.4	4	0	7	4	1	13	0
MSRF pond outfalls[1]	MSRF1	0.1	1	3	0	3	6	12	11
War Creek (log jam barrier - Conf.)	WR1	0.5	0	0	0	0	0	0	0
Eagle Creek (Rd 4430 - Confluence)	EA1	0.3	0	0	0	0	0	0	0
W. Fork Buttermilk Creek	BMW1	3.1	Ns	Ns	Ns	Ns	1	0	Ns
Buttermilk Cr. (Fork - Cattle Guard)	BM2	2.1	3	0	1	0	0	0	0
Buttermilk Cr. (Cattle Guard - Conf.)	BM1	2.0	1	0	0	0	2	0	0
South Creek (Falls - Confluence)	SO1	0.6	0	Ns	Ns	Ns	0	0	Ns
Twisp River tributary total		14.7	13	3	11	8	10	25	12

[1] Methow Salmon Recovery Foundation pond outfall.

Table 4. Lower Methow River redd counts and estimated escapement by reach(es). Redd totals in Methow River mainstem reaches (MRW8-1) are direct counts only; escapement for this area is derived from PIT-based escapement estimates (Truscott et al. 2017) using 1.92 fish per redd. Ns = not surveyed.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Methow River (MRW PIT array – Red Barn)	MRW8	4	376	150
Methow River (Red Barn – Halderman Hole)	MRW7	2		
Methow River (Halderman Hole – Braids)	MRW6	3		
Methow River (Braids – Carlton Bridge)	MRW5	0		
Methow River (Carlton Bridge – WDFW Access)	MRW4	0		
Methow River (WDFW Access – Upper Burma Br.)	MRW3	0		
Methow River (Upper Burma Br. – Lower Burma Br.)	MRW2	2		
Methow River (Lower Burma Bridge – Pateros)	MRW1	0		
Chewuch River (CRW PIT array to – Confluence)	CRW1	Ns	--	--
Methow Hatchery outfall	MH1	23	--	--
Winthrop NFH Outfall	WN1	100	--	--
1890's channel	18N	10	--	--
Beaver Creek (above PIT antenna)	Beaver	6	12 (0-74)	0 (0-0)
Beaver Creek (below PIT antenna)	BV1	Ns	--	--
Libby Creek (above PIT antenna)	Libby	36	17 (3-40)	52 (24-84)
Gold Creek (above PIT array)	Gold	33	24 (7-49)	39 (17-70)
Total		219	--	--

Table 5. Estimated escapement of HOR and NOR fish based on redd counts (Lower Methow) or expanded PIT tag array data (other subbasins) with 95% confidence intervals. Estimated redd totals in the Upper Methow, Chewuch, and Twisp Rivers are back-calculated from escapement totals (Truscott et al. 2017) using 1.92 fish per redd.

Location	Redds	Spawners		
		HOR	NOR	Total
Upper Methow River	93	85 (36-157)	93 (50-142)	178 (86-299)
Chewuch River	160	55 (22-95)	253 (185-330)	308 (207-425)
Twisp River	210[a]	183 (132-250)	220 (163-285)	403 (295-535)
Lower Methow River	219	--	--	--
Total	682	--	--	--

[a] Not from Table 3 redd counts.

Table 6. Summary of adult steelhead sampled at the Twisp weir in 2016, based on the first capture record of each fish (i.e., recaptured fish were excluded).

Origin	Sex	Mark	Month				Total	Released upstream
			March	April	May	June		
NOR	F	None	7	10	3	0	20	14
	M	None	10	12	0	0	22	16
	Total NOR		17	22	3	0	42	30
HOR	F	Ad-only	1	0	0	0	1	0
		HFN	0	2	0	0	2	0
		CWTO	6	33	0	0	39	12
	Total F		7	35	0	0	42	12
	M	Ad-only	0	1	0	0	1	0
		Ad+CWT	0	1	0	0	1	0
		CWTO	5	45	3	0	53	16
		LV	0	1	0	0	1	0
		None	1	0	1	0	2	1
	Total M		6	48	4	0	58	17
	Total HOR		13	83	4	0	100	29
Grand total			30	105	7	0	142	59

Table 7. Estimated 2016 steelhead redd totals from PIT-based expansions and surveyor efficiency model and estimated egg deposition in the Methow Basin. Fecundities are from Wells MEOK HOR females and Twisp/Omak NOR females and proportions are estimated from PIT-based escapement (mean; %): HOR 1-salt (4,615; 35.7), HOR 2-salt (6,063; 13.5), NOR 1-salt (4,982; 31.2), NOR 2-salt (5,941; 19.6). Twisp redd total is from Table 5.

Area	Redds	% of redds	Estimated egg deposition					
			2011	2012	2013	2014	2015	2016
U. Methow	93	13.6	2,394,516	1,548,633	1,647,444	1,086,444	1,562,172	477,834
Chewuch	160	23.5	693,972	184,224	1,211,707	1,075,896	1,189,116	822,080
Twisp	210	30.8	1,187,880	759,924	835,660	759,456	938,469	1,078,980
L. Methow	219	32.1	1,062,840	909,606	1,140,079	1,708,776	2,086,782	1,125,222
Total	682	100.0	5,339,208	3,402,387	4,834,890	4,630,572	5,776,539	3,504,116

Natural Replacement Rate (NRR)

A total of 442 steelhead were trapped and sampled at Wells Dam, of which 86 were determined to be NOR. The number of NOR fish observed during trapping was expanded to run-at-large weekly ladder counts to estimate the total number of NOR fish returning to Wells Dam after excluding fish that ascended the fish ladders multiple times (N = 2,094). Expanded return at age was based on scale analysis of NOR fish sampled during trapping, resulting in an estimated total of 1,483 NOR steelhead returning to the Methow Basin prior to broodstock collection, estimated fallback, and Columbia River fishery-related mortality (Table 8). The Methow estimate is a subtotal of total Wells returns and is apportioned based on radio-telemetry estimates (English et al. 2001, 2003). The NRR of the Methow Basin steelhead population was below replacement (i.e., < 1.0) in each of the fourteen brood years examined (Table 9). A plot of NRR verses run escapement suggests that high spawner escapement reduces overall productivity rates in the Methow Basin (Figure 1).

Table 8. NOR steelhead sampling at Wells Hatchery and expanded age composition by brood year of Methow Basin recruits (70.8% of NOR returns to Wells Dam). Brood year totals exclude the estimated number of double counted fish from 2009 through 2016.

Brood year	NOR fish (at Wells Dam)			Expanded return at age (Methow Basin)					Total
	Total	Sampled	Sample rate	1.1	1.2, 2.1	1.3, 3.1, 2.2	2.3, 3.2, 4.1	4.2	
1999	242	29	0.1198	7	55	109	0	0	171
2000	435	41	0.0943	24	166	102	16	0	308
2001	553	26	0.0470	15	302	75	0	0	392
2002	900	18	0.0200	35	212	319	71	0	637
2003	821	27	0.0329	0	0	511	70	0	581
2004	1,161	116	0.0999	14	642	159	7	0	822
2005	861	104	0.1208	10	276	324	0	0	610
2006	765	124	0.1621	6	159	332	45	0	542
2007	631	52	0.0824	0	214	204	29	0	447
2008	1,283	132	0.1029	15	679	192	22	0	908
2009	1,217	127	0.1044	72	471	283	36	0	862
2010	2,070	115	0.0556	59	762	601	44	0	1,466
2011	2,045	120	0.0587	13	642	717	76	0	1,448
2012	1,643	94	0.0572	15	471	662	15	0	1,163
2013	1,210	70	0.0579	46	337	321	153	0	857
2014	2,231	147	0.0659	12	839	668	61	0	1,580
2015	2,394	116	0.0580	35	311	1,090	242	17	1,695
2016	2,094	86	0.0499	20	850	475	138	0	1,483

Table 9. Run escapement and NRR of Methow Basin steelhead populations calculated from broodstock sampling at Wells Hatchery with corresponding HRR values from Wells Hatchery returns. Escapement values and recruits produced were derived from radio-telemetry data (English et al. 2001, 2003).

Parent brood	Methow run escapement	Brood at age					Adults produced	NRR
		1.1	1.2, 2.1	1.3, 3.1, 2.2	2.3, 3.2, 4.1	4.2		
1996	429	1999	2000	2001	2002	2003	319	0.7436
1997	1,972	2000	2001	2002	2003	2004	715	0.3626
1998	2,341	2001	2002	2003	2004	2005	745	0.3182
1999	1,636	2002	2003	2004	2005	2006	194	0.1186
2000	2,085	2003	2004	2005	2006	2007	1,011	0.4849
2001	3,758	2004	2005	2006	2007	2008	651	0.1732
2002	10,974	2005	2006	2007	2008	2009	395	0.0360
2003	5,064	2006	2007	2008	2009	2010	448	0.0885
2004	5,472	2007	2008	2009	2010	2011	1,006	0.1838
2005	4,779	2008	2009	2010	2011	2012	1,163	0.2434
2006	3,462	2009	2010	2011	2012	2013	1,565	0.4521
2007	3,748	2010	2011	2012	2013	2014	1,524	0.4045
2008	3,670	2011	2012	2013	2014	2015	883	0.2406
2009	4,475	2012	2013	2014	2015	2016	1,262	0.2820
2010	8,637	2013	2014	2015	2016	2017	2,113	0.2446

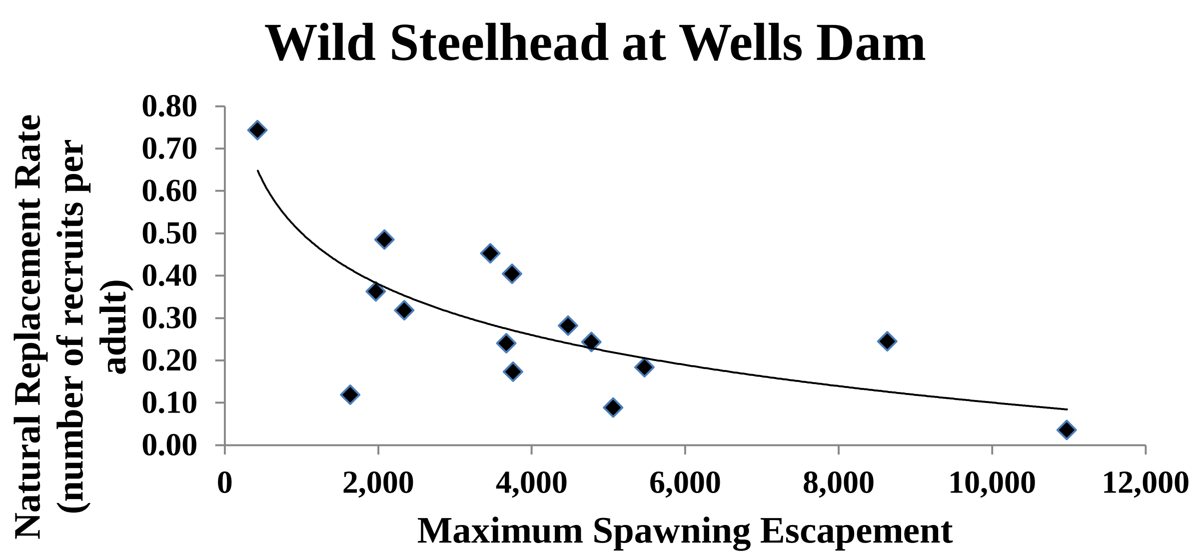

Figure 1. Methow Basin steelhead run escapement (HOR + NOR; x-axis) verses natural replacement rate (NRR; y-axis) for parent brood years 1996-2010.

Straying rates of Wells Hatchery Steelhead

Detections at PIT tag arrays were used to evaluate overall spawning escapement above the PIT tag array site and to estimate the contribution of Wells Hatchery steelhead releases to tributary-specific spawning escapement estimates. Based on completed adult return data from the 2012 brood, stray rates for Methow Basin steelhead releases averaged 9.6% across two release locations (Table 10). Though 2013 brood adult returns are incomplete, stray rates ranged from 3.3 to 11.8% for Methow Basin and Columbia releases (Table 10). One fish from the 2013 brood Columbia River release was detected in the Entiat Basin during the spring spawning period. Extrapolating the potential number of returns to the Entiat River is not feasible with one detection. Expansions with so few detections have exceedingly high uncertainty.

Table 10. Detection of adult HOR summer steelhead released from Wells Hatchery into Methow Basin tributaries. Detections of 2013 brood releases are considered incomplete because they include only 1-salt returns. Detections in the Lower Methow / Wells pool are not considered strays for any of the release groups. HOR steelhead were not released in the Chewuch River after the 2010 brood. All areas other than Wells Pool and tailrace are considered non-target locations for Columbia River (Wells Hatchery) releases.

		Recipient river, river area, or tributary								
Brood	Release river (donor pop.)	Upper Methow	Twisp	Chewuch	Lower Methow tribs	Lower Methow / Wells Pool	Foster Creek / tribs below Wells	Okanogan Basin	Total	% stray
2012	Columbia	0	0	0	0	1	0	0	1	N/A
2012	Methow	2	0	0	0	18	0	2	22	9.1
2012	Twisp	0	26	0	0	10	0	4	40	10.0
2013	Columbia	0	0	0	1	45[a]	3	2	51	11.8
2013	Methow	6	0	0	0	23	1	0	30	3.3
2013	Twisp	0	5	0	1	4	0	0	10	10.0

[a] Includes one return to Wells tailrace.

Discussion

2016 marked the second consecutive spring following major wildfires in the Methow Valley. A large portion of several tributary subbasins were burned. As a result, nearly every tributary, large or small contributed sediment to the Methow River during spring freshets. Coupled with early runoff, increased sediment and turbidity precluded effective spawner and redd surveys for nearly all of the survey period from March through May. Increased sediment transport and alterations to the timing and intensity of runoff in wildfire-burned areas may affect the timing, distribution, and success of steelhead spawning in the Methow Basin for years to come. The reliability and persistence of PIT tag arrays in the Methow Basin and the data collected through them is now critically valuable.

Historically, the population of steelhead escaping to the Methow Basin has been largely comprised of hatchery-origin fish (80-90%). Recreational fisheries can substantially reduce pHOS, but are often concluded because of take limits on incidental mortality of natural origin fish by anglers, not because few hatchery origin fish remain to be captured. In recent years, however, spawn escapement estimates derived through PIT tag detections throughout the Methow Basin indicate that pHOS goals are likely being achieved in some, often smaller, tributaries, particularly those without releases of juvenile hatchery steelhead. Between 2011 and 2015, mean pHOS was less than 0.50 in Gold Creek, Libby Creek, Beaver Creek, and the Chewuch River. During the same time period, mean pHOS in the Twisp River and Upper Methow River was 0.62 and 0.65, respectively. With the exception of Beaver Creek, pHOS was less than 0.50 in every major spawning tributary in the Methow Basin in 2016. The one area in the Methow Basin that consistently has more hatchery-origin fish in the spawning population is the Methow mainstem between Winthrop and Pateros. In the last three years, pHOS has ranged from 0.71 to 0.87. With the future possibility of hatchery-origin fish being released in the lower river, an effective and ongoing recreational fishery will be essential to achieving pHOS goals in all spawning areas of the Methow Basin.

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Appendix C. Summer steelhead run escapement, broodstock collection, fishery-related mortality, and maximum spawning escapement estimates at and above Wells Dam. Methow and Okanogan River escapements are based on radio-telemetry data (English et al. 2001, 2003), which account for 90.4% and 91.6% of the hatchery and wild escapement upstream of Wells Dam, respectively. Total count at Wells Dam includes passage from 15 June (run year) to 14 June (spawn year) for brood years 2003 to present; total Wells Dam count for previous years includes the total reported for the run year (prior to spawn). Ladder counts are based on DCPUD raw data for brood years 2000-2011; data for brood years 1999 and 2012 was based on data from FPC.org. For brood years 2007-2015, proportion of hatchery and wild fish at Wells Dam was estimated through run-at-large sampling; in previous years, proportions were calculated from broodstock trapping records. Estimated double counts and fallback were based on expanded PIT tag interrogation data. Estimated fishery mortality in the Columbia River for brood years 2003-2005 includes fishery-related mortality in the Wells Dam tailrace; all other fishery mortality in the Columbia River occurred in the section between Wells Dam and Chief Joseph Dam. Estimated fishery mortality for hatchery fish in the Methow Basin includes hatchery fish removed as excess. For brood years 2001 and 2002, WDFW fishery mortality (Columbia) was estimated from catch record cards. CCT fishery data were provided by Mike Rayton (unpublished data).

Brood year	Total count at Wells Dam based on trapping		Wells Hatchery broodstock retained		Estimated double counts at Wells Dam		Estimated fallback below Wells Dam		Estimated WDFW fishery mortality		Estimated CCT fishery mortality		Estimated run escapement (using radio-telemetry data)				Estimated fishery mortality				Local broodstock retained				Estimated maximum spawning escapement (using radio-telemetry data)			
									Columbia		Columbia		Methow		Okanogan		Methow		Okanogan		Methow		Okanogan		Methow		Okanogan	
	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W
1998	4,402	121	437	12	- -	- -	- -	- -	62	- -	- -	- -	2,264	77	1,285	23	- -	- -	- -	- -	- -	- -	- -	- -	2,264	77	1,285	23
1999	2,943	242	383	29	- -	- -	- -	- -	- -	- -	- -	- -	1,485	151	829	44	- -	- -	- -	- -	- -	- -	- -	- -	1,485	151	829	44
2000	3,448	435	334	41	- -	- -	- -	- -	- -	- -	- -	- -	1,806	279	1,009	82	- -	- -	- -	- -	- -	- -	- -	- -	1,806	279	1,009	82
2001	6,167	553	323	26	- -	- -	- -	- -	8	- -	- -	- -	3,385	373	1,893	110	- -	- -	- -	- -	- -	- -	- -	- -	3,385	373	1,893	110
2002	18,241	900	374	18	- -	- -	- -	- -	23	- -	- -	- -	10,350	624	5,789	183	- -	- -	- -	- -	- -	- -	- -	- -	10,350	624	5,789	183
2003	8,962	821	274	27	- -	- -	- -	- -	455	9	- -	- -	4,775	556	2,668	163	254	13	120	2	- -	- -	1	4	4,521	543	2,547	157
2004	9,388	1,161	325	120	- -	- -	- -	- -	298	4	- -	- -	5,084	734	2,840	216	336	10	385	1	- -	- -	11	5	4,748	724	2,444	210
2005	9,098	861	346	69	- -	- -	- -	- -	292	1	- -	- -	4,907	560	2,741	164	679	9	528	3	- -	- -	15	3	4,228	551	2,198	158
2006	6,901	765	324	91	- -	- -	- -	- -	237	1	- -	- -	3,677	476	2,054	140	683	8	492	5	- -	- -	10	3	2,994	468	1,552	132
2007	6,702	631	345	46	- -	- -	- -	- -	523	2	79	4	3,338	410	1,865	120	- -	- -	- -	- -	- -	- -	4	7	3,338	410	1,861	113
2008	7,033	1,283	289	90	- -	- -	- -	- -	872	8	106	28	3,344	819	1,868	241	470	9	288	7	14	0	5	3	2,860	810	1,575	231
2009	9,148	1,236	300	75	148	19	409	54	444	5	273	27	4,393	748	2,454	220	636	11	446	5	8	8	5	11	3,749	729	2,003	204
2010	24,091	2,120	279	88	583	50	1,207	103	1,068	17	719	48	11,736	1,284	6,556	377	4,312	48	3,110	16	12	12	4	13	7,412	1,224	3,442	348
2011	11,728	2,085	272	55	206	40	633	273	1,131	19	173	29	5,402	1,181	3,018	347	3,023	53	899	15	31	33	0	16	2,348	1,095	2,119	316
2012	11,164	1,732	259	67	495	89	628	250	551	6	180	19	5,249	921	2,932	271	1,408	20	400	5	29	46	10	5	3,812	855	2,522	261
2013	9,138	1,288	229	22	316	78	376	290	941	12	288	44	4,053	596	2,264	175	904	14	534	3	117	34	8	4	3,032	548	1,722	168
2014	5,530	2,318	209	0	118	87	292	412	389	11	82	45	2,575	1,248	1,439	367	791	43	223	8	79	92	42	16	1,694	1,113	1,174	343
2015	5,645	2,503	191	0	118	109	315	393	392	12	175	98	2,583	1,339	1,443	393	601	32	255	11	289	71	42	16	1,693	1,236	1,146	366
2016	7,915	2,264	211	0	732	170	274	370	517	9	105	69	3,524	1,165	1,969	342	736	25	152	3	320	94	42	16	2,468	1,046	1,775	323

Appendix D1. Upper Methow River subbasin steelhead redd counts by section and survey year. Ns = not surveyed.

River/section	Code	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
				Upper Methow River mainstem									
Ballard C.G. - Lost River	M15	ns	15	27	17	3	2	6	5	0	0	0	3
Lost River - Gate Creek	M14	ns		10	51	0	19	25	16	65	27	33	25
Gate Creek - Early Winters Creek	M13	ns	215[a]	23	60	15	11	19	11	65	69	9	20
Early Winters Creek - Mazama Bridge	M12	ns		0	43	3	5	25	8	27	19	15	9
Mazama Bridge - Suspension Bridge	M11	70	44[a]	12	25	9	24	27	5	27	36	10	17
Suspension Bridge - Weeman Bridge	M10	156		8	52	26	56	21	25	55	36	30	27
Weeman Bridge - Along HWY 20	M9	ns		93	180	30	14	34	94	123	91	84	65
Along HWY 20 - Wolf Creek	M8	ns	325[a]	0	9	0	1	1	0	0	3	0	0
Wolf Creek - Foghorn Dam	M7	ns		0	9	5	0	10	10	15	10	0	7
Foghorn Dam - Winthrop Bridge	M6	ns		0	34	0	0	10	2	6	3	0	5
Upper Methow River mainstem total		226	599	173	480	91	132	178	176	383	294	181	178
				Lost River									
Sunset Creek - Eureka Creek	L3	ns	ns	17	6	ns	ns	ns	ns	2	ns	ns	ns
Eureka Creek - Lost River Bridge	L2	10	25	11	7	ns	ns	ns	11	12	5	4	1
Lost River Bridge - Confluence	L1	1	0	3	7	2	10	3	6	5	3	2	2
				Early Winters Creek									
Klipchuck C,G. - Early Winters Bridge	EW5	ns	ns	0	0	ns	ns	ns	0	0	ns	ns	0
Early Winters Bridge - HWY 20 Bridge	EW4	ns	ns	0	0	ns	ns	ns	2	1	ns	0	0
HWY 20 Bridge - Diversion dam	EW3	ns	ns	23	6	ns	4	0	0	2	7	2	4
Diversion dam - HWY 20 Bridge	EW2	ns	ns	0	0	3	2	0	2	1	0	0	0
HWY 20 Bridge - Confluence	EW1	ns	ns	1	0	1	0	0	0	0	0	0	0
				Upper Methow River tributaries									
Suspension Creek (Entire length)	Susp1	ns	ns	43	37	31	49	37	32	43	26	30	29
Little Suspension Creek (Entire length)	Lsusp 1	ns	ns	ns[b]	ns[b]	ns[b]	29	4	1	11	3	2	5
Methow Hatchery Outfall (Entire length)	MH1	15	ns	18	15	14	25	9	12	6	12	7	8
Winthrop NFH Outfall (Entire length)	WN1	171	61	113	83	29	68	27	37	24	26	30	37
Hancock Cr. (Kumm Rd. to Wolf Cr. Rd.)	HA2	ns	ns	ns	ns	ns	21	9	7	12	2	9	11
Hancock Cr. (Wolf Cr. Rd. to Confluence)	HA1	ns	ns	3	0	0	2	4	1	2	4	0	1
Gate Creek (Culvert – Confluence)	GA1[c]	ns	0	0	0	0	0	0	0	1	0	ns	0
Wolf Creek (Rd 5505 access - footbridge)	W2	ns	ns	29	0	0	ns	ns	0	0	0	2	0
Wolf Creek (footbridge - Confluence)	W1	ns	ns	8	0	0	1	0	0	0	0	0	0
Little Boulder Creek (HWY 20 – Conf.)	LBO1	ns	ns	3	3	0	0	0	0	0	0	0	0
Goat Creek (FR 52 Bridge - Confluence)	GT1	ns	ns	33	4	0	0	0	0	0	1	0	0
Upper Methow River subbasin total		423	685	478	648	171	343	271	287	505	383	269	276

[a] Reaches M12-M14, M10 and M11, and M6-M9 were combined in 2003.
[b] Believed to be unsuitable habitat 2004 and 2006.
[c] Surveyed as part of M13 prior to 2010.

Appendix D2. Lower Methow River subbasin steelhead redd counts by section and survey year. Ns = not surveyed.

River/section	Code	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Lower Methow River mainstem													
Winthrop Bridge - MVID Dam	M5	ns	89[a]	14	44	15	0	0	23	24	11	11	25
MVID - Twisp Confluence	M4	ns		24	50	0	4	0	23	29	12	14	16
Twisp Confluence - Carlton	M3	ns	69	38	123	44	0	5	24	132	16	12	18
Carlton - Upper Burma Bridge	M2	ns	99	33	79	28	1	27	15	39	23	14	22
Upper Burma Bridge - Mouth	M1	ns	58	42	67	10	2	86	17	180	21	2	22
Lower Methow River mainstem total		ns	315	151	363	97	7	118	102	404	83	53	102
Beaver Creek													
Beaver Cr. (Lester Rd. Br. - Balky Hill Rd.)	BV3	ns	ns	16[b]	2	ns	9[c]	0	0	0	ns	ns	ns
Beaver Cr. (Balky Hill Rd. - Highway 20)	BV2	ns	ns		14	ns	ns	15	23	0	ns	ns	ns
Beaver Creek (Highway 20 - Confluence)	BV1	70	15	21	39	21	9	38	26	17	12	12	4
Lower Methow River tributaries													
Gold Cr. Up. N.F. (9.5 rkm – 5.8 rkm)[d]	GDN4	ns	ns	0	22	15	36	7	0	4	12	9	4
RP-Gold Cr. Mid. N.F. (5.8 rkm - N.F. Br.)	GDN3	ns	ns	0	3	2	5	1	7	8	3	0	2
RP-Gold Cr. Mid. N.F. (N.F. Br. - W. Pines)	GDN2	ns	ns	0	16	3	6	0	6	4	5	6	4
RP-Gold Cr. Low. N.F. (W. Pines - S.F. Br.)	GDN1	ns	ns	0	15	2	6	1	5	14	6	3	3
Gold Cr. S.F. (600 Rd. culvert - 4.0 rkm)	GDS4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	14	9
Gold Cr. S.F. (4.0 rkm - 1.7 rkm)	GDS3	ns	ns	0	30	10	25	0[e]	5	8	1	5	2
Gold Cr. S.F. (1.7 rkm - 0.6 rkm)	GDS2	ns	ns	0	8	3	6	9	4	13	0	2	3
Gold Cr. S.F. (0.6 rkm - Confluence)	GDS1	ns	ns	0	4	1	3	0[e]	1	1	0	1	2
RP-Gold Cr. Mainstem (S.F. Br. - 1.0 rkm)	GDM2	ns	ns	0	12	2	5	11	15	14	4	3	6
RP-Gold Cr. Mainstem (1.0 rkm – Conf.)	GDM1	ns	2	0	15	3	6	12	16	15	4	4	8
Foggy Dew Creek (1.8 rkm - Confluence)	FD1	ns	ns	0	14	10	24	2	2	6	2	5	2
Black Canyon Cr. (3.4 rkm - 1st Culvert)	BC3	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	1	1
Black Canyon Cr. (1st Culvert -1.0 rkm)	BC2	ns	ns	0	7	2	5	2	2	4	3	2	1
Black Canyon Cr. (1.0 rkm - Confluence)	BC1	ns	ns	0	6	2	5	2	0	1	2	3	1
Libby Creek (Mission Creek - Ben Creek)	LB7[f]	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0	ns
Libby Creek (Ben Creek - Hornet Draw)	LB6[f]	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	6	0
Libby Creek (Hornet Draw - 3.6 rkm)	LB5[f]	ns	ns	ns	ns	ns	ns	ns	ns	8	14	9	3
Libby Creek (3.6 rkm - 2.6 rkm)	LB4[f]	ns	ns	0	7	2	6	2	ns[f]	8	3	8	2
Libby Creek (2.6 rkm - WDFW Land)	LB3[f]	ns	ns	0	8	2	6	2	ns[f]	14	3	9	6
Libby Creek (WDFW Land)	LB2	ns	ns	0	2	1	2	1	0	7	3	0	5
Libby Creek (WDFW Land - Confluence)	LB1	ns	ns	0	7	3	6	2	5	9	10	3	21
Lower Methow River subbasin total		70	332	188	594	181	177	225	219	559	170	158	191

[a] Reaches M5 and M4 were combined in 2003.
[b] Reaches BV2 and BV3 were combined in 2004.
[c] Partial survey.
[d] Distance surveyed since 2009.
[e] No expansion due to possible unsuitable habitat.
[f] Beaver dam considered as barrier to upstream migration in 2009.

Appendix D3. Twisp River subbasin steelhead redd counts by section and survey year. Ns = not surveyed.

River/section	Code	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Twisp River mainstem														
Road's End C.G. - South Creek Bridge	T10	ns	ns	33	15	9	ns	ns[b]	ns	0	0	ns	ns	ns
South Creek Bridge - Poplar Flats C.G.	T9	ns	ns	5	9	6	4	ns[b]	ns	0	0	0	0	0
Poplar Flats C.G. - Mystery Bridge	T8	ns	ns	17	2	17	29	ns[b]	0	0	0	0	0	1
Mystery Bridge - War Creek Bridge	T7	2	ns	36	88	112	47	ns[b]	6	22	6	8	5	8
War Creek Bridge - Buttermilk Bridge	T6	40	ns	91	9	78	70	ns[b]	42	109	79	47	43	21
Buttermilk Bridge - Little Bridge Cr.	T5	47	156	322[a]	22	87	130	60	59	71	48	32	25	18
Little Bridge Creek - Twisp weir	T4	100	194		94	25	34	13	30	22	27	13	5	7
Twisp weir - Upper Poorman Bridge	T3	48	ns	88	3	32	32	5	18	47	78	48	20	46
Up. Poorman Br. - Lower Poorman Br.	T2	46	ns	14	1	29	18	ns[b]	16	47	54	34	12	24
Lower Poorman Bridge - Confluence	T1	29	ns	90	0	20	5	ns[b]	6	10	27	4	11	7
Twisp River mainstem total		312	350	696	243	415	369	78	177	328	319	186	121	132
Twisp River Tributaries														
Little Br. Cr. (Road's End – Vetch Cr.)	LBC4	ns	ns	ns	ns	ns	ns	0	ns	ns	0	ns	ns	ns
Little Br. Cr. (Vetch Cr. – 2nd Culvert)	LBC3	ns	ns	ns	ns	3	0	1	0	0	1	0[c]	3	0
Little Br. Cr. (2nd Culvert – 1st Culvert)	LBC2	ns	ns	ns	ns	4	1	0	2	1	3	0[c]	0	1
Little Br. Cr. (1st Culvert - Confluence)	LBC1	ns	ns	ns	11	20	3	2	2	17	4	0[c]	7	4
MSRF pond outfalls[1]	MSRF1	ns	ns	ns	2	11	0	1	0	0	1	3	0	3
War Creek (log jam barrier - Conf.)	WR1	ns	0	0	0	2	3	0	0	2	0	0	0	0
Eagle Creek (Rd 4430 - Confluence)	EA1	ns	ns	ns	0	2	1	0	0	2	0	0	0	0
Buttermilk Cr. (Fork - Cattle Guard)	BM2	ns	ns	ns	0	13	5	0	1	0	3	0	1	0
Buttermilk Cr. (Cattle Guard - Conf.)	BM1	ns	4	0	0	13	5	0	0	2	1	1	0	0
RP-South Creek (Falls - Confluence)	SO1	ns	ns	ns	0	1	2	0	0	0	0	0	ns	0
Twisp River subbasin total		312	354	696	256	484	389	82	182	352	332	190	132	140

[a] Reaches T4 and T5 were combined in 2003.
[b] Not surveyed due to prolonged high flow.
[c] Surveys ended early due to high flow.

Appendix D4. Chewuch River subbasin steelhead redd counts by section and survey year. Ns = not surveyed.

River/section	Code	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Chewuch River mainstem													
Chewuch Falls - 30 Mile Bridge	C13	ns	ns	0	ns	ns	ns	ns	0	0	ns	ns	0
30 Mile Bridge - Road Side Camp	C12	ns	14	3	ns	ns	ns	ns	4	19	0	ns	1
Road Side Camp - Andrews Creek	C11	ns	3	8	ns	ns	ns	ns	2	9	2	ns	0
Andrews Creek - Lake Creek	C10	ns	8	23	ns	ns	ns	ns	4	13	0	ns	7
Lake Creek - Buck Creek	C9	ns	9	0	ns	ns	ns	ns	0	ns	0	ns	1
Buck Creek - Camp 4 C.G.	C8	ns	3	3	ns	ns	ns	ns	34	60	0	9	26
Camp 4 C.G. - Chewuch Campground	C7	ns	6	10	ns	ns	16	13	9	32	18	ns	32
Chewuch C.G. - Falls Creek C.G.	C6	ns	26	3	0	ns	21	30	30	87	20	ns	46
Falls Creek C.G. - Eightmile Creek	C5	ns	44	8	0	ns	7	22	11	51	18	ns	42
Eightmile Creek - Boulder Creek	C4	105	134	5	20	2	19	55	28	34	33	16	29
Boulder Creek - Chewuch Bridge	C3	ns	0	0	ns	ns	0	4	2	0	3	ns	4
Chewuch Bridge - WDFW Land	C2	ns	35	8	ns	ns	3	37	24	15	7	7	11
WDFW Land - Confluence	C1	ns	3	3	ns	ns	0	25	7	2	2	0	2
Chewuch River mainstem total		105	285	74	20	2	66	186	155	322	103	32	201
Chewuch River tributaries													
Eightmile Creek (300m abv. div. - Bridge)	EM2	5[a]	20[a]	0	11	0	0	3	0	0	0	0	0
Eightmile Creek (Bridge - Conf.)	EM1			1	17	4	1	0	2	1	0	0	0
Cub Creek (W. Chewuch Rd. - Conf.)	CU1	ns	ns	ns	ns	ns	ns	ns	ns	1	ns	ns	2
Boulder Creek (Falls - 1st Bridge)	BD2	ns	0	0	5	6	4	0	1	0	1	0	0
Boulder Creek (1st Bridge - Conf.)	BD1	4	0	0	2	1	4	0	0	0	0	0	0
Lake Creek (Black Lk. - 1st Bridge)	LK2	ns	ns	0	0	44	51	0	13	0	6	ns	ns
Lake Creek (1st Bridge – Conf.)	LK1	1	1	0	0	4	4	0	1	0	0	0	0
Andrews Creek (L. And. Cr. – 1st Br.)	AN2	ns	ns	0	1	1	2	0	0	0	0	ns	ns
Andrews Creek (1st Bridge - Conf.)	AN1	ns	ns	0	1	1	1	0	0	0	0	ns	0
Twentymile Creek (Falls - FR 5010)	TW2	ns	ns	0[b]	1[b]	4[b]	0	0	0	0	1	ns	0
Twentymile Creek (FR 5010 - Conf.)	TW1	ns	ns				5	0	0	0	0	0	0
Chewuch River subbasin total		115	306	75	58	67	138	189	172	324	111	32	203

[a] Reaches EM2 and EM1 combined 2002 and 2003.