MONITORING AND EVALUATION OF THE WELLS HATCHERY AND METHOW HATCHERY PROGRAMS

2017 ANNUAL REPORT

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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. And 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 2007; Hillman et al. 2013, 2017). 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 reproduce at a sufficiently high rate in the natural environment. 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. 2017) 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 recipient 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 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. 2017). This report is the twelfth annual report, summarizing data collected during 2017 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 2016). Data collection in 2017 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 2017 followed the general methods described within the M&E Plans (Wells HCP HC 2007; Hillman et al. 2017) 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 2017 were described in full in annual broodstock collection protocols (Tonseth 2016, 2017). 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 4 June and 8 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 typically 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 off-station 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. Size-at-release and number at release were compared to target release values described in Murdoch et al. (2012) or Hillman et al. 2017 (Table 2.1). In-hatchery survival rates were compared with target survival rates within the Wells HCP HC (2007; Table 2.2).

Table 2.1. Draft target release values for Wells and Methow hatchery program steelhead and salmon in 2017 (Hillman et al. 2017).

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	~100,000	191	<10	75.6	5-8
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 stray rates. 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, fin-clip, or dye) 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. The Twisp surveys were comprehensive 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, 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). Twisp River escapement estimates were produced in the same way, but adjusted by the number of hatchery- and natural-origin adults removed at the Twisp River weir.

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	100,000	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., 2017). 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. Harvest or broodstock extraction by local tribal agencies was provided by personal communication upon request.

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 2017 brood Methow Hatchery spring Chinook occurred concurrently with run-at-large evaluation at Wells Dam between 10 May and 27 June, 2017. During this time, a total of 67 wild origin fish were retained for broodstock, representing 12.3% of the estimated wild fish escapement above Wells Dam during the trapping period (N = 545). 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; Attachment C). Spring Chinook trapping occurred at the Twisp River weir between 19 June and 7 July, 2017. During this time, a total of 11 wild and 4 hatchery origin fish were retained for broodstock (Table 3.1); 14 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	12	0	0	12	0	319	0	76	243	0	255
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	253	9	129	109	6	136
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
2017	64	4	0	60	0	137	35[a]	32	70	0	130
Mean	48	1	1	46	0	158	6	25	123	3	169
					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	--	--	--	--	--	--	--	--	--	--	--
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

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					
2000	6	0	0	6	0	63	2	0	61	0	67
2001	18	2	0	16	0	18	1	0	17	0	33
2002	0	0	0	0	0	15	3	1	11	0	11
2003	13	1	0	12	0	18	2	0	16	0	28
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	4	21	0	50
2011	17	2	3	12	0	6	0	2	4	0	16
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	1	0	0	1	0	20
2016	6	0	0	6	0	4	0	0	4	0	11
2017	11	0	0	11	0	4	0	1	3	0	14
Mean	14	1	0	13	0	17	1	1	15	0	29

[a] Includes facility morts at Wells Hatchery.

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	-	-	-	-	-	-	-	-	-

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											
2001	H	F	-	-	-	77	67	4	-	-	-
2001	W	F	-	-	-	-	-	-	-	-	-
2002	H	F	-	-	-	76	145	4	87	6	8
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	-	-	-	77	16	4	83	1	-
2014	W	F	-	-	-	77	53	4	89	3	5
2015	H	F	-	-	-	76	26	3	89	2	2
2015	W	F	-	-	-	77	27	4	88	11	4
Mean	H	F	66	1	-	76	74	4	85	7	5
Mean	W	F	-	-	-	76	24	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	-	-	-

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						
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	-	-	-	-	-	-	-	-	-
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	-	-	-
2015	H	M	-	-	-	76	24	6	102	1	-
2015	W	M	-	-	-	75	37	6	95	2	6
Mean	H	M	54	11	5	75	55	6	92	6	6
Mean	W	M	54	11	5	75	25	6	97	4	7
					Twisp Spring Chinook						
1998	H	F	-	-	-	77	2	2	77	4	16
1998	W	F	-	-	-	-	-	-	-	-	-
1999	H	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					
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	-	-	-	-	-	-	-	-	-
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	-
2015	H	F	-	-	-	-	-	-	96	1	-
2015	W	F	-	-	-	79	9	3	89	1	-
Mean	H	F	-	-	-	75	11	4	89	2	9
Mean	W	F	-	-	-	77	8	4	90	2	2
1998	H	M	-	-	-	80	3	1	87	1	-
1998	W	M	-	-	-	-	-	-	98	1	-

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					
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	50	4	3	-	-		-	-	-
2003	W	M	50	5	3	67	1	-	94	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	-	-	-
2015	H	M	-	-	-	-	-	-	-	-	-
2015	W	M	-	-	-	73	8	7	-	-	-
Mean	H	M	51	5	3	72	7	6	87	1	-
Mean	W	M	50	4	3	72	9	6	97	1	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 males (Table 3.3). For the 2015 brood, the sex ratio favored female fish in both the Methow Composite and Twisp programs. Of the female fish retained, fecundity of the 2015 brood was higher for natural origin fish than for hatchery origin fish in the Methow Composite program. Overall fecundities of the 2015 brood were above the value used in broodstock protocol calculations for hatchery (3,671) and natural origin (4,058) Methow Composite females. Similarly, fecundity of Twisp hatchery and natural origin females was above the value used in broodstock protocols (3,557 and 4,153, respectively).

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	41	43	4,367	0.95:1	26	68	4,606	0.38:1	0.60:1	4,525
1999	113	36	4,121	3.14:1	16	17	4,530	0.94:1	2.43:1	4,279
2000	150	104	3,759	1.44:1	2	0	-	-	1.46:1	3,759
2001	155	99	3,938	1.57:1	17	10	3,753	1.70:1	1.58:1	3,920
2002	142	134	3,866	1.06:1	0	0	-	-	1.06:1	3,866
2003	88	51	4,469	1.73:1	2	0	-	-	1.76:1	4,469
2004	117	102	3,450	1.15:1	0	1	3,565	-	1.14:1	3,451
2005	137	127	3,490	1.08:1	0	2	3,823	-	1.06:1	3,495
2006	153	152	3,447	1.01:1	5	4	3,894	1.25:1	1.01:1	3,457
2007	104	65	3,850	1.60:1	10	9	5,048	1.11:1	1.54:1	3,998
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	68	73	3,827	0.93:1	1.02:1	3,876
2011	136	144	3,773	0.94:1	54	45	4,384	1.20:1	1.01:1	3,920
2012	48	56	3,261	0.86:1	21	27	4,184	0.78:1	0.83:1	3,557
2013	26	26	3,521	1.00:1	18	22	3,657	0.82:1	0.92:1	3,585
2014	27	26	4,329	1.04:1	61	56	4,140	1.09:1	1.07:1	4,065
2015	25	28	4,003	0.89:1	39	38	4,330	1.03:1	0.97:1	4,191
Mean	96	86	3,843	1.22:1	23	25	4,102	1.03:1	1.16:1	3,895

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										
1998	4	4	4,116	1.00:1	0	0	-	-	1.00:1	4,116
1999	24	0	-	-	0	16	4,595	-	1.50:1	4,595
2000	24	39	3,820	0.62:1	2	3	5,292	0.67:1	0.62:1	3,927
2001	8	10	3,691	0.80:1	10	8	4,689	1.25:1	1.00:1	4,160
2002	9	6	4,224	1.50:1	0	0	-	-	1.50:1	4,224
2003	6	12	3,239	0.50:1	8	5	5,867	1.60:1	0.82:1	4,012
2004	8	17	3,579	0.47:1	26	21	3,811	1.24:1	0.89:1	3,704
2005	9	0	-	-	1	6	4,393	0.17:1	1.67:1	4,393
2006	6	11	3,355	0.55:1	0	0	-	-	0.55:1	3,355
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	3.00:1	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	10	7	3,466	1.43:1	1.56:1	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
2015	0	1	4,931	-	9	10	4,667	0.90:1	0.82:1	4,691
Mean	9	10	3,726	0.91:1	7	7	4,306	1.11:1	1.07:1	3,920

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 62% 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 2015) have increased the proportion of progeny with lower ELISA OD values retained at Methow Hatchery. For the 2015 brood, all Twisp females were in the below-low category, and all Methow Composite females were in the below-low category except for one hatchery female that was later culled (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 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
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

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						
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
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
2015	H	96.4	100.0	3.6	0.0	0.0	0.0	0.0	0.0	28	12
2015	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	38	38
Mean	H	62.2	69.5	26.2	22.9	4.2	3.1	7.5	4.5	85	62
Mean	W	87.4	87.5	8.6	8.9	1.0	1.0	3.1	2.6	27	27
					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	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

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											
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
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
2015	H	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0
2015	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	10	10
Mean	H	68.4	64.1	21.0	18.2	6.3	3.2	4.2	3.4	11	11
Mean	W	78.0	79.0	13.9	13.9	3.6	2.5	4.5	4.6	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 2000-2015 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), Mid-Valley Pond (Methow River; broods 2010, 2011, and 2012), or Goat Wall Pond (brood 2015). Acclimation time averaged 27 days for the Chewuch River releases (Chewuch Acclimation Pond) and 157 days for Methow Hatchery releases (on-station releases; Table 3.5). Twisp River releases (Twisp Acclimation Pond) have been acclimated for 29 days on average prior to release (Table 3.6).

For the 2015 brood, Twisp River Acclimation Pond releases achieved 135% of the release goal of 30,000 smolts specified in broodstock collection protocols (Tonseth 2015; Table 3.6). Releases into the Methow River achieved only 64% of the release goal of 133,249 smolts specified for Methow Composite stock release in the broodstock collection protocols (Table 3.5). This was primarily due to severe predation at Methow Hatchery during the 2016-17 winter. Brood year 2015 Chewuch River Acclimation Pond releases achieved 108% 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

Table 3.5. Continued.

Brood	Release date	Days acclimated	CWT code (s)	Total released
			Chewuch River spring Chinook	
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
2015	18-Apr-17	20	636903	65,621
			Methow River spring Chinook	
1993	15-Apr-95	227	635410, 635551	210,849
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
2015	19-Apr-17	140	637015, 637016	59,260

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
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
2015	18-Apr-17	22	636996	40,351

Juvenile Size and Condition at Release

Size-at-release fork length and weight targets for hatchery fish are described in Murdoch et al. (2012) and Hillman et al. (2017). Releases in 2017 into the Chewuch, Methow, and Twisp rivers all attained 97% of the target fork lengths prior to release (Table 3.7). Coefficient of variation (CV) in length for 2015 brood releases was slightly above the target value of nine for Chewuch releases (9.8), but below nine for Methow (7.8) and Twisp (8.4) releases. In addition to length and weight sampling, 300 of the Methow Composite juveniles were lethally sampled for early maturation sampling prior to release. Of these fish, 50% were males (N = 149), and 11 of those males were identified as maturing. Thus, we estimate that 7.4% of the male fish, or 3.7% of the overall population, were maturing early.

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
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	7.5	27.3	6.9	25.2	16.6	1.14
2015	131.5	12.9	9.8	29.1	10.5	36.2	15.6	1.28
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

Table 3.7. Continued.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
				Methow River spring Chinook				
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
2015	133.2	10.4	7.8	28.0	8.5	30.4	16.2	1.19
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
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
2015	131.0	11.0	8.4	27.2	7.6	27.9	16.7	1.21
Target	135.0	- -	9.0	30.2	- -	- -	15.0	1.23

Survival Estimates

In-hatchery survival of the 2015 brood Methow Composite program fish was below the target values for both ponding-to-release and unfertilized-egg-to-release metrics (Wells HCP HC 2005; Table 3.8). This was due to severe predation in Pond 13 during the 2016-17 winter. Twisp program fish from the 2015 brood exceeded target values (Wells HCP HC 2005; Table 3.8). Overall (all-year average) mean survival in most categories was above target values (Table 3.8).

Table 3.8. Survival (%) of Methow Hatchery spring Chinook 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							
				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
2015	100.0	98.4	96.1	99.8	99.4	99.1	73.7	99.9	70.6
Mean	98.4	97.8	95.0	99.1	99.2	98.9	93.9	97.5	87.3
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	78.6	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

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							
				Twisp spring Chinook					
2015	100.0	100.0	98.8	99.7	87.5	87.3	87.1	100.0	85.8
Mean	96.3	94.1	94.2	99.4	98.6	98.1	92.0	95.4	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 2017 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 1 March and 6 December 2017 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 three occasions for a total of 33 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 490 wild yearling spring Chinook emigrants between 1 March and 30 June at the Methow River trapping location, with peak capture on 9 April (N = 78). Overall mortality of wild Chinook captured totaled three of the 490 fish captured (0.61%). We PIT tagged 473 of the wild Chinook emigrants and released 471 after subtracting two mortalities. We also captured 13,322 hatchery Chinook at the Methow River trap, which included spring and summer races. Overall mortality of the hatchery Chinook captured totaled nine fish (0.07%).

We captured 172 emigrant Chinook parr between 1 October and 6 December with peak capture occurring on 25 November (*N* = 56). We DNA sampled 170 of the Chinook captured and genetic analysis indicated that 156 (91.8%) of the sampled parr were spring Chinook, and 14 (8.2%) were summer Chinook (Attachment A). We inserted PIT tags into 164 of the Chinook parr captured and no mortality or shed tags were observed.

No mark/recapture trials were conducted with Chinook smolts for the low position in the spring at the Methow trap because too few wild smolts were captured. 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 ($y = -2.57E\text{-}05x + 0.161723324$) to determine estimates for the low trapping position in 2017. For the upper trapping position, we were able to conduct one mark/recapture trial with wild Chinook, and two trials with hatchery Chinook. Adding these groups to the previous years' model resulted in a significant relationship ($P < 0.01$, $r^2 = 0.69$; Table 4) and the regression ($y = -2.16E\text{-}05x + 0.245227106$) was used for this position in 2017 to produce estimates. Using both these flow models, the estimated number of yearling spring Chinook emigrants was 20,653 (± 3,147, 95% CI). When combined with the estimate of parr that emigrated past the trap in 2016 (5,847 ± 16,007, 95% CI), we estimated that 26,500 (± 16,314, 95% CI) 2015 brood wild spring Chinook migrated from the Methow River basin between 1 October 2016 and 30 June 2017 (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.

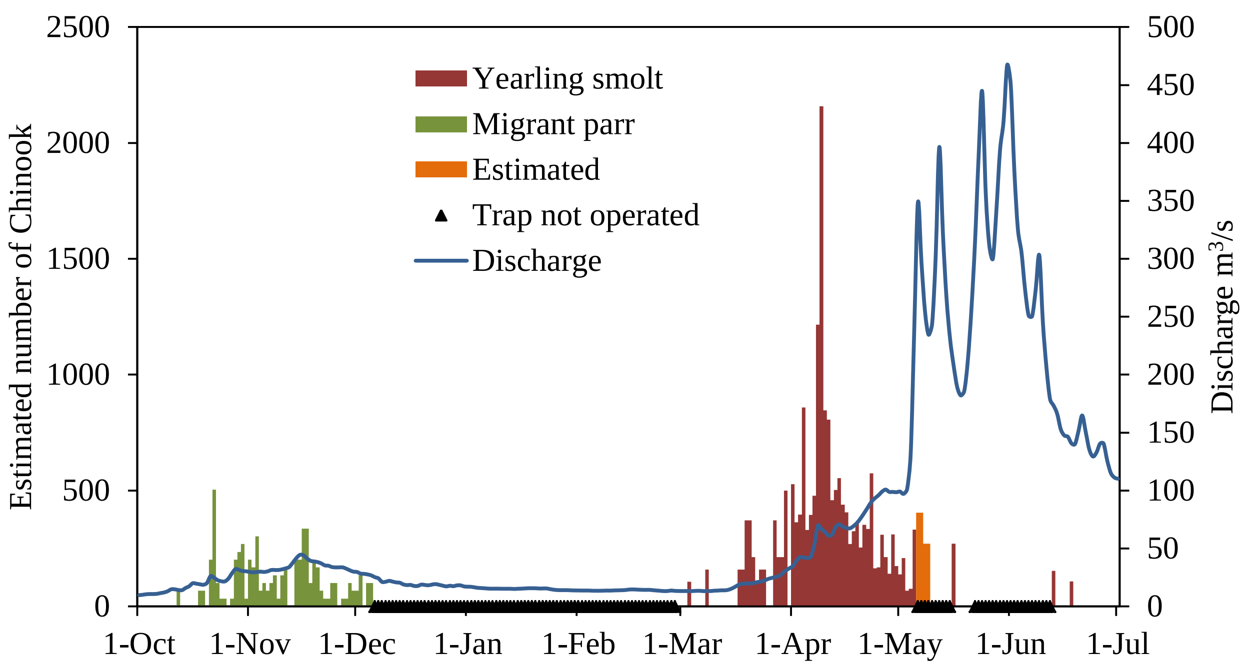

Figure 3.1. Daily emigration of 2015 brood spring Chinook from the Methow River by life stage.

Twisp Trap

Trapping at the Twisp River trap site (rkm 2) occurred between 17 March and 3 December 2017 using a rotary screw smolt trap with a 1.5 m cone diameter. Trapping at the Twisp site was interrupted on one occasion for a total of 39 days in 2017 because of high flow and debris. We captured 809 wild yearling spring Chinook emigrants at the Twisp trap between 17 March and 30 June. Peak capture occurred on 8 April (N = 71; Figure 3.2). We PIT tagged 797 wild yearling emigrants and released 793 after subtracting two mortalities and two shed tags. Overall mortality of wild yearling Chinook totaled five of the 809 fish captured (0.62%). We also captured 3,827 hatchery spring Chinook and no mortality of these fish was recorded.

We captured 1,009 subyearling spring Chinook between 17 March and 3 December at the Twisp trap with peak capture occurring on 23 November (N = 157). Although many subyearling Chinook were too small for PIT tagging, we implanted 687 PIT tags into Chinook parr and no mortalities occurred although one shed tag was detected (Attachment A). Overall, three mortalities of subyearling Chinook occurred (0.30%).

Five mark/recapture trials were conducted with Chinook smolts at the Twisp trap in the spring of 2017, two with hatchery spring Chinook, two with wild spring Chinook, and one with both hatchery and wild fish. Combining these groups with historical trials, a significant relationship existed between river discharge and trap efficiency ($P < 0.01$, $r^2 = 0.54$). Using the flow model regression parameters ($y = -0.000454006x + 0.505722751$) derived from these trials, we estimated that 8,653 (± 1,653, 95% CI) smolts emigrated from the Twisp River between 17 March and 30 June 2017. There were no spring Chinook redds identified below the Twisp trap in 2015, so no expansion for this area was necessary. An estimated 13,831 (± 3,198, 95% CI) 2015 brood spring Chinook salmon parr emigrated from the Twisp River in the fall of 2016 (Attachment A). In addition to the smolt trap estimates, mark/detection trials performed at the Twisp PIT tag array were used to estimate that 142 (± 29, 95% CI) spring Chinook emigrated between 6 December 2016 and 16 March 2017 when the smolt trap was not operating. Adding all emigrants totals, an estimated 22,626 (± 3,600, 95% CI) 2015 brood spring Chinook emigrated from the Twisp River.

Three mark/recapture trials were conducted at the Twisp trap site in the fall of 2017 but a significant model could not be developed from these release groups. We therefore used a significant efficiency discharge model from release groups conducted during previous seasons ($P < 0.01$, $r^2 = 0.57$), and the regression ($y = 0.000908708x + 0.119169681$) was used to estimate that 15,241 (± 3,758, 95% CI) 2016 brood spring Chinook salmon parr emigrated past the Twisp trap between 1 July and 3 December 2017. However, there was a very sharp increase in river discharge and debris loading on 23 November which made daytime trap operation impossible. The trap was pulled for eleven hours during the day, but the TWR PIT tag array indicated significant fish movement during this time. Mark/detection trials performed at the Twisp PIT tag array (Attachment A) were used to estimate that 5,815 (± 4,578, 95% CI) spring Chinook emigrated during the day on 23 November 2017 while the smolt trap was not operating. Summing these estimates, the total fall emigration estimate for the 2016 brood was 21,056 (± 5,923, 95% CI). No Chinook redds observed below the Twisp trap site in 2016, 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	8,653	22,626	4.3	190
Twisp	2016	46	209,262	21,056	--	21,056	--	--
Twisp	Mean 2003-2015	86	325,103	7,024	5,632	13,212	4.4	168
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

Table 3.9. Continued.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants			Egg to emigrant (%)	Emigrants per redd
				Age-0	Age-1	Total		
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	20,653	26,500	0.7	27
Methow	2016	361	1,426,641	13,227	--	13,227	--	--
Methow	Mean 2003-2015	765	2,900,219	10,410	25,376	34,299	1.2	46

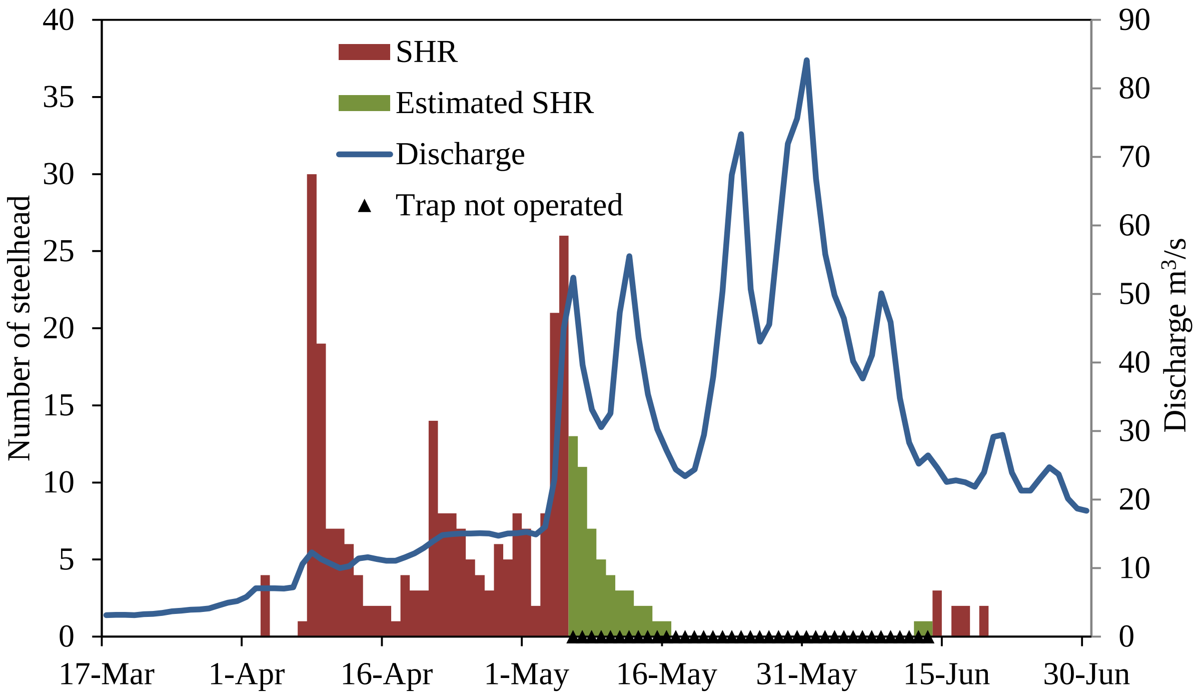

Figure 3.2. Daily emigration of 2015 brood yearling spring Chinook (YCW) from the Twisp River in 2017.

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 0.52% and 0.63%, respectively for the 2003-2012 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	0	2	0.30
2013	2015	434	0	1	--	1	0.23
2014	2016	400	0	--	--	0	0.00
2003-2012 brood mean							0.52
				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	0	2	0.23
2013	2015	441	0	1	--	1	0.23
2014	2016	478	0	--	--	0	0.00
2003-2012 brood mean							0.63

In-stream PIT Tagging

Some natural origin juvenile spring Chinook were PIT tagged in the Twisp and Methow basins in 2017 (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 2010-2016 (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 six years (2011-2016 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	19	3.7	0.21	0.08
2017	883	--	--	--	--
Mean 2010-2016		28.7	3.6	0.24	0.10
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	12	3	0.26	0.12
2017	176	--	--	--	--
Mean 2010-2016		18.6	3.3	0.19	0.09

Table 3.11. Continued.

Tag year	Parr tagged	Recovered at RRJ		CJS estimate from DART	
		Age-1 smolt	%	Probability of survival	SE
		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	9	5.1	0.3	0.13
2017	0	--	--	--	--
Mean 2011-2016		41.5	3.1	0.25	0.09

3.4 Spawning Ground Surveys

Spring Chinook spawning ground surveys were conducted in the Methow River basin between 31 July and 22 September 2017 (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 210 spring Chinook redds were constructed in the Methow Basin in 2017, lower than the overall mean number of redds found in the 2003-2016 spawning years (Table 3.12). Redd counts within individual spawning areas were lower than the overall mean totals basin wide (Table 3.12). Within the 2017 spawning year, most redds were found in the Methow River and tributaries (59.0%). The Chewuch and Twisp rivers accounted for 30.5% and 10.5% 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
2017	96	3	2	14	9	22	64	210
Mean	338	8	28	26	16	79	178	673

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* = 35; 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 T6 (50.0%) and in section C6 of the Chewuch River (23.3%). 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 2017.

Methow				Twisp				Chewuch			
Reach	Redds	Redds/ km	% within basin	Reach	Redds	Redds/ km	% within basin	Reach	Redds	Redds/ km	% within basin
M15	1	0.3	0.8	T10	0	0.0	0.0	C13	1	0.2	1.6
M14	4	0.8	3.2	T9	0	0.0	0.0	C12	0	0.0	0.0
M13	4	1.0	3.2	T8	2	0.6	9.1	C11	0	0.0	0.0
M12	1	0.3	0.8	T7	2	0.3	9.1	C10	2	0.5	3.1
M11	9	2.3	7.3	T6	11	1.5	50.0	C9	1	0.4	1.6
M10	18	3.5	14.5	T5	6	1.0	27.3	C8	6	2.5	9.4
M9	35	3.9	28.2	T4	0	0.0	0.0	C7	5	1.0	7.8
M8	3	1.4	2.4	T3	1	0.3	4.5	C6	15	2.6	23.3
M7	13	7.2	10.5	T2	0	0.0	0.0	C5	11	3.0	17.2
M6	4	1.5	3.2	T1	0	0.0	0.0	C4	12	3.2	18.8
M5,4	1	0.1	0.8					C3	0	0.0	0.0
Lost R.	9	1.4	7.3					C2	8	1.1	12.5
Early Winters Cr.	3	0.4	2.4					C1	3	0.6	4.7
Hatchery outfalls	16	20.0	12.9								
Other tributaries	3	2.0	2.4								
Total	124	1.7			46	0.5			84	1.2	

Spawn Timing

Fish were actively spawning in two of the three subbasins by the week starting on 13 August, and peak redd counts occurred earlier in the Methow subbasin than the Chewuch subbasin (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 2017.

Subbasin	Week starting date (Sunday)									Total
	30-Jul	6-Aug	13-Aug	20-Aug	27-Aug	3-Sep	10-Sep	17-Sep	24-Sep	
Chewuch	0	0	0	2	26	21	12	3	0	64
Methow	0	0	4	27	45	20	23	5	0	124
Twisp	0	0	9	0	3	9	1	0	0	22

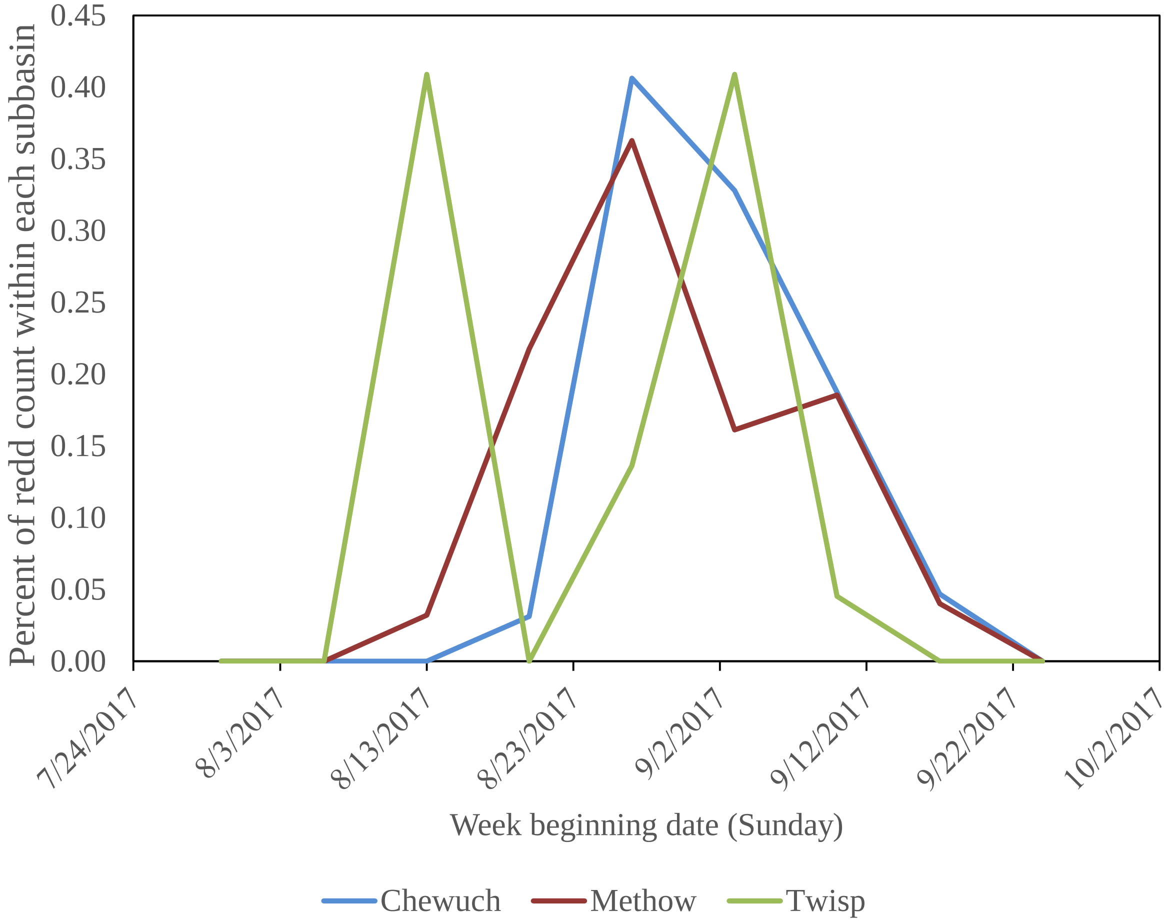

Figure 3.3. Percent of completed spring Chinook redds by subbasin and week of detection in 2017.

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 2017 FPR value (2.21), there were an estimated 464 spawners in the Methow River basin in 2017, of which 174 (37.5%) 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 46.8%, 41.1%, and 34.1% of the estimated spawning escapement in the Twisp, Chewuch, and Methow subbasins, respectively (Attachment C).

Table 3.15. Estimated spawning escapement by stream in the Methow River Basin in 2017.

Survey stream	Redds	Estimated spawning escapement		
		H	W	Total
Chewuch River	64	83	58	141
Early Winters Creek	3	7	0	7
Hancock Creek	0	0	0	0
Lost River	9	0	20	20
Methow River	93	136	71	207
MH outfall	2	4	0	4
Suspension Creek	3	4	3	7
Twisp River	22	25	22	47
WNFH outfall	14	31	0	31
Wolf Creek	0	0	0	0
Total	210	290	174	464

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 and Chewuch river subbasins were hatchery origin fish (Table 3.17). Due to very low spawning and subsequent carcass recovery in the Twisp subbasin, estimated escapement in upper reaches was based on hatchery and natural-origin proportions from 2016. Surveyors (WDFW and USFWS) sampled 30.0% of the overall Methow Basin estimated spawning population in 2017 (Attachment C).

Egg retention was estimated for 69 of the 88 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 823,356 eggs were deposited in the Methow River basin in 2017 (Table 3.18).

Table 3.17. Carcass recoveries and expanded count by tributary and reach from Methow Basin spring Chinook surveys in 2017.

Reach	Redds		Estimated	Carcasses				
	Count	Subbasin	spawning	Recoveries			Expanded count	
		Prop. (%)	escapement	H	W	Total	H	W
				Methow River mainstem				
M15	1	0.8	2	0	0	0	0[b]	2[b]
M14	4	3.2	9	0	2	3[a]	0	9
M13	4	3.2	9	0	2	2	2	9
M12	1	0.8	2	1	2	3		
M11	9	7.3	20	3	2	9[a]	12	8
M10	18	14.5	40	7	6	15[a]	22	18
M9	35	28.2	78	13	5	18	58	20
M8	3	2.4	7	2	0	2	7	0
M7	13	10.5	29	2	0	2	29	0
M6	4	3.2	9	1	1	2	5	4
M5,4	1	0.8	2	0	0	0	1[c]	1[c]
Total	93	75.0	207	29	20	56[a]	136	71
				Lost River				
L2	9	7.3	20	0	0	0	0[b]	20[b]
L1	0	0.0	0	0	0	0	0	0
Total	9	7.3	20	0	0	0	0	20
				Early Winters Creek				
EW5,4	0	0.0	0	0	0	0	0	0
EW3	3	2.4	7	1	0	1	7	0
EW2,1	0	0.0	0	0	0	0	0	0
Total	3	2.4	7	1	0	1	7	0
				Methow River tributaries				
HA2	0	0.0	0	0	0	0	0	0
HA1	0	0.0	0	0	0	0	0	0
MH1	2	1.6	4	3	0	3	4	0
Lsusp1	0	0.0	0	0	0	0	0	0
Susp1	3	2.4	7	0	0	0	4[d]	3[d]
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	14	11.3	31	2	0	2	31	0
Total	19	15.3	42	5	0	5	39	3
Grand total	124	100.0	276	35	20	62[a]	182	94

Table 3.17. Continued.

Reach	Redds Count	Redds Subbasin Prop. (%)	Estimated spawning escapement	Carcasses Recoveries H	Recoveries W	Recoveries Total	Expanded count H	Expanded count W
			Chewuch River mainstem					
C13	1	1.6	2	1	0	1	2	0
C12	0	0.0	0	0	0	0	0	0
C11	0	0.0	0	0	0	0	0	0
C10	2	3.1	4	0	1	1	0	4
C9	1	1.6	2	1	1	2	8	7
C8	6	9.4	13	1	1	2	0	12
C7	5	7.8	11	6	5	11	6	5
C6	15	23.3	33	5	6	12[a]	15	18
C5	11	17.2	24	8	5	13	15	9
C4	12	18.8	27	4	1	6[a]	19	8
C3	0	0.0	0	1	1	2		
C2	8	12.5	18	6	6	12	9	9
C1	3	4.7	7	3	0	3	7	0
Total	64	100.0	141	36	27	65[a]	81	60
			Twisp River mainstem					
T10	0	0.0	0	0	0	0	0	0
T9	0	0.0	0	0	0	0	0	0
T8	2	9.1	4	0	0	0	0	4[b]
T7	2	9.1	4	0	0	0	0	4[b]
T6	11	50.0	24	1	0	1	10	14[b]
T5	6	27.3	13	6	0	6	13	0
T4	0	0.0	0	0	0	0	0	0
T3	1	4.5	2	2	0	2	2	0
T2	0	0.0	0	0	0	0	0	0
T1	0	0.0	0	1	0	0	0	0
Total	22	100.0	47	10	0	10	25	22

[a] Includes fish of unknown origin.
[b] Estimates based on recoveries of HOR and NOR spawners in T8,7, and 6 in 2016.

Table 3.18. Estimated egg deposition for spring Chinook in the Methow Basin in 2017. 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		
						2015	2016	2017
Chewuch	34	4,018	1.6	64	30.5	819,011	351,373	253,038
Methow	30	3,991	1.3	124	59.0	2,523,595	866,006	488,451
Twisp	5	3,755	0.9	22	10.5	524,425	209,262	81,867
Total				210		3,867,031	1,426,641	823,356

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 72 – 77% for hatchery fish and 73 – 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 1998-2011 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
2011	H	0.06	0.88	0.06	3,489
2011	W	0.04	0.82	0.13	186
Mean	H	0.16	0.77	0.07	970
Mean	W	0.10	0.73	0.17	209
		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

Table 3.19. Continued.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Chewuch spring Chinook			
2003	H	0.04	0.79	0.18	56
2003	W	0.00	0.31	0.69	48
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
2011	H	0.05	0.91	0.04	627
2011	W	0.05	0.79	0.16	183
Mean	H	0.17	0.77	0.06	506
Mean	W	0.04	0.73	0.23	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

Table 3.19. Continued.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Twisp spring Chinook			
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
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
2011	H	0.24	0.66	0.10	59
2011	W	0.07	0.85	0.08	125
Mean	H	0.20	0.72	0.08	142
Mean	W	0.10	0.77	0.13	108

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

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										
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	--	--	--	--	--	--	--
2000	W	38	3	1	60	26	6	72	4	2
2001	H	39	73	3	58	81	5	70	3	5
2001	W	40	1	--	59	25	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	44	5	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
2011	H	40	58	3	60	43	4	--	--	--
2011	W	41	3	4	58	25	6	72	2	2
Mean	H	41	38	4	60	61	4	72	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

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					
1997	H	--	--	--	63	283	3	70	19	4
1997	W	--	--	--	63	33	2	77	10	4
1998	W	--	--	--	68	9	6	--	--	--
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
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
2011	H	54	1	--	61	143	3	70	4	3
2011	W	--	--	--	60	42	3	70	2	1
Mean	H	50	2	7	61	118	3	69	8	4
Mean	W	--	--	--	60	25	3	71	8	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	--	--	--

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					
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	65	4	77	11	4
1998	W	52	1	--	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
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	--
2011	H	41	11	3	59	33	5	67	1	--
2011	W	41	3	5	60	39	4	74	3	7
Mean	H	40	24	3	59	49	5	71	4	4
Mean	W	42	2	4	60	21	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	--	--	--

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					
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	61	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
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
2011	H	--	--	--	60	88	3	66	6	2
2011	W	58	1	--	60	39	3	69	6	4
Mean	H	60	1	--	60	85	3	69	7	4
Mean	W	56	1	--	60	22	3	70	7	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 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	--	--	--
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
2011	H	39	6	3	56	4	2	--	--	--

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										
2011	W	43	4	4	56	36	4	--	--	--
Mean	H	40	12	3	57	11	5	72	1	--
Mean	W	40	5	2	57	20	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
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	--

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					
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
2011	H	--	--	--	59	16	3	70	2	6
2011	W	--	--	--	61	40	3	73	4	2
Mean	H	--	--	--	60	24	3	69	2	4
Mean	W	--	--	--	61	17	4	71	4	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 for Wenatchee Basin fisheries primarily targeting Leavenworth National Fish Hatchery stocks in Icicle Creek. 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 12 exceeding 10%, while mean harvest rates have been below 9% 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 2000-2011). 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	601	738	0	0	0	0	4	68	1,411	5.1
2011	2,941	448	3	0	0	2	7	88	3,489	2.8
Mean	418	250	1	0	0	7	25	34	734	7.3
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

Table 3.21. Continued.

Brood	Hatchery	Spawning ground	Ocean fishery			Freshwater fishery			Total	Harvest %
			Comm.	Sport	Tribal	Comm.	Sport	Tribal		
Twisp spring Chinook										
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	1	3	289	1.4
2011	8	51	0	0	0	0	0	0	59	0.0
Mean	30	77	0	0	0	1	4	6	118	9.0
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	3	303	1.3
2011	380	230	0	0	1	4	1	11	627	2.7
Mean	93	262	0	0	0	4	20	16	395	8.2

Migration Timing

The 2017 spring Chinook migration to Wells Dam was monitored between 10 May and 27 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 vs. CCT-Riverside, WNFH vs. Chief Joseph Hatchery) 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 all age classes (Table 3.22), although several groups had low sample sizes. Although the recent (2010-2017) migration trend for HOR and NOR fish within years is similar, the trend was slightly different for earlier (2006-2009) broods. 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 2017. Totals do not include fish of unknown origin or age.

Age	Origin	Percentile					Mean	*N*
		10	25	50	75	90		
3	H	2-June	6-June	8-June	13-June	19-June	9-June	145
3	W	5-June	8-June	9-June	13-June	14-June	9-June	19
4	H	30-May	2-June	6-June	13-June	19-June	8-June	590
4	W	1-June	2-June	6-June	13-June	16-June	7-June	51
5	H	25-May	1-June	6-June	12-June	20-June	6-June	19
5	W	25-May	25-May	6-June	8-June	14-June	3-June	16
All	H	1-June	5-June	8-June	13-June	19-June	8-June	754
All	W	30-May	2-June	6-June	13-June	14-June	7-June	86

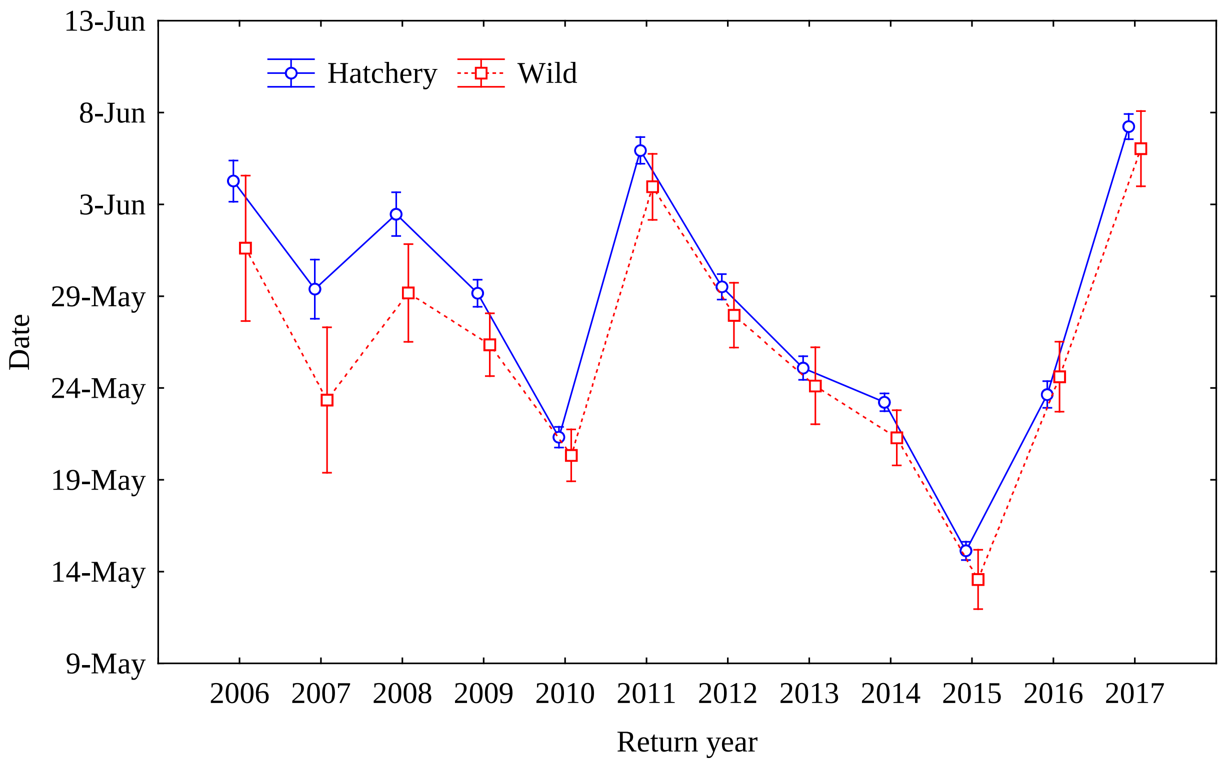

Figure 3.4. Mean (+/- 95% CI) arrival day of the year at Wells Dam of hatchery and wild spring Chinook by return year.

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%. Although no target brood year stray rates are identified, monitoring are important to determine if hatchery operations affect homing and straying of specific broods (Hillman et al. 2017). Stray rates from adult returns of Chewuch and Twisp River releases averaged over 30% for each release location overall (Table 3.23). Conversely, adult returns from Methow River (on-station) releases rarely strayed into non-target recipient populations, averaging only about 3% overall (Table 3.23). Methow Hatchery spring Chinook have constituted less than 5% of the spawning escapement by return year of other spring Chinook populations (e.g., Chiwawa and Entiat rivers), but Chewuch River releases have averaged over 10% of the spawning escapement in the Methow River (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
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	303	112	6	118	38.94
2011	627	122	2	124	19.78
Mean	395	141	6	146	32.40
		Methow River releases			
1993	191	1	0	1	0.52
1994	1	0	0	0	0.00
1995	122	0	0	0	0.00

Table 3.23. Continued.

Brood year	Total return	Recipient (stray) area			% stray
		Stream	Hatchery	Total	
		Methow River releases			
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	1,411	81	36	117	8.29
2011	3,489	39	0	39	1.12
Mean	711	23	2	23	2.81
		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
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	289	70	58	128	44.29
2011	59	6	8	14	23.73
Mean	118	24	16	41	30.86

Table 3.24. Percentage contribution from Methow Basin spring Chinook salmon releases to spawning escapements by recipient tributary and return year. Adult returns from 1998 brood Methow Composite stock releases were excluded because release site (Methow or Chewuch) could not be identified by CWT code.

Return year	Recipient tributary				
	Chiwawa R.	Entiat R.	Methow R.	Twisp R.	Chewuch R.
			Chewuch River releases		
2000	0.0	0.0	2.5	0.0	8.4
2001	0.0	0.0	7.9	1.5	33.8
2002	0.0	0.0	0.6	0.0	3.6
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	3.6	0.0	5.1
2005	0.0	0.0	32.2	2.6	41.9
2006	0.4	1.6	22.8	0.0	28.8
2007	0.0	0.0	12.3	0.0	20.0
2008	0.0	0.0	12.9	2.7	26.7
2009	0.0	0.0	10.9	0.0	30.8
2010	0.6	1.2	10.8	1.4	39.0
2011	0.0	0.0	28.1	2.5	39.2
2012	0.0	0.0	28.0	2.2	51.8
2013	0.0	0.0	20.2	1.7	51.4
2014	0.0	0.0	7.3	1.8	28.9
2015	0.0	0.0	11.3	1.0	31.1
2016	0.0	0.0	1.4	0.0	7.2
Mean %	0.1	0.2	12.5	1.0	26.3
			Methow River releases		
2000	0.0	3.4	38.0	0.0	8.4
2001	0.0	0.6	27.8	0.8	2.0
2002	0.0	0.0	4.6	0.0	0.0
2003	0.0	0.0	5.1	0.0	1.5
2004	0.0	0.0	4.5	0.0	1.1
2005	0.0	0.0	16.2	0.0	3.6
2006	0.0	0.0	25.2	2.5	3.2
2007	0.0	0.0	6.8	0.0	8.4
2008	0.0	0.0	17.7	0.0	4.5
2009	0.0	0.0	27.2	0.0	9.9
2010	0.0	1.2	34.9	0.0	6.7
2011	0.0	0.0	21.4	0.0	4.1
2012	0.0	0.0	40.2	1.1	3.2
2013	0.0	0.0	38.0	3.4	5.4
2014	0.0	0.0	48.6	3.6	17.3

Table 3.24. Continued.

Return year	Recipient tributary				
	Chiwawa R.	Entiat R.	Methow R.	Twisp R.	Chewuch R.
			Methow River releases		
2015	0.0	0.6	36.4	5.0	6.5
2016	0.0	0.0	22.3	2.7	5.7
Mean %	0.0	0.3	24.4	1.1	5.4
			Twisp River releases		
2000	0.0	0.0	2.9	72.6	0.0
2001	0.0	0.0	0.4	19.6	0.2
2002	0.0	0.0	1.1	9.1	0.0
2003	0.0	0.0	4.0	30.2	0.0
2004	0.0	0.0	4.4	19.7	0.0
2005	0.0	0.0	1.6	15.8	0.4
2006	0.0	0.0	4.6	40.0	0.9
2007	0.0	2.5	7.2	55.2	0.0
2008	0.0	0.0	0.4	60.1	0.0
2009	0.0	0.0	2.3	55.6	1.5
2010	0.0	0.0	0.8	30.1	0.4
2011	0.0	0.0	3.9	17.4	0.0
2012	0.0	0.0	8.1	62.4	2.3
2013	0.0	0.0	8.4	56.2	2.7
2014	0.0	0.0	1.9	52.1	1.5
2015	0.0	0.0	0.2	21.4	0.5
2016	0.0	0.0	0.0	34.9	2.9
Mean %	0.0	0.1	3.1	38.4	0.8

Smolt to Adult Survival and HRR

The overall smolt-to-adult return of Methow Hatchery spring Chinook stocks was calculated from expanded CWT recoveries and averaged 0.23%, 0.37%, and 0.25%, respectively for Twisp, Methow, and Chewuch river releases (Table 3.25). Smolt to adult return of 2011 brood fish was above the overall mean value for all populations in the Methow River Basin. HRR values (harvest included), calculated as the number of adult returns divided by the number of adult broodstock, were higher than average for 2011 brood Methow and Chewuch releases (Table 3.25). Only the Methow release group had an overall mean HRR value above 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	1.0	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	8.0	117	0.570	7.8
2003	33	50,627	44	0.087	1.3	44	0.087	1.3
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	0.540	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	3.0	121	0.181	3.0
2010	58	81,380	288	0.354	5.0	284	0.349	4.9
2011	23	18,190	59	0.324	2.6	59	0.324	2.6
Mean	36	52,672	118	0.226	3.3	107	0.204	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
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	2.7	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

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					
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	182	288,013	680	0.236	4.2	668	0.232	4.1
2010	217	284,389	1,411	0.496	6.5	1,339	0.471	6.2
2011	306	388,869	3,489	0.897	11.4	3,389	0.872	11.1
Mean	143	195,437	821	0.367	5.2	712	0.329	4.6
			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	95	149,863	357	0.238	3.8	338	0.226	4.0
2010	68	88,788	303	0.341	4.5	299	0.337	4.4
2011	73	93,372	627	0.672	8.6	610	0.653	8.4
Mean	111	157,187	395	0.251	3.4	355	0.228	3.1

Post-Release Travel Time and PIT-Tag Based Survival

Most hatchery spring Chinook Salmon releases by location have included some PIT-tagged fish in order to estimate survival and emigration parameters (e.g., travel time) during the juvenile out-migration and returning adult life-stages. Although data for adult survival is incomplete for the most recent three broods reported, juvenile emigration survival and travel times to Rocky Reach Dam are complete and have been similar among the release groups within years (Table 3.26). Chewuch Acclimation Pond releases have generally achieved a greater survival to Rocky Reach

Dam than releases from the other two groups within years, despite having very similar travel times (Table 3.26).

Table 3.26. Cormack/Jolly-Seber probability of survival ("Survival") and travel time estimates, including standard error (SE) from release to Rocky Reach Dam for Methow Hatchery spring Chinook releases. Estimates were derived from the web-based tool provided by Columbia Basin Research's Data Access in Real Time website (www.cbr.washington.edu/dart). Release to Bonneville Dam smolt to adult survival (SAR) was calculated as the number of observed PIT tags per release group at the Bonneville Dam fish ladders (*N*) divided by the number of PIT tagged fish released. Brood years with incomplete adult returns are denoted with an asterick.

Brood year	PIT tagged fish	Survival to Rocky Reach Dam (SE)	Travel time (d) to Rocky Reach Dam (SE)	Release to Bonneville Dam SAR (%, (*N*))
		Methow Hatchery release		
2008	10,001	0.807 (0.022)	25.4 (0.21)	1.46 (146)
2009	7,998	0.777 (0.032)	13.2 (0.19)	0.40 (32)
2010	5,993	0.895 (0.059)	15.7 (0.27)	1.05 (63)
2011	5,996	0.639 (0.037)	19.4 (0.25)	0.97 (58)
2012	6,978	0.618 (0.032)	16.3 (0.20)	0.27 (19)
2013*	4,988	0.668 (0.032)	17.3 (0.19)	0.18 (9)
2014*	4,998	0.719 (0.029)	18.3 (0.19)	0.20 (10)
2015*	4,996	0.682 (0.039)	21.6 (0.38)	0.10 (5)
Mean[1]	6,494	0.726	18.4	0.83
		Twisp River Acclimation Pond release		
2010	514	1.049 (0.268)	12.7 (1.00)	0.78 (4)
2011	4,996	0.637 (0.035)	18.3 (0.31)	0.96 (48)
2012	4,988	0.578 (0.041)	11.4 (0.12)	0.12 (6)
2013*	4,996	0.636 (0.032)	15.5 (0.21)	0.20 (10)
2014*	4,990	0.621 (0.027)	16.4 (0.25)	0.32 (16)
2015*	5,001	0.740 (0.046)	21.7 (0.40)	0.16 (8)
Mean[1]	4,248	0.710	16.0	0.62
		Chewuch Acclimation Pond release		
2011	5,000	0.672 (0.033)	19.3 (0.29)	0.92 (46)
2013*	15,077	0.655 (0.018)	21.1 (0.12)	0.27 (40)
2014*	4,984	0.732 (0.028)	18.9 (0.17)	0.18 (9)
2015*	4,991	0.783 (0.046)	21.3 (0.38)	0.14 (7)
Mean[1]	7,513	0.711	20.2	0.92

[1] Mean SAR values exclude years of incomplete adult returns (denoted by *), but juvenile metrics are complete.

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 (2011 brood) was < 1 and less than the overall median NRR values in the Chewuch and Methow subbasins (Table 3.27).

Table 3.27. The natural replacement rate (NRR) and hatchery replacement rate (HRR) 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	218	566	1.1	4.8
2007	277	8	178	36	285	1.0	8.3
2008	252	21	81	16	152	0.6	5.3
2009	771	3	89	6	107	0.1	3.8
2010	499	2	187	25	272	0.6	4.5
2011	869	10	144	29	194	0.2	8.6
Median	306	2	73	20	105	0.6	3.8
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 3.27. Continued.

Parent brood	Est. spawning escapement	Return age 1.1	Return age 1.2	Return age 1.3	Total expanded recruits (NOR)	NRR	HRR
			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	12.6
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	5.4
2002	1,730	0	96	93	209	0.1	5.2
2003	605	0	59	27	95	0.2	1.1
2004	821	13	163	35	248	0.3	3.8
2005	747	11	239	3	269	0.4	2.7
2006	1,070	33	363	199	775	0.7	9.4
2007	697	9	269	39	407	0.6	5.7
2008	584	16	85	19	155	0.3	8.8
2009	1,741	0	103	18	131	0.1	3.7
2010	1,618	13	281	29	410	0.3	6.5
2011	1,823	8	153	25	198	0.1	11.4
Median	722	5	100	31	204	0.3	3.8
			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	2.1
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	1.3
2004	341	8	48	9	76	0.2	2.5
2005	121	4	28	5	39	0.3	1.9
2006	165	19	179	61	338	2.1	8.9
2007	105	5	105	9	152	1.5	0.9
2008	166	10	63	4	99	0.6	10.4
2009	129	5	25	3	36	0.3	3.0
2010	251	17	105	20	180	0.7	5.0
2011	243	9	106	10	133	0.6	2.6
Median	147	5	51	15	94	0.5	2.1

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. For Methow Basin spring Chinook Salmon, PNI was calculated from a three-population model provided by C. Busack (NOAA Fisheries, 10 August 2015). 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 spawn years 2003-2017, mean PNI was higher in the Twisp Basin than in the Methow or Chewuch river basins (Table 3.28). 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 3.28).

Table 3.28. The proportion of natural influence (PNI) calculated for specific broods of spawning spring Chinook Salmon in the Methow River basin. The PNI was calculated using a three-population model incorporating the proportion of Methow Hatchery (PUD), Winthrop National Fish Hatchery (WNFH), and natural origin (Wild) fish on the spawning grounds.

Year	Chewuch				Methow				Twisp			
	PUD	WNFH	Wild	PNI	PUD	WNFH	Wild	PNI	PUD	WNFH	Wild	PNI
2003	0.92	0.03	0.05	0.40	0.65	0.33	0.01	0.36	0.42	0.00	0.58	0.50
2004	0.84	0.03	0.14	0.10	0.61	0.15	0.24	0.15	0.23	0.06	0.71	0.39
2005	0.54	0.03	0.43	0.43	0.60	0.10	0.30	0.37	0.28	0.00	0.72	0.68
2006	0.57	0.16	0.26	0.13	0.64	0.24	0.12	0.07	0.60	0.01	0.39	0.08
2007	0.46	0.28	0.27	0.07	0.39	0.39	0.22	0.20	0.62	0.00	0.38	0.48
2008	0.46	0.20	0.34	0.09	0.42	0.29	0.29	0.08	0.72	0.04	0.24	0.46
2009	0.52	0.12	0.35	0.10	0.49	0.36	0.15	0.09	0.68	0.08	0.25	0.23
2010	0.56	0.13	0.31	0.12	0.56	0.26	0.18	0.10	0.38	0.00	0.62	0.18
2011	0.47	0.11	0.43	0.26	0.56	0.20	0.24	0.22	0.13	0.22	0.65	0.38
2012	0.66	0.06	0.28	0.28	0.78	0.09	0.14	0.26	0.66	0.02	0.32	0.29
2013	0.69	0.03	0.28	0.38	0.76	0.06	0.18	0.37	0.73	0.02	0.25	0.44
2014	0.56	0.06	0.38	0.46	0.66	0.16	0.18	0.38	0.62	0.01	0.37	0.52
2015	0.46	0.07	0.47	0.41	0.62	0.21	0.17	0.30	0.31	0.02	0.67	0.68
2016	0.29	0.08	0.62	0.53	0.41	0.23	0.36	0.41	0.28	0.04	0.67	0.65
2017	0.46	0.11	0.43	0.23	0.44	0.22	0.34	0.39	0.43	0.11	0.47	0.50
Mean	0.56	0.10	0.34	0.26	0.57	0.22	0.21	0.25	0.47	0.04	0.49	0.43

Pecocial Maturation Rates

Yearling spring Chinook (BY 2015; *N* = 300; 149 males) were sampled prior to release on 17 April, 2017. The estimate of early maturation rate was 7.4% based on a mixture model analysis (developed by Dr. Lea Medeiros, University of Idaho; K. Phannenstein, USFWS, personal communication). The model revealed distinct separation in gondal somatic index (GSI) between maturing and non-maturing male yearling spring Chinook (Figure 3.29).

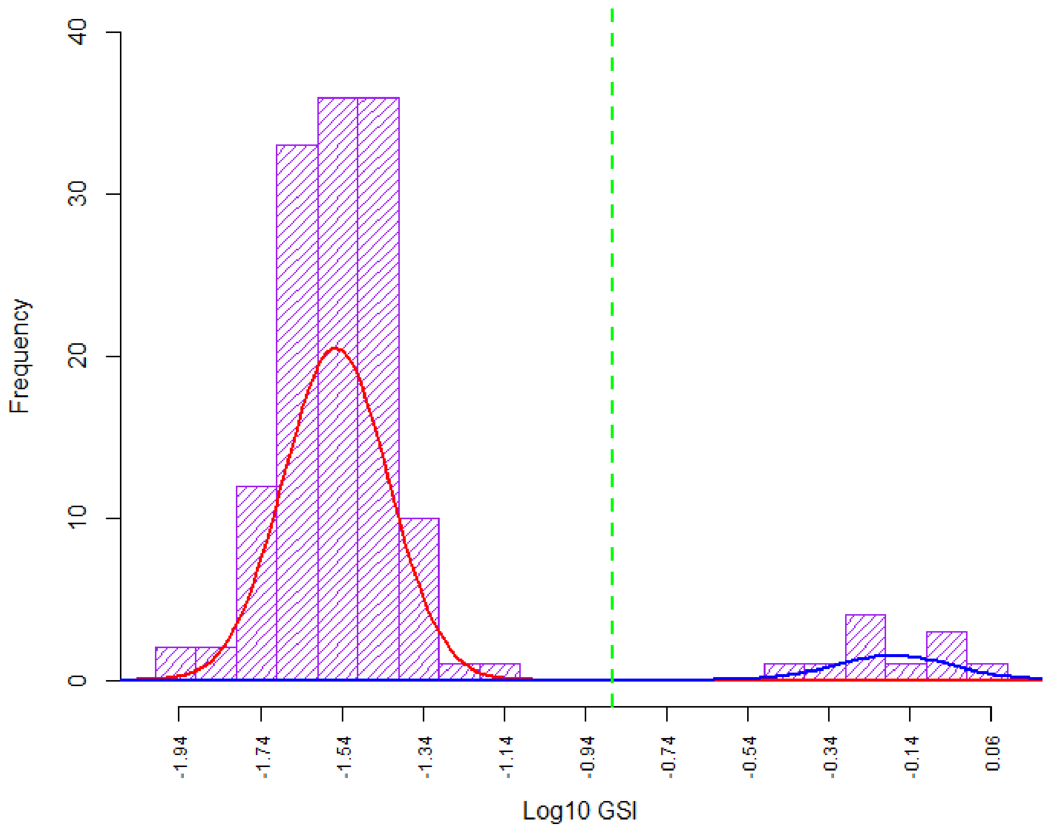

Figure 3.29. Pre-release gondal somatic index (GSI) sampling and mixture model results of the 2015 brood Methow Hatchery yearling spring Chinook.

Section 4: Wells Hatchery Summer Chinook Salmon

This section focuses on the most recent brood for which hatchery releases were completed during the report year (2015 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 are also currently used for the Yakima River reintroduction program. The relatively short rearing period for subyearling program fish negates the need to conduct ELISA survellience of adult females spawned for that program.

4.1: Broodstock Collection and Sampling

Trapping of the 2015 brood of Wells Hatchery summer Chinook Salmon occurred between 29 June and 20 July, 2015. During this time a total of 720 hatchery origin and 58 wild origin fish were collected. The overall collection represented 6% 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. Recent collections of adult fish have included surplus fish provided to local tribes (Table 4.1), but no surplus fish from the 2015 brood were collected because the adult collection and holding facility was undergoing reconstruction.

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
2015	58	1	6	51	0	720	6	38	676	0	0	727

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 2015 return year, age-4 and age-5 fish were 58.7% and 33.6% 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 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
2015	M	72	34	3	79	247	6	89	62	8	96	2	3
2015	F	73	7	2	81	173	5	88	151	5	90	14	6

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	--	--	--
2015	M	--	--	--	82	10	6	100	12	7	--	--	--
2015	F	--	--	--	84	8	4	93	26	5	--	--	--

Sex Ratio and Fecundity

The long-term mean sex ratio of fish retained for broodstock (excludes released fish) favored females (Table 4.3), although the sex ratio of the 2015 brood was very slightly skewed towards male fish overall. Of the 2015 brood female Chinook sampled, overall fecundity (3,969) was less than the long-term mean fecundity (Table 4.3). Fecundity for 2015 brood hatchery females was less than the mean fecundity value (4,183) used to estimate broodstock collection quotas in the broodstock collection protocols, but fecundity for wild females sampled was above broodstock protocol values (4,552), although relatively few wild females were retained for broodstock.

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
2015	368	352	3,912	1.05:1	23	35	4,841	0.66:1	1.01:1	3,969
Mean	457	471	4,446	0.98:1	53	51	4,470	1.30:1	0.98:1	4,469

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, and all females from the 2015 brood had OD values in the Below-low category (Table 4.4).

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 <0.099	Low 0.099 - 0.199	Med 0.20 - 0.449	High > 0.450	Total number
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
2015	100.0	0.0	0.0	0.0	133
Mean	95.7	2.9	0.5	0.9	160

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 97.6% and 95.6% 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 2015 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	0602	0.975	4-Jun-98	541,923	0611	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	0267	0.964	19-Jun-00	363,600	0468	0.98	16-Apr-01	312,098
2000	0775	1	20-Jun-01	498,500	0995	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
2015	6966	0.988	14-May-16	439,709	6964	0.985	15-Apr-17	329,809
Mean	--	0.976	--	432,592	--	0.956	--	335,903

Juvenile Size and Condition at Release

Size-at-release (FPP) targets for DCPUD program fish are described in Hillman et al. (2017). The 2015 brood yearling program fish were smaller than their target FPP goal of 10, but their fork length coefficient of variation (CV) was very close to the release goal of 7.0, indicating that length-at-release variability was low. Length-at-release of the 2015 brood subyearling program fish was also very uniform (CV = 6.7; Table 4.6). Hillman et al. (2017) identifies a weight-at-release target of 50 FPP for the subyearling program, but it is noted that release goals prioritize time-at-release (mid-May) instead of weight-at-release to improve survival.

Table 4.6. Mean fork length (mm), weight (g), coefficient of variation (CV), standard deviation (SD), fish per pound (FPP), 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
2015	152.6	10.9	7.1	37.9	7.9	20.9	12.0	1.07
Target	- -	- -	<7.0	- -	- -	- -	10.0	- -
				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

Table 4.6. Continued.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
				Wells subyearling Chinook Salmon				
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
2007	108.1	7.3	6.7	13.5	- -	- -	33.5	1.07
2008	88.5	6.8	7.6	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
2015	84.8	5.6	6.7	7.1	1.5	21.1	64.0	1.16
Target	- -	- -	<7.0	- -	- -	- -	50.0	- -

Survival Estimates

In-hatchery survival from fertilization to release of the 2015 brood fish was greater than the target value for the yearling releases but below the target value for subyearling releases (Table 4.7). Subyearling survival was primarily impacted during the eyed-egg-to-ponding category. In general, yearling program fish survival was below 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

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									
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
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
2015	98.7	99.4	90.0	96.4	100.0	99.7	97.5	--	84.6
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
2015	--	--	92.8	87.6	93.3	93.3	93.3	--	75.9
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 and yearling fish from the 2010 brood returned primarily as age-4 adults (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 1992-2010 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	0.057	0.044	0.254	0.587	0.058	0.000	1,258
1994	Subyearling	0.000	0.000	0.731	0.269	0.000	0.000	11
1994	Yearling	0.000	0.019	0.373	0.579	0.029	0.000	104
1995	Subyearling	0.014	0.102	0.675	0.208	0.000	0.000	70
1995	Yearling	0.007	0.040	0.314	0.569	0.069	0.000	651
1996	Subyearling	0.052	0.211	0.662	0.075	0.000	0.000	369
1996	Yearling	0.003	0.044	0.402	0.535	0.015	0.000	834
1997	Subyearling	0.019	0.057	0.842	0.083	0.000	0.000	106
1997	Yearling	0.006	0.019	0.476	0.480	0.018	0.001	3,533
1998	Subyearling	0.054	0.105	0.742	0.100	0.000	0.000	110
1998	Yearling	0.011	0.015	0.270	0.553	0.150	0.001	2,375
1999	Subyearling	0.005	0.115	0.390	0.445	0.045	0.000	184
1999	Yearling	0.009	0.074	0.201	0.586	0.126	0.003	599

Table 4.8. Continued.

Brood year	Release type	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Total
2000	Subyearling	0.000	0.051	0.425	0.524	0.000	0.000	99
2000	Yearling	0.000	0.002	0.232	0.586	0.176	0.003	4,233
2001	Subyearling	0.000	0.102	0.511	0.381	0.006	0.000	453
2001	Yearling	0.000	0.033	0.291	0.617	0.059	0.000	1,539
2002	Subyearling	0.000	0.092	0.816	0.092	0.000	0.000	76
2002	Yearling	0.000	0.015	0.333	0.574	0.078	0.000	2,475
2003	Subyearling	0.000	0.144	0.773	0.083	0.000	0.000	94
2003	Yearling	0.008	0.039	0.344	0.586	0.021	0.002	1,177
2004	Subyearling	0.029	0.247	0.615	0.109	0.000	0.000	529
2004	Yearling	0.007	0.077	0.599	0.305	0.012	0.000	2,548
2005	Subyearling	0.058	0.323	0.526	0.091	0.002	0.000	1,724
2005	Yearling	0.015	0.070	0.363	0.520	0.033	0.000	1,030
2006	Subyearling	0.037	0.199	0.645	0.119	0.000	0.000	366
2006	Yearling	0.003	0.045	0.547	0.395	0.009	0.000	4,969
2007	Subyearling	0.004	0.218	0.718	0.061	0.000	0.000	821
2007	Yearling	0.006	0.095	0.428	0.439	0.031	0.000	791
2008	Subyearling	0.106	0.389	0.451	0.054	0.000	0.000	366
2008	Yearling	0.003	0.098	0.439	0.448	0.011	0.000	2,634
2009	Subyearling	0.000	0.159	0.723	0.117	0.001	0.000	984
2009	Yearling	0.002	0.025	0.414	0.549	0.010	0.000	2,590
2010	Subyearling	0.012	0.311	0.631	0.046	0.000	0.000	961
2010	Yearling	0.016	0.037	0.535	0.393	0.020	0.000	1,896
Mean	Subyearling	0.022	0.159	0.627	0.189	0.003	0.000	408
Mean	Yearling	0.008	0.043	0.378	0.519	0.051	0.001	1,876

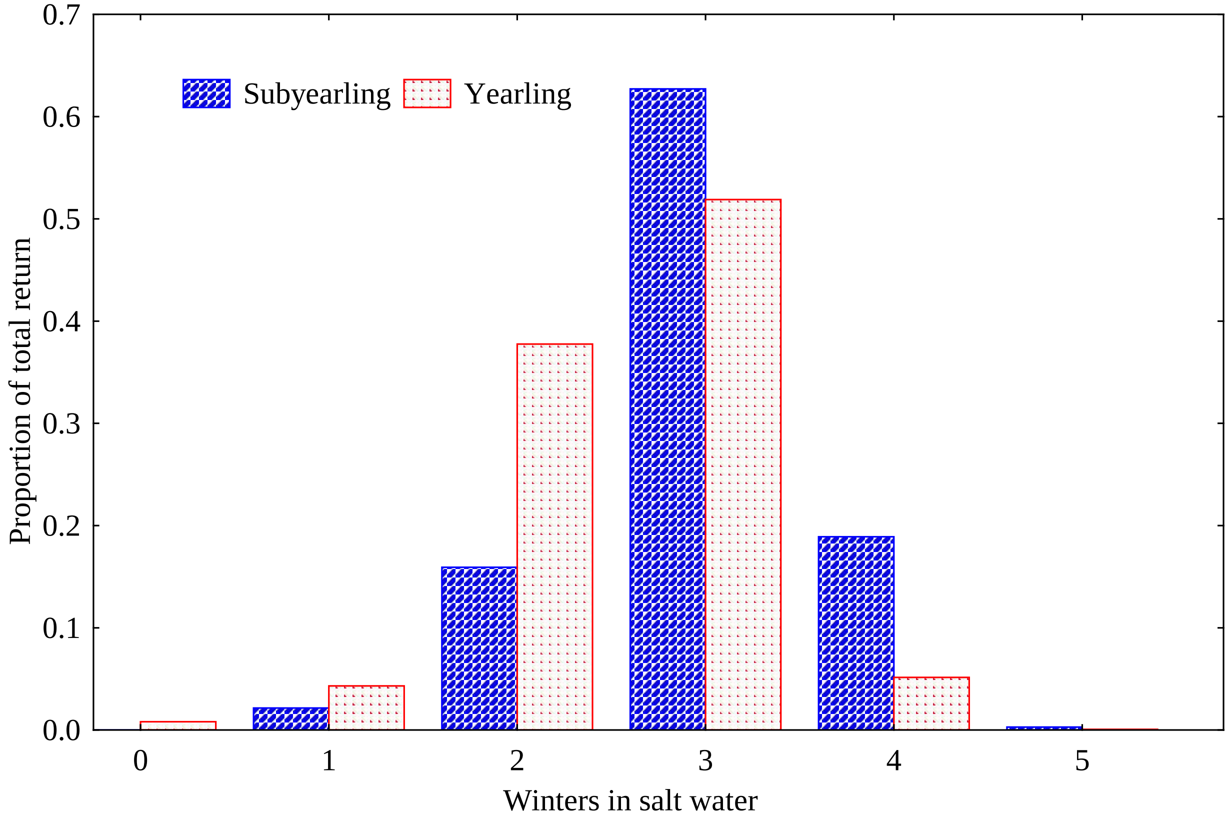

Figure 4.1. Mean salt water age of Wells Hatchery summer Chinook Salmon from the 1992-2010 broods released as subyearling or yearling program fish. Adult returns are from broodstock, spawning ground, or freshwater sport, commercial, and tribal fisheries.

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 1993-2010 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	--	--	--
2010	M	56	26	3	63	35	6	--	--	--	--	--	--
2010	F	61	1	--	66	85	4	68	9	6	--	--	--
Mean	M	57	23	5	66	22	6	76	4	4	78	1	0
Mean	F	66	4	5	68	33	3	74	17	4	75	5	3

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								
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
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	--	--	--
2010	M	--	--	--	62	142	4	70	34	6	--	--	--
2010	F	--	--	--	66	53	4	72	75	4	--	--	--
Mean	M	45	17	3	62	146	5	72	107	6	77	11	6
Mean	F	--	--	--	66	73	4	75	181	26	78	27	5

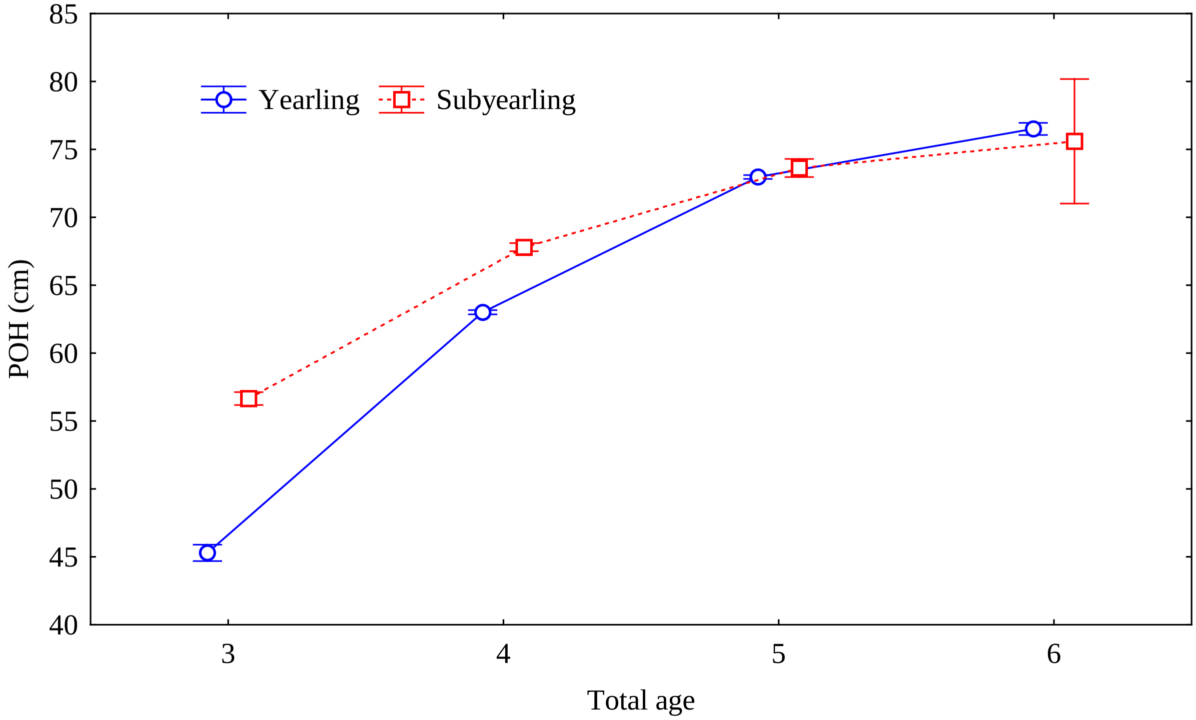

Figure 4.2. Mean (+/- 95% CI) POH length (cm) of adult returns of summer Chinook Salmon released as subyearling or yearling fish from the 1992-2010 broods.

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 (2006-2010), harvest was primarily in freshwater fisheries for subyearling releases (36% freshwater; 32% ocean). Yearling releases were primarily captured in ocean fisheries (34% 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

Table 4.10. Continued.

Brood year	Broodstock		Freshwater commercial		Freshwater sport		Freshwater tribal		Ocean fisheries		Spawning ground		Total
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*
							Subyearling program						
1997	47	21	1	0	23	10	6	3	114	52	30	14	221
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	486	33	46	3	251	17	177	12	489	33	29	2	1,478
2010	462	32	41	3	159	11	302	21	456	32	20	1	1,440
Mean	191	34	17	2	70	8	99	12	224	39	38	5	640
							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	159	14	194	16	381	32	14	1	1,178
2008	1,225	27	103	2	717	16	535	12	1,900	41	97	2	4,577
2009	1,571	27	168	3	735	13	1,098	19	2,069	36	92	2	5,733
2010	648	20	129	4	327	10	773	24	1,297	41	21	1	3,195
Mean	1,031	33	85	2	352	9	361	10	1,869	41	223	5	3,921

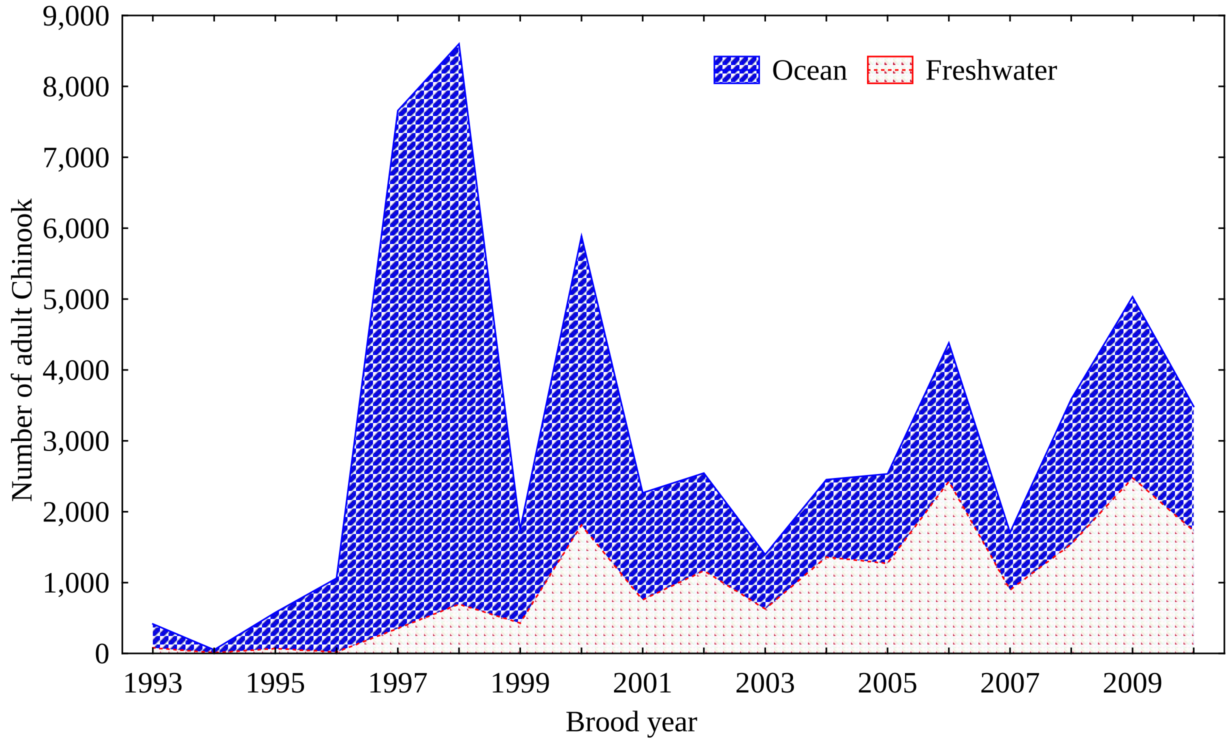

Figure 4.3. Cumulative retention of Wells summer Chinook Salmon by brood year in commercial, sport, and tribal fisheries in ocean and freshwater areas.

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 1992-2010 broods averaged 6.1%, 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	11,003	1,760	135	1,895	17.20
1998	10,486	604	44	648	6.18
1999	2,122	97	17	114	5.37
2000	8,506	353	2	355	4.17
2001	3,524	63	0	63	1.79
2002	3,959	75	0	75	1.89
2003	2,074	47	0	47	2.26
2004	4,324	210	5	215	4.97
2005	4,055	298	0	298	7.35
2006	7,303	191	0	191	2.62
2007	2,447	74	0	74	3.02
2008	5,103	121	2	123	2.41
2009	7,211	121	1	122	1.69
2010	4,635	41	2	43	0.93
Mean	4,364	250	18	267	6.14

Table 4.12. Recovery number and proportion (*N* (%)) of Wells Hatchery summer Chinook Salmon released as yearling and subyearling smolts within recipient 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	20	0.3	0	0.0	0	0.0	31	2.8
2015	6	1.5	5	0.1	0	0.0	0	0.0	0	0.0	4	0.3
2016	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Mean	8	1.5	97	3.1	62	2.4	3	0.1	3	0.0	59	9.6

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 (20.0) than for subyearling releases (2.4). Average HRR values were greater than target values in the M&E Plan for yearling (target = 5.3) and subyearling releases (target = 2.2). For the latest brood for which adult return information is expected to be complete (2010 brood) the HRR rate was above target 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	1,627	0.419	7.2
1994	Yearling	185	365,000	142	0.039	0.8
1995	Yearling	144	290,000	1,120	0.386	7.8
1996	Yearling	193	356,707	1,582	0.444	8.2
1997	Yearling	189	381,867	10,782	2.823	57.0
1998	Yearling	207	457,770	10,137	2.214	49.0
1999	Yearling	176	312,098	1,607	0.515	9.1
2000	Yearling	175	343,423	8,319	2.422	47.5
2001	Yearling	248	185,200	2,723	1.470	11.0
2002	Yearling	182	306,810	3,831	1.249	21.0
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	1,715	0.514	10.5
2006	Yearling	200	311,880	6,766	2.169	33.8
2007	Yearling	179	318,902	1,178	0.369	6.6
2008	Yearling	191	336,881	4,577	1.359	24.0
2009	Yearling	164	350,000	5,733	1.638	35.0
2010	Yearling	203	350,218	3,195	0.912	15.7
Mean	Yearling	187	334,023	3,742	1.098	20.0
1993	Subyearling	173	187,382	41	0.022	0.2
1994	Subyearling	255	450,935	14	0.003	0.1
1995	Subyearling	221	408,000	126	0.031	0.6
1996	Subyearling	336	473,000	686	0.145	2.0
1997	Subyearling	274	541,923	221	0.041	0.8
1998	Subyearling	179	370,617	349	0.094	1.9
1999	Subyearling	212	363,600	515	0.142	2.4
2000	Subyearling	257	498,500	187	0.038	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	2,340	0.544	8.9
2006	Subyearling	333	396,538	537	0.135	1.6
2007	Subyearling	334	499,365	1,269	0.254	3.8
2008	Subyearling	279	427,131	526	0.123	1.9
2009	Subyearling	254	464,137	1,478	0.318	5.8
2010	Subyearling	323	442,821	1,440	0.325	4.5
Mean	Subyearling	260	427760	640	0.147	2.4

Section 5: Wells Hatchery Summer Steelhead

This section focuses on the most recent brood for which releases were completed during the report year (2016 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 Wells, Methow, and Winthrop (USFWS) fish hatcheries. Returning adult steelhead from the Wells Hatchery Complex programs support steelhead recovery goals and provide harvest opportunities in years of high abundance.

5.1: Broodstock Collection and Sampling

Trapping of the 2016 brood of Wells Hatchery summer steelhead occurred between 3 August and 27 October 2015 at Wells Dam. During this time a total of 212 adipose fin-clipped hatchery origin fish were retained, representing 4.1% of the estimated adipose fin-clipped hatchery fish returning to Wells Dam during the trapping period. Overall, pre-spawn mortality totaled 1.9% 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, Wild Horse Spring Creek, and from the Methow Hatchery outfall channel. Spring 2016 trapping at the Twisp River weir and the Methow Hatchery outfall provided 14 and three 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
2016	0	0	0	0	0	266	3	58	205	0	205
Mean	48	2	0	44	2	310	19	11	271	9	314
						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
2016	3	0	0	3	0	40	1	0	39	0	43
Mean	--	--	--	--	--	42	1	0	41	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
2016	13	0	0	13	0	0	0	0	0	0	13
Mean	15	0	0	14	0	0	0	0	0	0	14
						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
2016	12	0	0	12	0	8	0	0	8	0	20
Mean	21	0	0	21	0	16	0	7	9	0	24

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 hatchery origin fish, and were mostly 2-salt fish on average (Table 5.2). Hatchery origin fish spawned for broodstock from the Twisp River weir in 2016 were primarily 2-salt fish, although not all the 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	--	--	--
2016	0.77	0.23	179	--	--	--
Average	0.55	0.45	293	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
2016	0.32	0.68	22	0.82	0.18	11
Average	0.41	0.59	22	0.45	0.55	21

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 2016 brood was skewed towards female fish in the Twisp River and Omak Creek broodstocks, but spawning of the Wells and Okanogan programs used equal numbers of male and female fish overall (Table 5.3). Of the female fish spawned, fecundity of the 2016 brood was lower than overall mean values for the Wells and Okanogan programs and higher than mean values for the Twisp River and Omak Creek programs. Fecundity values for all programs were lower than the values used in broodstock collection protocols for hatchery (6,022) and wild (5,610) females (Tonseth 2015), except for the hatchery females spawned for the Twisp program (Table 5.3). Gonadal mass (estimated weight of eggs (g) prior to fertilization) was recorded for females spawned at the Wells and Methow hatchery facilities. Although variance in the gonad mass-fork length relationships for hatchery and wild females was similar (Figure 5.1), relatively few wild females were available for comparison.

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
Wells broodstock										
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
2016	100	100	5,163	1.00:1	--	--	--	--	1.00:1	5,163
Mean	134	151	5,804	0.90:1	24	34	5,715	0.75:1	0.86:1	5,774

Table 5.3. Continued.

Brood year	Hatchery steelhead				Wild steelhead				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
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
2016	19	20	4,888	0.95:1	2	1	5,163	2.00:1	1.00:1	4,901
Mean	20	21	5,457	0.93:1	2	1	5,163	2.00:1	0.95:1	5,461
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
2016	--	--	--	--	6	7	5,335	0.86:1	0.86:1	5,335
Mean	--	--	--	--	7	8	5,248	0.87:1	0.87:1	5,248
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
2016	1	7	6,421	0.14:1	6	6	5,381	1.00:1	0.54:1	5,940
Mean	4	5	6,615	1.82:1	9	12	5,267	0.80:1	0.79:1	5,399

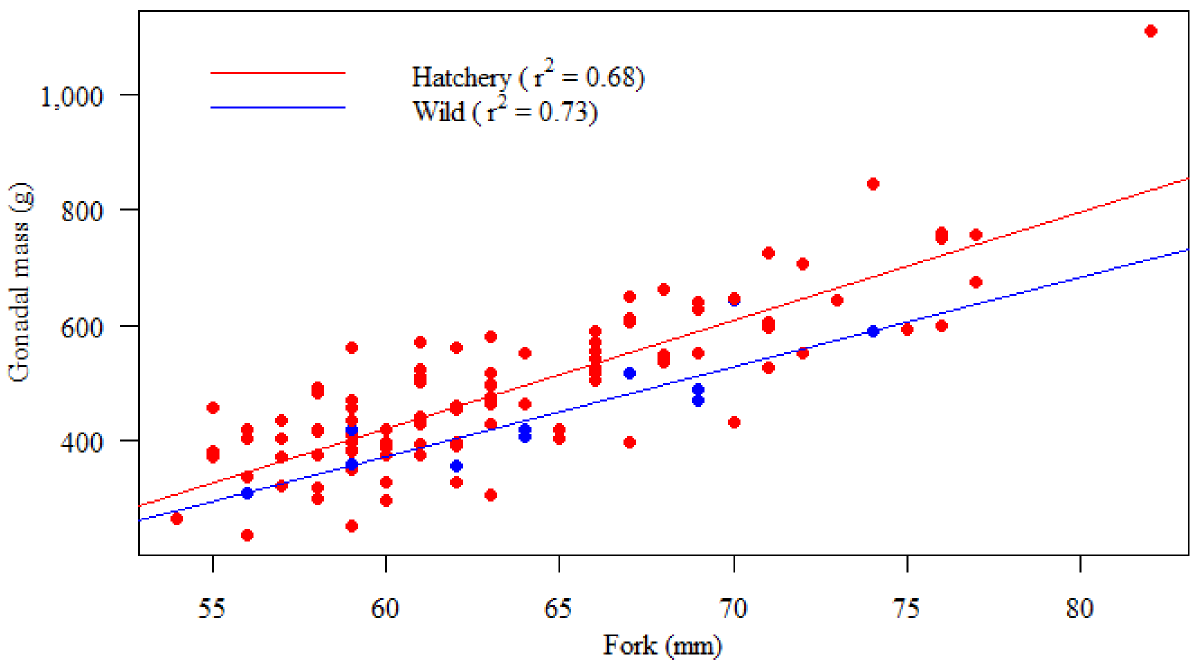

Figure 5.1. Total egg mass (g) vs. fork length (cm) relationship for 2016 brood hatchery and wild steelhead spawned at the Wells and Methow hatchery facilities.

5.2: Within-hatchery Monitoring

Juvenile Marking and Tagging

Juvenile releases from the 2016 brood were below the overall release goal of 438,000 fish for PUD programs (Tonseth 2015). Safety-net releases into the Methow and Columbia Rivers achieved 101% and 103% of their respective release goals. Releases into the Twisp River were also at program goals (48,000) but an additional 11,214 fish were released into the river from WNFH to improve future return demographics. Steelhead releases into the Okanogan River basin achieved 95% of the release goal of 100,000 fish. Okanogan basin releases 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 only those fish released by WNFH were also 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
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
2016	101,276	59,226	0	165,550	29,267	16,017	0	39,998	5,033	5,004	421,371

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), peduncle blank-wire tag (PBWT), 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 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
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

Table 5.5. Continued.

Brood year	Mark	CWT code(s)	Release location	Mark rate	*N*
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
2016	CWTO	636985;6991	Twisp River	0.9847	48,012
2016	Ad+CWT	054648	Twisp River	0.9688	11,214
2016	CWT+PBWT	636878;6991	Omak Creek	0.9444	16,017
2016	PBWT	--	Aeneas & Antoine Cr’s.	0.9444	10,037
2016	Ad+CWT	637058	Okanogan Basin	0.9118	69,265

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 2016 brood Wells and Twisp program fish were 97.2% and 81.3% of the target release fork length goal, respectively (Table 5.6). Coefficient of variation (CV) of fork length for Wells 2016 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

Table 5.6. Continued.

Brood	Stock	Fork length (mm)			Weight (g)				K
		Mean	SD	CV	Mean	SD	CV	FPP	
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
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
2016	Wells SN	185.8	18.5	9.9	60.8	17.7	29.1	7.5	0.95

Table 5.6. Continued.

Brood	Stock	Fork length (mm)			Weight (g)				K
		Mean	SD	CV	Mean	SD	CV	FPP	
2016	Twisp WxW	155.3	23.4	15.0	46.0	20.2	44.0	9.9	1.23
2016	Omak WxW*	156.9	18.8	12.0	46.5	17.1	36.9	9.8	1.20
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 2016 brood adults for all programs was above 98% (Table 5.7). Survival from eyed-egg-to-ponding for the 2016 brood was below target levels for the Wells Hatchery program but survival values for most other categories were above target levels. Survival for the Twisp and Omak Creek programs was below target levels after ponding, affecting the ponding-to-release and unfertilized-egg-to-release categories for those programs. Transportation-to-release values for the 2016 brood were calculated for the Methow Hatchery release group (Wells program; Table 5.7), but the Twisp and Omak Creek programs were direct-planted in 2017 so no transport-to-release survival was reported (Tables 5.7; 5.8).

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
2016	99.2	98.6	92.0	93.7	98.4	97.7	92.7	99.9	79.9
				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
2016	100.0	100.0	94.1	99.0	97.7	95.3	80.3	--	74.7
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
2016	100.0	100.0	95.2	97.9	98.4	97.2	69.5	--	64.8

5.3 Natural Origin Juvenile Productivity

Smolt trapping was conducted in 2017 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 1 March and 6 December 2017 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 three occasions for a total of 33 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 373 wild summer steelhead emigrants (smolt and transitional) between 1 March and 30 June in the Methow River trap, with peak capture on 9 April (*N* = 35). We PIT tagged 363 wild steelhead emigrants and released 360 tagged fish after three fish shed their tags prior to release. No mortality of wild emigrant steelhead was observed in 2017. We also captured 2,700 hatchery steelhead juveniles at the Methow River trap, and a single mortality of these fish was recorded (0.04%).

We captured six wild fry and 52 wild summer steelhead parr during trapping in 2017 at the Methow trap site. Steelhead parr greater than 65 mm and in good physical condition were PIT tagged (*N* = 49), and 48 were releases after subtracting a single mortality. Overall mortality of fry (*N* = 0) and parr (*N* = 1) totaled (1.7%) of the total fry and parr captured.

Due to low capture numbers of migratory steelhead, no mark/recapture trials were conducted with steelhead in 2017 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 22,526 (± 5,103, 95% CI) summer steelhead emigrated from the Methow River basin. However, an additional 141 migrants were estimated from redds located downstream of the trap in 2013 through 2016, which resulted in a total estimated migration of 22,667 (± 5,119, 95% CI) summer steelhead from the Methow River basin in 2017. We estimated the entire 2013 brood migration to be 19,278 (± 4,085, 95% CI) fish, including 642 migrants that were expected from redds (*N* = 27) located downstream of the Methow trap in 2013. The mean number of emigrants (smolts) produced per redd in the Methow Basin for the 2003-2013 broods was 20 (Table 5.9).

Twisp Trap

Trapping at the Twisp River trap site (rkm 2) occurred between 17 March and 3 December 2017 using a rotary screw smolt trap with a 1.5 m cone diameter. Trapping at the Twisp site was interrupted on one occasions for a total of 39 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 160 wild summer steelhead emigrants at the Twisp trap between 17 March and 30 June. Peak capture occurred on 8 April (N = 30). We PIT tagged 224 wild steelhead emigrants and no shed tags or mortalities were recorded (Attachment A). Non-migrant summer steelhead captured at the Twisp trap included 23 wild fry and 524 wild parr. We PIT tagged 474 steelhead parr with a fork length greater than 65 mm and released 472 tagged parr after subtracting two mortalities. Overall mortality of fry (N = 0) and parr (N = 2) represented 0.37% of the total fry and parr captured (N = 547). Wild summer steelhead parr had a mean fork length of 105.0 mm. A total of 2,638 juvenile hatchery summer steelhead were captured at the Twisp River trap and no mortalities were recorded.

A single mark/recapture trials was conducted with wild summer steelhead at the Twisp site in 2017. Combining this group with historical trials, a significant relationship existed between river discharge and trap efficiency ($P < 0.01$, $r^2 = 0.53$; Table 11). The flow model regression ($y = -0.00029807x + 0.410559405$) was used to estimate that 5,926 (± 1,670, 95% CI) wild summer steelhead migrated past the Twisp River trap between 17 March and 30 June 2017. An additional 465 migrants were estimated from redds located downstream of the trap in 2013 through 2016, which provides a total estimated migration of 6,391 (± 1,734, 95% CI) summer steelhead from the Twisp River in 2017. Most 2017 migrants were age-2 fish (83.7%) from the 2015 brood (Table 5.8). Combining numbers from the last four years, the entire 2013 brood migration is estimated to be 5,715 (± 1,580, 95% CI) fish, which includes 327 expected migrants produced from redds (N = 8) that were identified downstream of the Twisp trap in 2013. The mean number of emigrants (smolts) produced per redd in the Twisp Basin for the 2004-2013 broods was 39 (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

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		
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	0	19,278	0.40	24
Methow	2014	878	4,630,572	1,008	11,569	1,863	--	14,440	--	--
Methow	2015	991	5,776,539	3,495	18,609	--	--	22,104	--	--
Methow	2016	682	3,504,116	2,195	--	--	--	2,195	--	--
Mean 2003-2013		1,111	6,585,415	1,642	12,795	3,038	304	17,778	0.35	20

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	0	5,715	0.68	41
Twisp	2014	144	759,465	288	4,273	624	--	5,185	--	--
Twisp	2015	161	938,469	424	5,353	--	--	5,777	--	--
Twisp	2016	210	1,078,980	414	--	--	--	414	--	--
Mean 2004-2013		235	1,369,610	166	4,647	1,401	125	5,737	0.69	39

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 1.10% and 0.99%, respectively for the 2006-2015 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	0	1	0.37
2016	159	1	--	1	0.63
Mean 2006-2015					1.10
		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

Table 5.11. Continued.

Release year	Released	Age at return (*N*) to Wells Dam		Total	SAR (%)
		1-Salt	2-Salt		
		Methow trap			
2013	432	1	4	5	1.16
2014	591	2	1	3	0.51
2015	442	1	0	1	0.23
2016	188	1	--	1	0.53
Mean 2006-2014					0.99

In-stream PIT Tagging

Natural origin juvenile steelhead were primarily PIT tagged in the Twisp subbasin in 2017 (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	2017	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	--	--	--	--	243	36	--	279	0.18 (0.02)
2015	3,803	--	--	--	--	2	177	29	208	0.15 (0.01)
2016	2,210	--	--	--	--	--	--	84	84	0.17 (0.03)
2017	3,320	--	--	--	--	--	--	--	--	--

Table 5.12. Continued.

Tag year	SHR tagged	Recovered at Rocky Reach juvenile bypass								CJS survival (SE)
		2011	2012	2013	2014	2015	2016	2017	Total	
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	174	--	--	--	--	--	1	9	10	0.10 (0.03)
2017	192	--	--	--	--	--	--	--	--	--
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	605	--	--	--	--	--	--	16	16	0.32 (0.29)
2017	0	--	--	--	--	--	--	--	--	--

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 13 March and 31 May 2017 in the Twisp River and between 3 March and 2 May 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 709 steelhead were estimated to have spawned in the Methow River Basin in 2017 (Table 5.13), with most spawners found in the Lower Methow subbasin (N = 241). The 2017 escapement estimates were derived from redd counts and from PIT tag detections at arrays located throughout the Methow Basin (Attachment D). Escapement estimates in all river sections in 2017 were lower than the overall mean values (Table 5.13).

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	372	336	1,582
2015	394	1,217	629	300	2,540
2016	178	925	403	308	1,814
2017	134	241	187	148	710
Mean	613	540	510	276	1,938

Redd Distribution

Because most of the spawning escapement of steelhead in 2017 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. Subsequent observations of Floy-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 four of 105 redds (4%). Based on these Floy tag observations, wild female steelhead were observed spawning farther upstream than hatchery steelhead females in 2017 but sample sizes were low, and no significant differences in spawning location between hatchery and wild females were found when fish from all broods (2009-2017) were considered (Goodman et al. 2018; Figure 5.2).

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. 2018) using 1.33 fish per redd. Ns = not surveyed.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Methow River (MRW PIT array – Red Barn)	MRW8	24	192	63
Methow River (Red Barn – Halderman Hole)	MRW7	13		
Methow River (Halderman Hole – Braids)	MRW6	12		
Methow River (Braids – Carlton Bridge)	MRW5	Ns		
Methow River (Carlton Bridge – WDFW Access)	MRW4	2		
Methow River (WDFW Access – Upper Burma Br.)	MRW3	Ns		
Methow River (Upper Burma Br. – Lower Burma Br.)	MRW2	0		
Methow River (Lower Burma Bridge – Pateros)	MRW1	Ns		
Chewuch River (CRW PIT array to – Confluence)	CRW1	0	--	--
Methow Hatchery outfall	MH1	15	--	--
Winthrop NFH Outfall	WN1	55	--	--
1890's channel	18N	1	--	--
Beaver Creek (above PIT antenna)	Beaver	22	13 (1-33)	16 (2-37)
Beaver Creek (below PIT antenna)	BV1	Ns	--	--
Libby Creek (above PIT antenna)	Libby	17	7 (0-21)	15 (2-32)
Gold Creek (above PIT array)	Gold	20	12 (2-29)	15 (2-33)
Total		181	--	--

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)	2011	2012	2013	2014	2015	2016	2017
			Twisp River mainstem						
Road's End C.G. - South Creek Bridge	T10	4.6	Ns	Ns	Ns	Ns	Ns	Ns	Ns
South Creek Bridge - Poplar Flats C.G.	T9	3.2	0	0	0	0	2	0	0
Poplar Flats C.G. - Mystery Bridge	T8	3.2	0	0	1	1	2	1	0
Mystery Bridge - War Creek Bridge	T7	6.9	8	5	8	4	9	2	6
War Creek Bridge - Buttermilk Bridge	T6	7.4	43	43	21	36	30	3	13
Buttermilk Bridge - Little Bridge Creek	T5	5.9	33	26	18	25	10	4	7
Little Bridge Creek - Twisp weir	T4	3.8	13	5	7	3	10	1	6
Twisp weir - Upper Poorman Bridge	T3	3.5	46	20	46	30	44	7	38
Up. Poorman Br. - Lower Poorman Br.	T2	5.0	30	12	23	23	18	1	21
Lower Poorman Bridge - Confluence	T1	2.9	4	11	7	12	11	2	10
Twisp River mainstem total		46.4	177	122	131	134	136	21	101
			Twisp River tributaries						
Little Br. Cr. (Road's End - Vetch Cr.)	LBC4	1.3	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Little Br. Cr. (Vetch Cr. - 2nd Culvert)	LBC3	3.0	0	3	0	0	0	1	0
Little Br. Cr. (2nd Culvert - 1st Culvert)	LBC2	2.4	0	0	1	0	0	0	0
Little Br. Cr. (1st Culvert - Confluence)	LBC1	2.4	0	7	4	1	13	0	0
MSRF pond outfalls[1]	MSRF1	0.1	3	0	3	6	12	11	4
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	1	0	Ns	0
Buttermilk Cr. (Fork - Cattle Guard)	BM2	2.1	0	1	0	0	0	0	0
Buttermilk Cr. (Cattle Guard - Conf.)	BM1	2.0	0	0	0	2	0	0	0
South Creek (Falls - Confluence)	SO1	0.6	Ns	Ns	Ns	0	0	Ns	0
Twisp River tributary total		14.7	3	11	8	10	25	12	4

[1] Methow Salmon Recovery Foundation pond outfall.

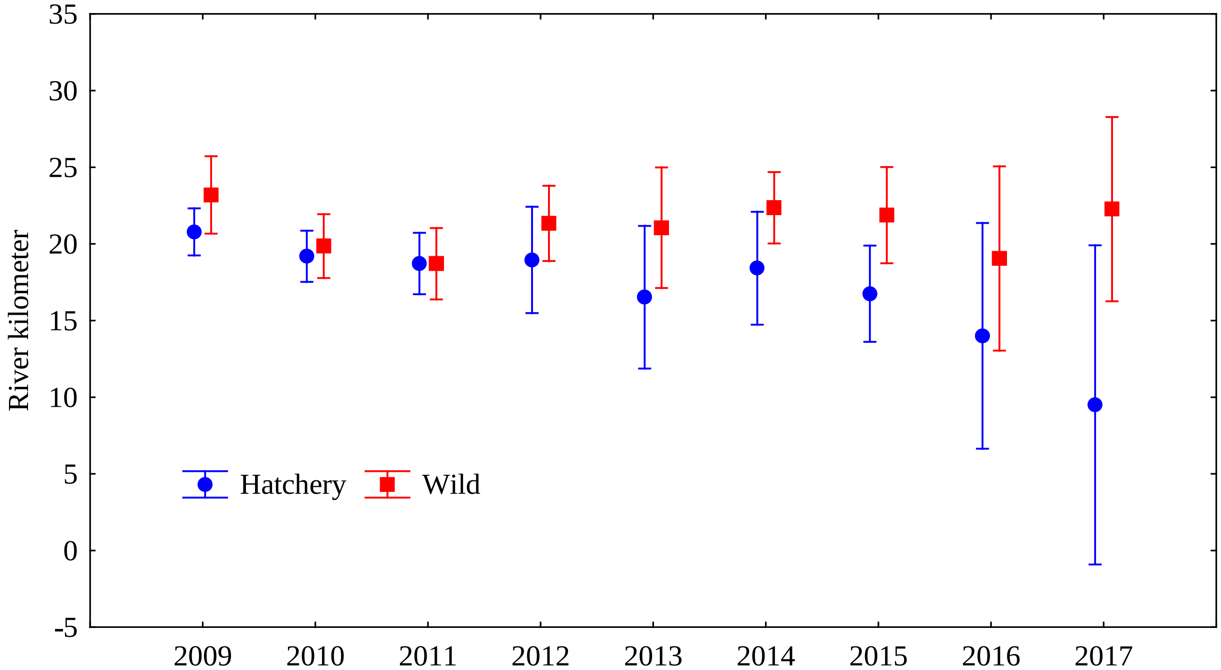

Figure 5.2. Mean spawning location (rkm; center point) and 95% CI (whiskers) by origin of female steelhead released upstream of the Twisp River weir based on PIT tag detections and Floy tag observations in 2009 (H = 45; W = 19), 2010 (H = 40; W = 27), 2011 (H = 26; W = 20), 2012 (H = 10; W = 19), 2013 (H = 5; W = 7), 2014 (H = 8; W = 18), 2015 (H = 11; W = 11), 2016 (H = 2; W = 3), and 2017 (H = 1; 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. Subsequent observations of Floy-tagged fish on the spawning grounds, allowed us to evaluate the spawn timing of hatchery and wild steelhead in the Twisp River (Figure 5.3). No significant differences in spawn timing were observed between hatchery and wild female steelhead from 2009 to 2017 (Goodman et al. 2018).

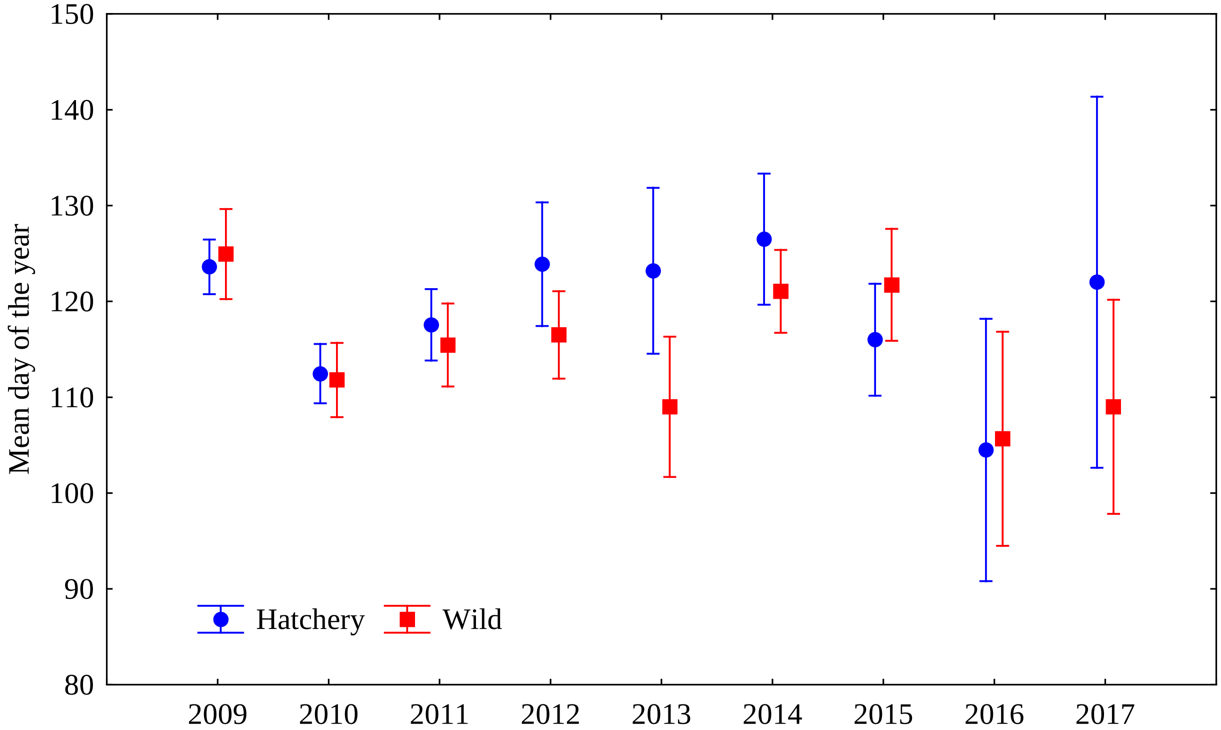

Figure 5.3. Mean spawn timing (day of year; center point) and 95% CI (whiskers) of female steelhead by origin and year released upstream of the Twisp River weir based on PIT tag, Floy tag, or radio telemetry observations in 2009 (H = 44; W = 17), 2010 (H = 38; W = 24), 2011 (H = 27; W = 20), 2012 (H = 8; W = 17), 2013 (H = 5; W = 7), 2014 (H = 8; W = 19), 2015 (H = 11; W = 11), 2016 (H = 2; W = 3), and 2017 (H = 1; 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

Table 5.16. Continued.

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
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
2016	H	57	6	5	73	60	5	58	9	3	73	209	4
2016	W	64	11	4	75	19	5	65	4	6	74	48	4
Average	H	61	88	3	75	31	5	60	57	3	72	91	4
Average	W	63	25	4	76	12	4	62	28	4	73	31	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 2006-2016 run years overall, wild fish arrived at Wells Dam an average of 14 days earlier than hatchery fish (Figure 5.4). Wild steelhead PIT tagged in 2016 had an earlier mean passage date (13 October) than hatchery steelhead (15 November) over the Lower Methow PIT array (LMR), but mean run-timing of hatchery and wild fish was similar at most other sites (Figure 5.5), regardless of salt-age at return (Figure 5.6).

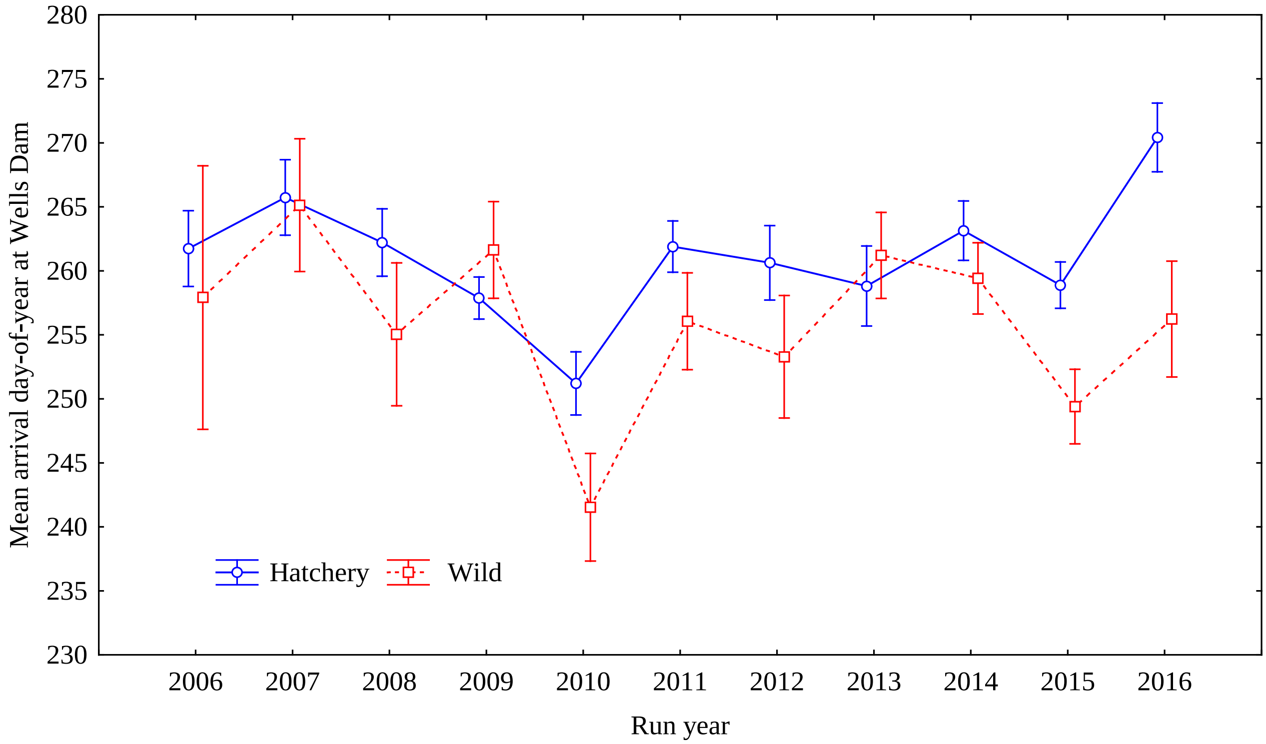

Figure 5.4. Migration timing (mean +/- 95% CI) by run year at Wells Dam of hatchery and wild steelhead PIT tagged and released from Priest Rapids Dam. Hatchery origin fish included those marked with an adipose fin-clip, an adipose fin-clip+CWT, a CWT-only, and left- or right-side yellow elastomer.

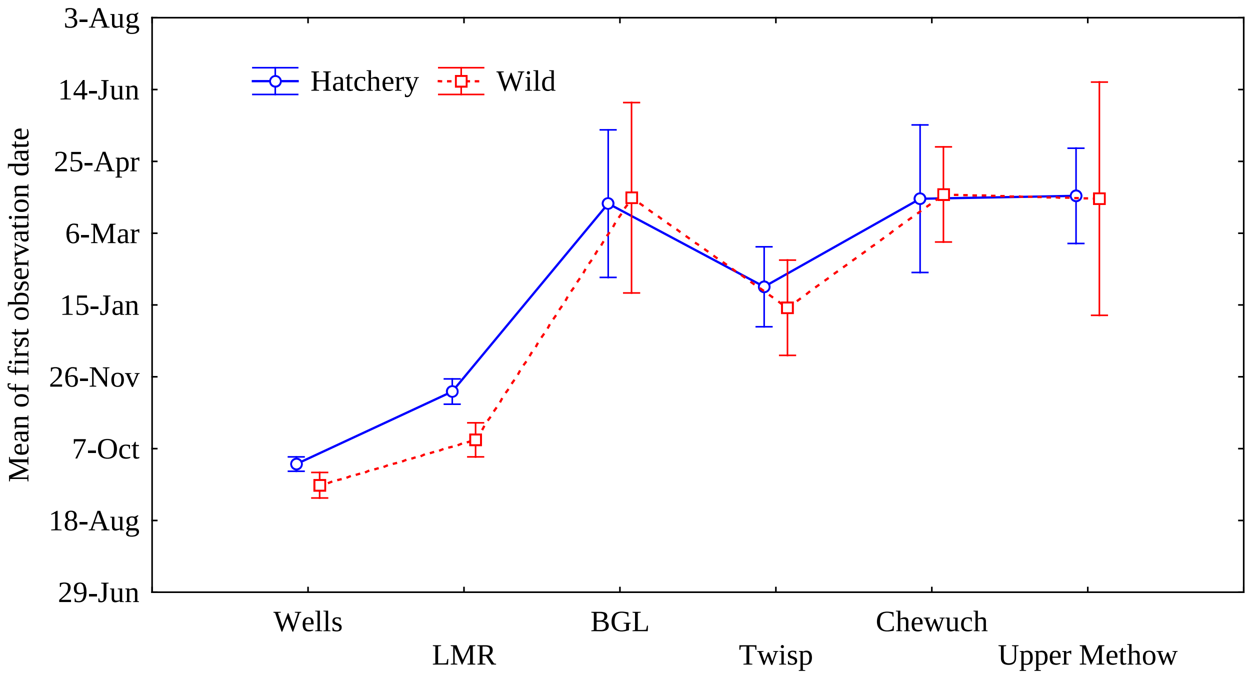

Figure 5.5. Mean (+/- 95% CI) migration timing of hatchery and wild steelhead PIT tagged at Priest Rapids Dam in 2016. Detection locations include the Lower Methow River (LMR), and the Beaver, Gold, and Libby Creek (BGL) antenna arrays. The Upper Methow category was estimated from the Methow-at-Winthrop (MRW) array.

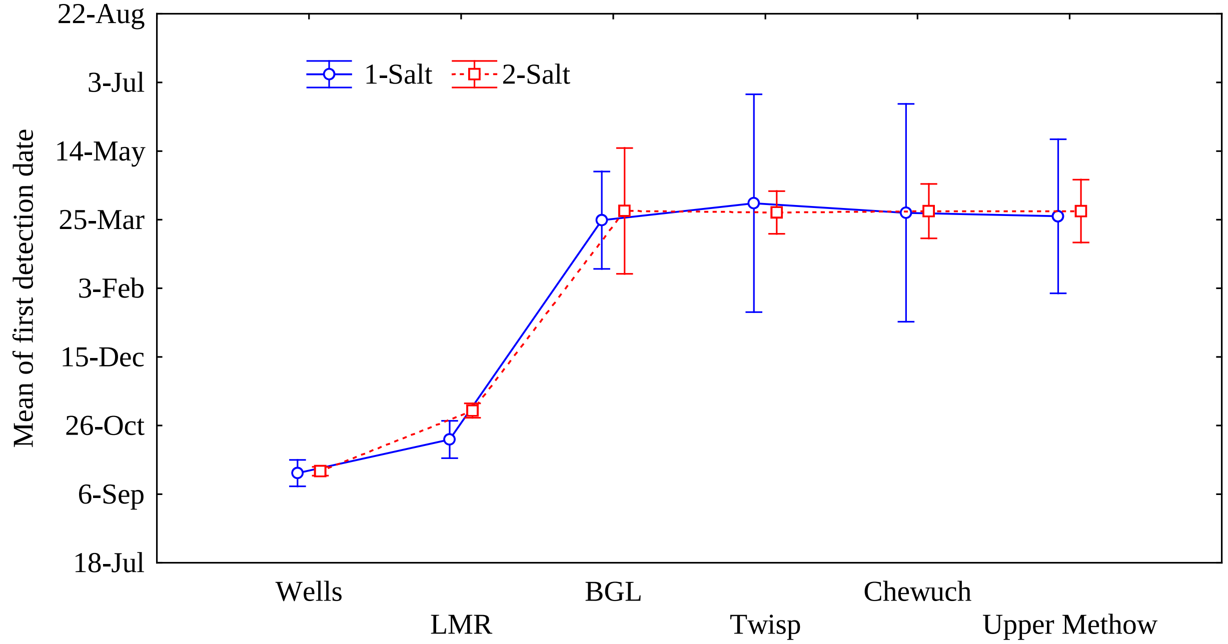

Figure 5.6. Mean (+/- 95% CI) migration timing based on salt-age of hatchery and wild steelhead PIT tagged at Priest Rapids Dam in 2015. Detection locations include the Lower Methow River (LMR), and the Beaver, Gold, and Libby Creek (BGL) antenna arrays. The Upper Methow category includes the Lost River, 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). Although no local sport fisheries were enacted on the 2017 brood, sport fisheries in the Columbia River upstream of Wells Dam over the past 15 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 6% 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
2017	4,158	1,104	144	0	574	207	60	45	3,380	852
Mean	9,678	1,442	273	48	825	333	619	36	8,285	1,164

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 16 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 2017 (Table 5.18). Estimates of pHOS for the 2017 brood in both the Methow and Okanogan rivers were close to the overall mean values for those rivers, due primarily to the lack of tributary fisheries that would have removed additional hatchery origin fish from the respective spawning escapements.

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 5.17.

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
2017	1,976	603	387	82	-	-	1,589	521	0.753
Mean	4,828	830	181	52	1,022	21	3,820	782	0.800
Okanogan Basin[1]									
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

Table 5.18. Continued.

Brood	Tributary escapement		Local broodstock		Tributary fisheries		Net escapement		pHOS
	H	W	H	W	H	W	H	W	
Okanogan Basin[1]									
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
2017	1,104	177	2	10	-	-	1,102	167	0.868
Mean	2,697	244	14	9	559	6	2,195	231	0.891

[1] Net escapement and pHOS values for the Okanogan Basin differ from those reported in the Okanogan Basin Monitoring and Evaluation Project (OBMEP) 2017 Annual Report, because different methods to estimate escapment were employed. See the OBMEP report(s) for more information (https://www.okanoganmonitoring.org/).

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 2013 and 2014 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 2013 brood, stray rates for Methow Basin steelhead releases (Methow and Twisp) averaged 6.1% (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., all 2014 brood 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 2014 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		
2013	Columbia	0	0	0	1	76[a]	5	2	84[a]	14.1
2013	Methow	9	0	2	0	25	1	0	37	8.1
2013	Twisp	0	13	0	1	11	0	0	25	4.0
2014	Columbia	0	0	0	0	1	0	0	1	N/A
2014	Methow	0	0	0	0	0	0	0	0	N/A
2014	Twisp	1	0	0	0	0	0	0	1	N/A

[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 (2013 brood) was 29.4 for Wells Hatchery releases, and 15.2 for Twisp River conservation program releases (Table 5.20). These values were above the HRR target of 19.6 for Wells releases but below the target value for Twisp River releases.

Table 5.20. Smolt to adult return (SAR) and hatchery replacement rate (HRR) of summer steelhead released for the Wells and Twisp River programs. 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
2013	236	369,718	6,949	1.880	53	29.4
Mean	253	512,528	7,210	1.401	98	28.3
			Twisp releases			
2011	25	41,170	379	0.921	109	15.2
2012	26	51,473	629	1.222	82	24.2
2013	23	50,787	350	0.689	145	15.2
Mean	25	47,810	453	0.944	112	18.2

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 (2011 brood) was 0.249 (Table 5.21), which is slightly above the mean NRR of the 1996-2011 broods (0.247).

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	2,120	0.245
2011	2,348	1,095	3,443	857	0.249
Median	3,166	506	3,709	870	0.247

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: 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 2002-2017 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 5.18. 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), and includes all hatchery origin fish in the spawning escapement (pHOS) regardless of program (e.g., WNFH, Wells, Twisp, etc.).

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
2017	2,110	0.75	0.06	0.94	0.28	0.17	0.18	0.19
Mean	4,602	0.80	0.51	0.49	0.18	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[1]				
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
2017	1,269	0.87	0.06	0.94	0.27	0.13	0.14	0.14
Mean	2,424	0.89	0.51	0.49	0.18	0.16	0.17	0.16

[1] Net escapement and pHOS values for the Okanogan Basin differ from those reported in the Okanogan Basin Monitoring and Evaluation Project (OBMEP) 2017 Annual Report, because different methods to estimate escapment were employed. See the OBMEP report(s) for more information (https://www.okanoganmonitoring.org/).

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Attachment A. 2017 Twisp and Methow River Smolt Estimates.

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18 May, 2018

To: Charlie Snow

From: David Grundy

Subject: 2017 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 (M&E Plan 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], Passive Integrated Transponder [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 DNA analysis suggests that spring Chinook tend to emigrate as yearlings 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 required the use of some groups with fewer than 50 fish. Fish utilized in mark/recapture trials were marked using a top or bottom caudal fin-clip, PIT tag, or were stained with Bismarck brown dye. To prepare for efficiency trials, the fish 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 = $E_i = \frac{(R_i+1)}{M_i}$

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 = $\widehat{N}_i = \frac{(C_i+1)}{\hat{e}_i}$ 6

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 =

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

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 = $E_p = \frac{\sum_{k=1}^{n} r_k}{\sum_{k=1}^{n} m_k}$

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 = $\widehat{N}_i = C_i/E_p$

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

Variance for daily emigration estimate = $var[\widehat{N}_i] = \widehat{N}_i^2 \frac{E_p(1-E_p)/\sum M}{E_p^2}$ 13

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

Total emigration estimate = $\sum \widehat{N}_i$ 7

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 Chinook during the entire migration period. This estimate was expanded by the estimated daily detection efficiency based on flow at the TWR 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 or expansions performed on PIT tag interrogation.

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 river 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 2017 began at the Methow River site on 1 March and at the Twisp River site on 17 March. 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 three occasions for a total of 33 days between 1 March and 6 December. Trapping at the Twisp site was interrupted on one occasion for a total of 39 days between 17 March and 3 December. River discharge was near or slightly above normal until a sharp increase in flow on 5 May forced us to cease trapping activities at both sampling locations (Figures 1 and 2). The river reached the highest level it has been since 2006, and stayed above average until the middle of June. Near average discharge was then experienced for the remainder of the year, with the exception of a rain induced increase on Thanksgiving (23 November). Trap operation ultimately ended in early December because of ice accumulation.

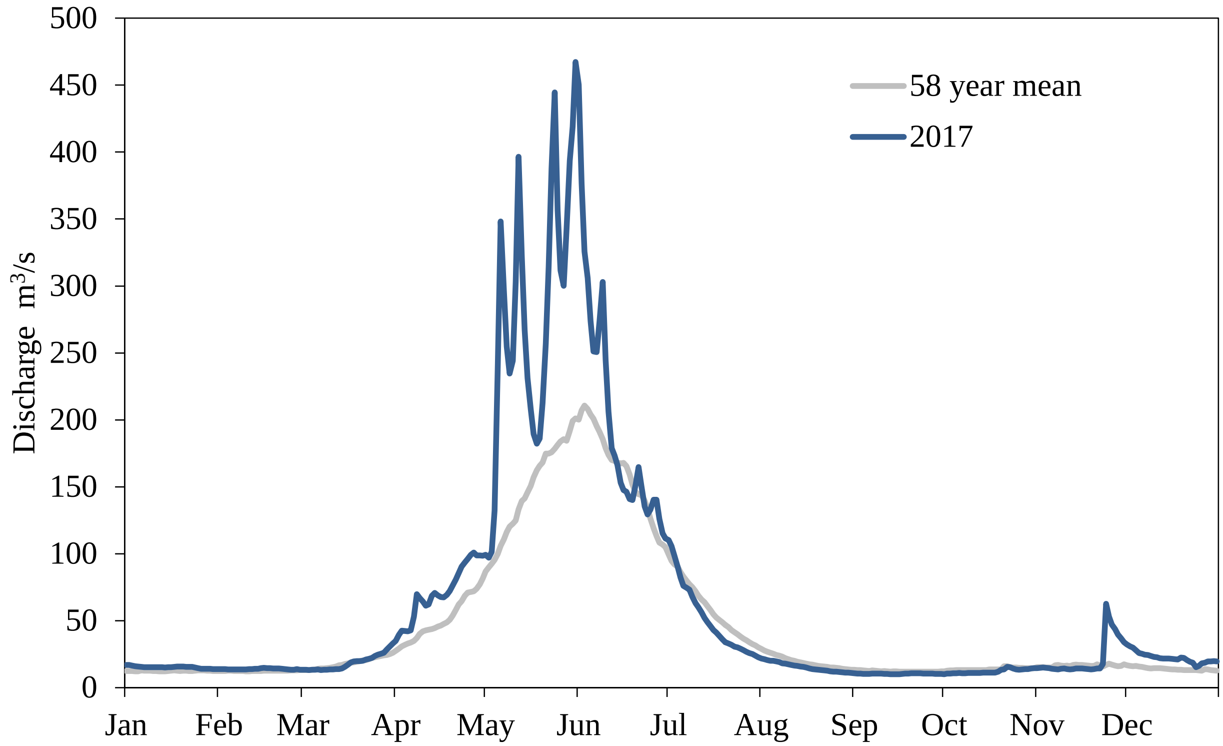

Figure 1. Methow River 2017 daily discharge and 58-year mean as measured at the USGS gauging station No. 12449950 (Methow River near Pateros, Washington).

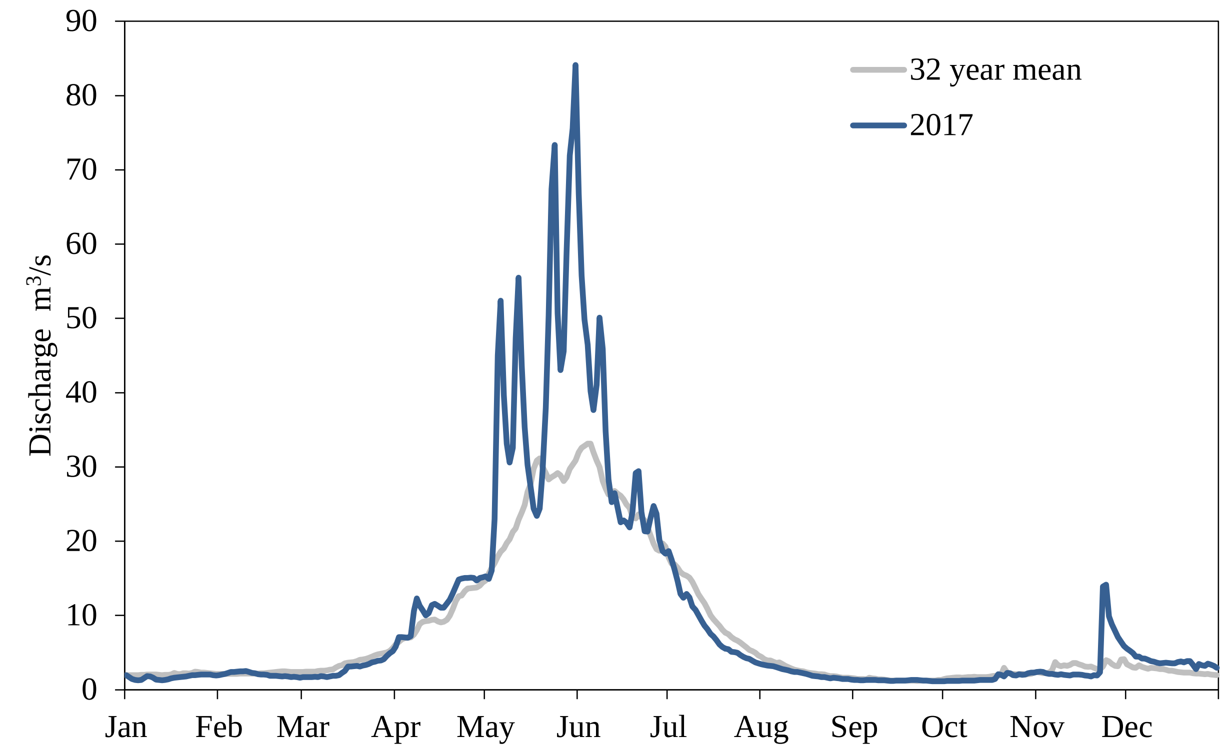

Figure 2. Twisp River 2017 daily discharge and 32-year mean as measured at the USGS gauging station No. 12448998 (Twisp River near Twisp, Washington).

Daily Captures and Biological Sampling

2015 Brood Chinook Salmon

A total of 490 wild yearling Chinook salmon emigrants were captured at the Methow site between 1 March and 30 June, with the peak capture (N = 78) occurring on 9 April (Figure 3). We inserted PIT tags into 473 of the wild smolts captured, and subsequently released 471 after subtracting two mortalities (Appendix A). Overall mortality of wild yearling Chinook totaled three of the 490 fish captured (0.61%). Instead of PIT tagging hatchery fish, we utilized 548 hatchery Chinook salmon that had existing PIT tags to facilitate trap efficiency mark/recapture trials. Overall mortality of hatchery Chinook at the Methow site totaled 9 out of 13,322 fish captured (0.07%). Hatchery smolts had a significantly greater mean fork length (134.4 mm) than wild Chinook smolts (103.6 mm) captured at the Methow trap (Mann-Whitney U-test: $P < 0.001$; Table 2).

The Twisp River trap captured 809 wild yearling spring Chinook salmon smolts between 17 March and 30 June. Peak capture occurred on 8 April (N = 71; Figure 4). We inserted PIT tags into 797 of the wild smolts captured, and subsequently released 793 after subtracting two mortalities and two shed tags (Appendix A). Overall mortality of wild yearling Chinook at the Twisp site totaled 5 of the 809 fish captured (0.62%). In addition to the seven hatchery spring Chinook that were caudal clipped, we used 498 hatchery spring Chinook that had existing PIT tags to help with mark/recapture trials. There was no mortality experienced by any of the 3,827 hatchery Chinook salmon smolts captured at the Twisp trap (0.0%).

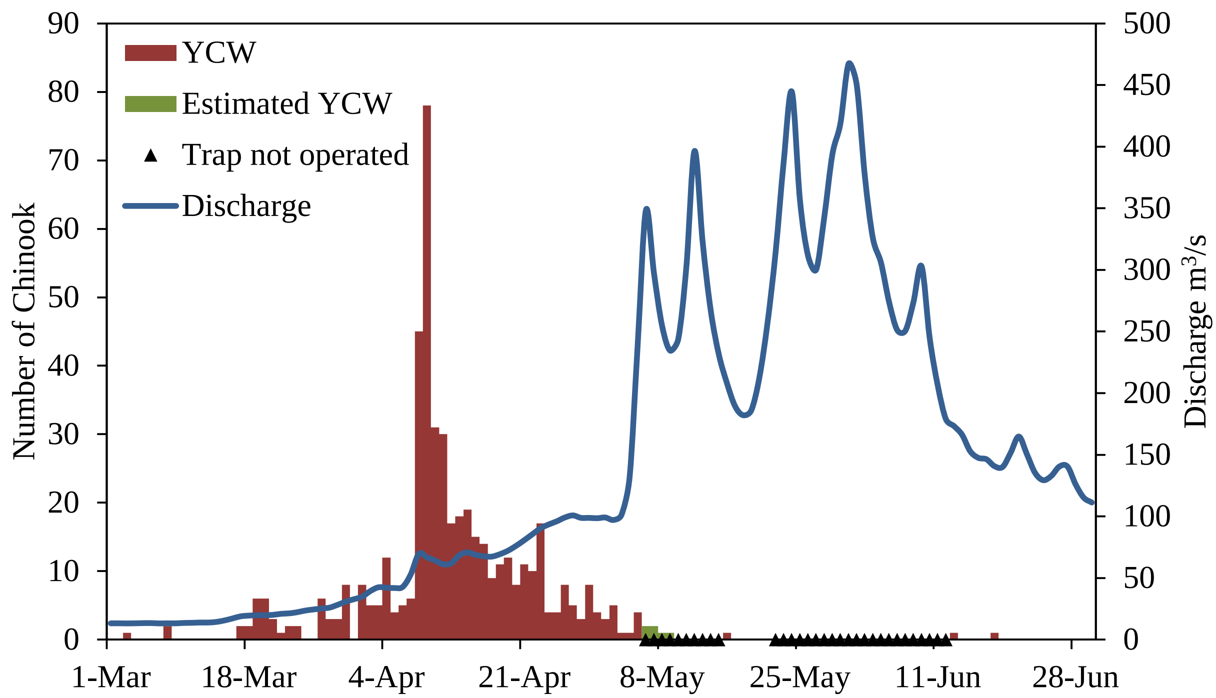

Figure 3. Daily capture of wild Chinook salmon smolts (YCW) at the Methow River smolt trap in 2017.

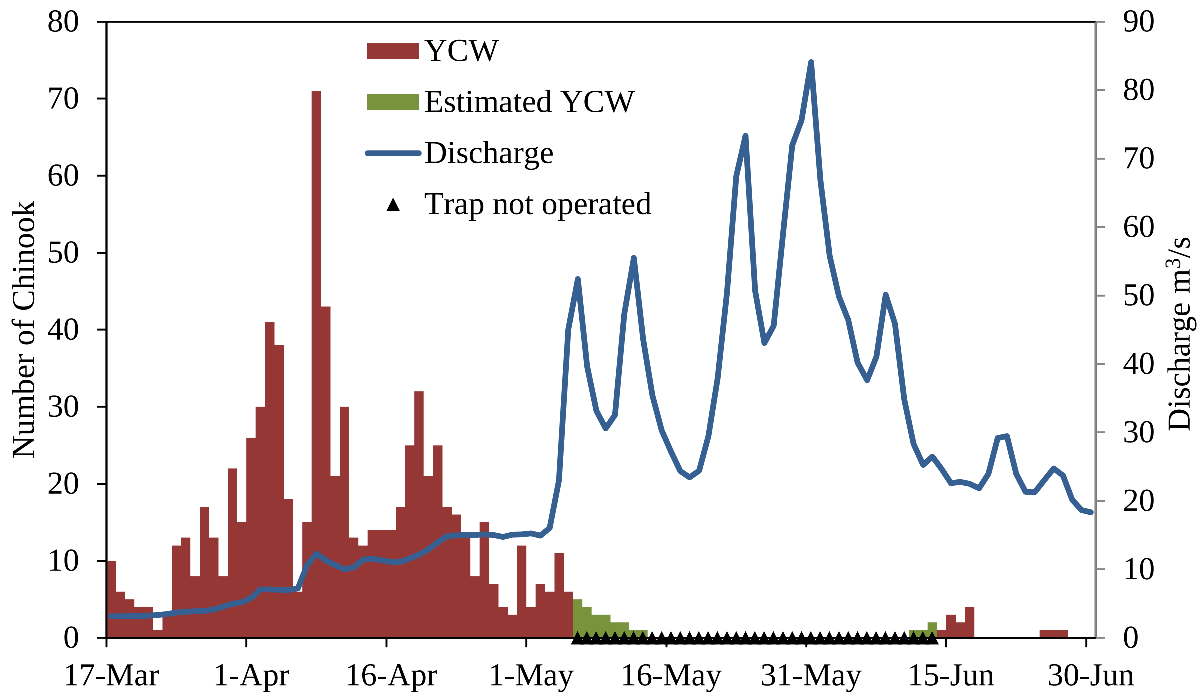

Figure 4. Daily capture of wild spring Chinook salmon smolts (YCW) at the Twisp River smolt trap in 2017.

<u>*2016 Brood Chinook Salmon*</u>

Subyearling Chinook salmon fry (*N* = 3,842) and parr (*N* = 582) captured at the Methow trap between 1 March and 30 September had mean fork lengths of 40.4 mm and 67.0 mm, respectively (Table 2). Mortality during this period totaled 12 fry (0.31%) and 8 parr (1.4%). An additional 172 emigrant Chinook parr were captured during the fall trapping period between 1 October and 6 December. The mean fork length of Chinook parr during this period was 97.6 mm (Table 2), and peak captures occurred on 25 November (*N* = 56). We inserted PIT tags into 164 of the Chinook parr captured and all were released with no mortalities experienced (0.0%; Appendix A). Nine of the parr captured had existing PIT tags from upstream sources. Tissue samples were collected from 170 of the fall-captured parr, and genetic analysis was conducted on all samples. Of the 170 samples, analysis indicated that 156 (91.8%) of the sampled parr were spring Chinook, and 14 (8.2%) 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 1,009 subyearling spring Chinook salmon between 17 March and 3 December, and peak captures occurred on 23 November (*N* = 157; Figure 5). We inserted PIT tags into 687 subyearling Chinook and 686 were released with tags after one fish shed a tag (Appendix A). There were also 19 subyearling Chinook that had existing PIT tags at capture. Overall, three subyearling Chinook mortalities occurred (0.30%). Fall migrant parr had a mean fork length of 91.3 mm (Table 2).

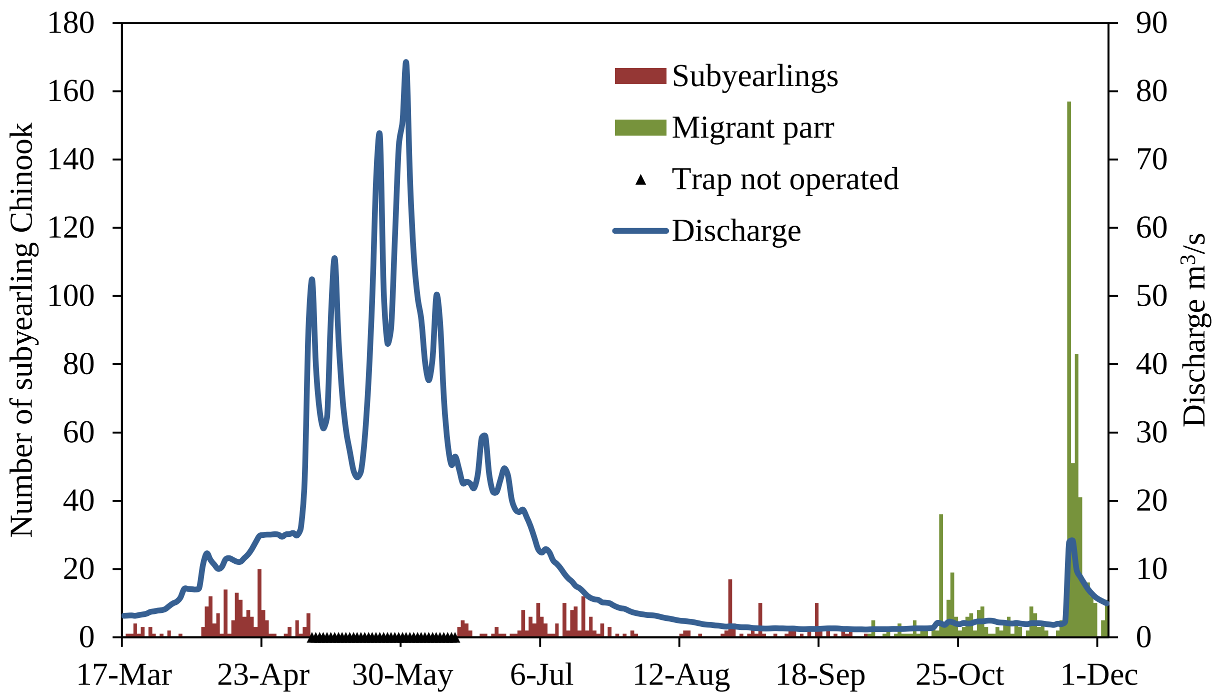

Figure 5. Daily capture of subyearling wild spring Chinook salmon (Feb-Sep) and migrant parr (Oct-Dec) at the Twisp River smolt trap in 2017.

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 capture 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
2017	N/A	N/A	91.8
Mean	Yearling = 97.8, parr = 9.7	11.5	93.5

Table 2. Summary of length and weight sampling of Chinook salmon captured at Methow basin smolt traps in 2017.

Brood	Origin/stage	Fork length (mm)			Weight (g)			Mean K-factor
		Mean	*N*	SD	Mean	*N*	SD	
				Methow River trap				
2016	Wild fry	40.4	747	3.5	--	--	--	--
2016	Wild parr (Mar-Sep)	67.0	430	14.1	4.0	424	3.0	1.1
2016	Wild parr (Oct-Dec)	97.6	172	8.4	10.0	172	2.7	1.1
2015	Wild smolt	103.6	489	9.6	12.4	456	3.4	1.1
2015	Hatchery smolt	134.4	643	10.7	28.6	474	7.5	1.1
				Twisp River trap				
2016	Wild fry	39.2	140	4.3	--	--	--	--
2016	Wild parr (Mar-Sep)	71.5	175	17.1	5.0	175	3.5	1.1
2016	Wild parr (Oct-Dec)	91.3	617	7.8	8.4	617	2.1	1.1
2015	Wild smolt	93.5	809	6.9	8.8	788	2.1	1.1
2015	Hatchery smolt	132.1	505	9.5	26.9	505	6.6	1.1

<u>*Summer Steelhead*</u>

The Methow River trap captured 373 wild summer steelhead emigrants (smolt and transitional) between 1 March and 30 June, with peak capture on 9 April (*N* = 35; Figure 6). We inserted PIT tags into 363 wild steelhead emigrants and 360 were released with tags after three fish shed their tags (Appendix A). There were no mortalities experienced by emigrant steelhead at the Methow trap (0.0%). Most wild summer steelhead migrants were age-2 fish (82.4%), which had a mean fork length of 178.1 mm (Table 3). A total of 2,700 hatchery steelhead juveniles were captured at the Methow River trap, with only a single mortality experienced (0.04%).

The Methow River trap captured six wild summer steelhead fry and 52 wild parr between 1 March and 6 December. Steelhead parr greater than 65 mm and in good physical condition were PIT tagged (*N* = 49), and 48 were released after subtracting a single mortality (Appendix A). Overall mortality of fry (*N* = 0) and parr (*N* = 1) totaled (1.7%) of the total fry and parr captured. Wild steelhead parr and fry had mean fork lengths of 113.0 mm and 29.8 mm respectively.

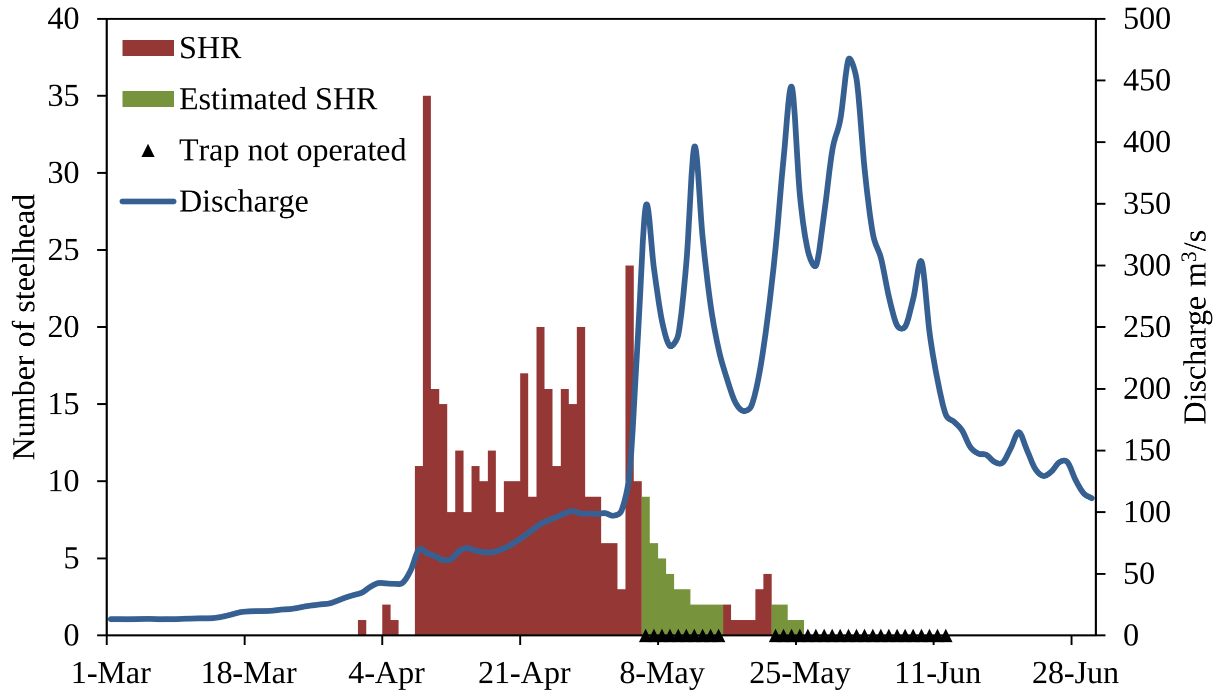

Figure 6. Daily capture of wild steelhead smolt and transitional migrants at the Methow River smolt trap in 2017.

Table 3. Mean length, weight and condition factor by age class of wild transitional and smolt summer steelhead emigrants captured in Methow basin traps in 2017.

Age	*N* (%)	Fork (mm)			Weight (g)			Mean
		Mean	*N*	SD	Mean	*N*	SD	K-factor
				Methow River trap				
1	31 (9.7)	140.1	31	10.5	28.8	30	6.5	1.0
2	263 (82.4)	178.1	263	21.0	56.7	257	21.6	1.0
3	25 (7.8)	185.8	25	21.1	63.7	25	23.0	1.0
4	0 (0.0)	--	--	--	--	--	--	--
				Twisp River trap				
1	12 (6.6)	129.2	12	17.6	24.0	12	9.0	1.1
2	154 (84.2)	163.3	154	15.6	41.8	154	10.7	0.9
3	17 (9.3)	175.8	17	20.0	53.3	17	18.8	1.0
4	0 (0.0)	--	--	--	--	--	--	--

A total of 236 wild summer steelhead emigrants (smolt and transitional) were captured at the Twisp trap between 17 March and 30 June, and the peak capture occurred on 8 April (*N* = 30; Figure 7). Wild emigrants (all ages combined) had a mean fork length of 164.5 mm, and were primarily age-2 fish (84.2%; Table 3). We inserted PIT tags into 224 wild steelhead emigrants and all were released alive (Appendix A). There were no mortalities experienced by smolt or transitional steelhead at the Twisp site (0.0%). A total of 2,638 hatchery summer steelhead juveniles were captured at the Twisp River trap, and no mortalities were experienced (0.0%). We conducted upstream releases of 100 hatchery steelhead to aid in mark/efficiency trials, of which 96 had existing PIT tags, and 4 received caudal clips for later identification.

Non-migrant summer steelhead captured at the Twisp trap included 23 wild fry and 524 wild parr captured between 17 March and 3 December (Figure 8). We inserted PIT tags into 474 steelhead parr greater than 65 mm and 472 were released after two mortalities (Appendix A). Overall mortality of fry (*N* = 0) and parr (*N* = 2) represented 0.37% of the total fry and parr captured (*N* = 547). Wild steelhead parr and fry had mean fork lengths of 105.0 mm and 32.3 mm respectively.

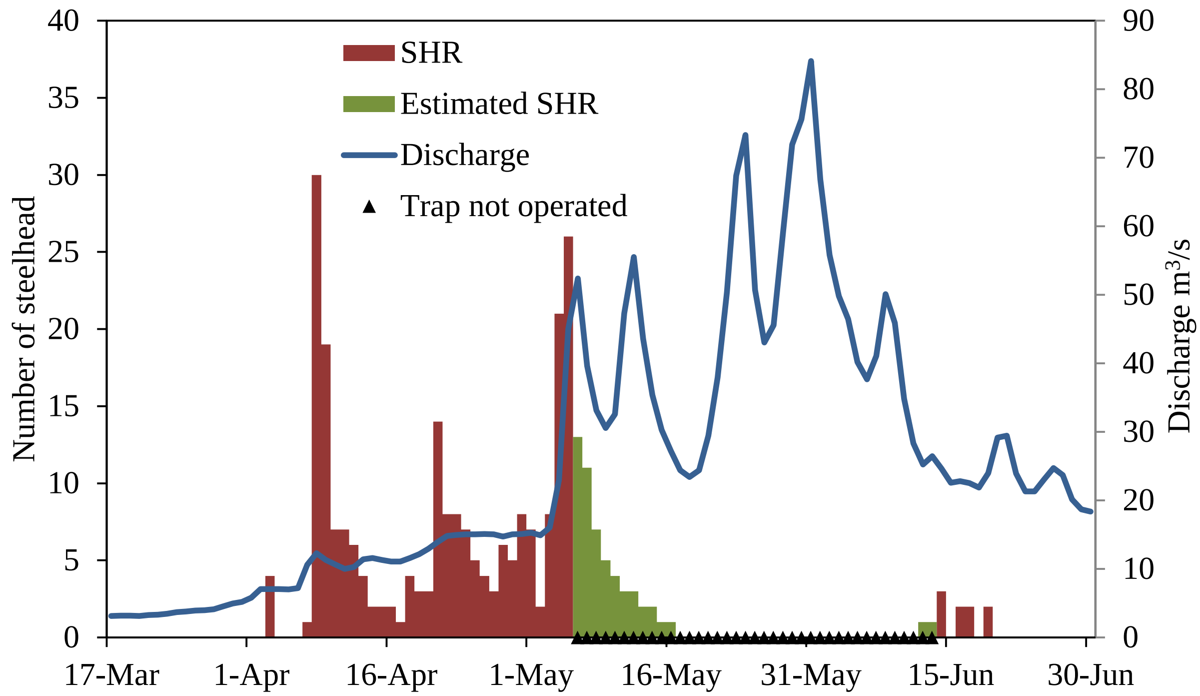

Figure 7. Daily capture of wild steelhead (SHR) smolt and transitional migrants at the Twisp River smolt trap in 2017.

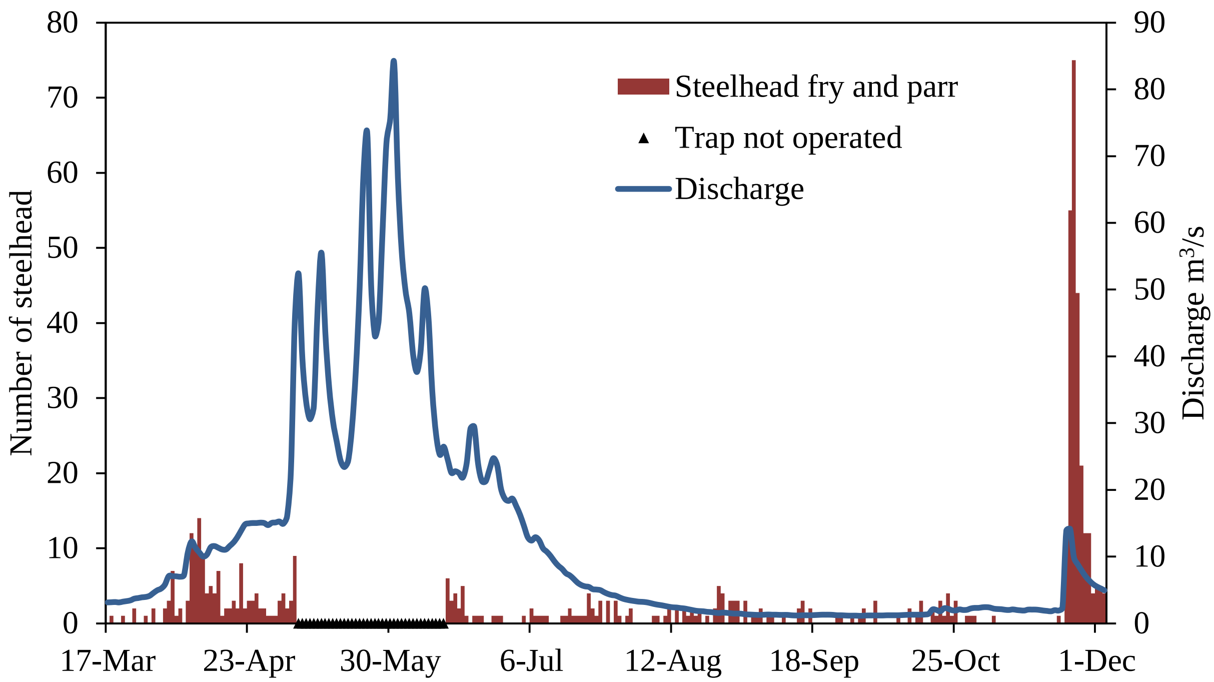

Figure 8. Daily capture of wild steelhead fry and parr at the Twisp River smolt trap in 2017.

<u>*Incidental Species*</u>

Hatchery Coho salmon (*O. kisutch*) were the most abundant incidental species captured at the Methow River trap, while Longnose Dace (*Rhinichthys cataractae*) were the most abundant incidental species captured at the Twisp River trap. 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 2017.

Species	Captured	Fork length (mm)			Weight (g)		
		Mean	*N*	SD	Mean	*N*	SD
Methow River trap							
Hatchery Coho (*O. kisutch*)	2,223	136.8	126	10.4	28.4	123	6.5
Longnose Dace (*Rhinichthys cataractae*)	977	34.0	585	20.9	7.3	77	8.1
Sockeye fry (*O. nerka*)	261	28.1	112	1.8	--	--	--
Pacific Lamprey (*Lampetra tridentata*)	176	152.4	74	28.5	6.6	67	2.4
Sucker (*Catostomus spp.*)	158	66.5	105	36.9	15.3	52	15.7
Redside Shiner (*Richardsonius balteatus*)	57	28.3	57	12.2	17.6	1	--
Sculpin (*Cottus spp.*)	50	53.5	46	29.1	8.0	23	7.8
Mountain Whitefish (*Prosopium williamsoni*)	24	38.7	18	18.3	6.5	2	5.6
Wild Coho smolt (*O. kisutch*)	5	123.0	5	10.5	20.3	5	5.0
Bull Trout (*Salvelinus confluentus*)	4	194.0	4	76.5	99.3	4	104.7
Brown Bullhead (*Ictalurus nebulosus*)	3	122.3	3	34.3	29.6	3	17.4
Wild Coho fry (*O. kisutch*)	2	43.0	2	5.7	--	--	--
Wild Coho parr (*O. kisutch*)	1	96.0	1	--	11.1	1	--
Cutthroat Trout (*O. clarki*)	1	150.0	1	--	34.5	1	--
Umatilla Dace (*Rhinichthys umatilla*)	1	38.0	1	--	--	--	--
Twisp River trap							
Longnose Dace (*Rhinichthys cataractae*)	1,247	95.1	876	21.3	12.4	834	6.5
Sculpin (*Cottus spp.*)	94	70.1	89	30.7	12.0	54	8.6
Sucker (*Catostomus spp.*)	55	81.9	52	38.0	11.8	50	14.8
Mountain Whitefish (*Prosopium williamsoni*)	52	48.3	49	42.1	35.9	10	98.4
Bull Trout (*Salvelinus confluentus*)	17	196.6	16	34.3	80.1	16	47.6
Cutthroat Trout (*O. clarki*)	6	167.6	5	24.5	48.8	5	22.7
Wild Coho parr (*O. kisutch*)	6	100.0	6	23.2	11.6	6	5.0
Wild Coho smolt (*O. kisutch*)	4	112.0	4	8.8	14.9	4	3.1
Bridge lip sucker (*Catostomus columbianus*)	2	407.5	2	10.6	599.0	1	--
Sockeye fry (*O. nerka*)	2	30.5	2	2.1	--	--	--

Population Estimates

2015 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 were unable to conduct any mark/recapture trials for the low trap position because fish abundance was fairly low for the early trapping period. 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-05x+0.161723324) was used for the low trapping position in 2017. For the upper trapping position, a mark/recapture trial was conducted with wild spring Chinook in addition to two trials utilizing hatchery Chinook. These three groups were combined with releases conducted during the previous three years, which resulted in a significant relationship ($P < 0.01$, $r^2 = 0.69$; Table 5) and the regression (y = -2.16E-05x + 0.245227106) was used for the upper position in 2017. Using both these flow models, the estimated number of yearling spring Chinook salmon emigrants was 20,653 (± 3,147, 95% CI). Combining the yearling emigrants with the estimate of parr that emigrated past the trap in the fall of 2016 (5,847 ± 16,007, 95% CI), an estimated 26,500 (± 16,314, 95% CI) 2015 brood wild spring Chinook migrated from the Methow River basin between 1 October 2016 and 30 June 2017. The majority of the emigrants (55.4%) moved as smolts during the month of April 2017 (Figure 9).

Five mark/recapture trials were conducted with Chinook at the Twisp trap in the spring of 2017, two with wild spring Chinook, two with hatchery spring Chinook, and another with both wild and hatchery spring Chinook. Combining these groups with historical trials, a significant relationship existed between river discharge and trap efficiency ($P < 0.01$, $r^2 = 0.54$; Table 6). The flow model regression (y = -0.000454006x + 0.505722751) was used to estimate that 8,653 (± 1,653, 95% CI) smolts emigrated past the Twisp River trap between 17 March and 30 June 2017. There were no spring Chinook redds identified below the Twisp trap in 2015, so no expansion for this area was necessary. Snow et al. (2017) estimated that 13,831 (± 3,198, 95% CI) 2015 brood spring Chinook salmon parr emigrated from the Twisp River in the fall of 2016. In addition to the smolt trap estimates, mark/detection trials performed at the Twisp PIT tag array (Table 7) were used to estimate that 142 (± 29, 95% CI) spring Chinook emigrated between 6 December 2016 and 16 March 2017 when the smolt trap was not operating. Adding all emigrant totals, the complete emigration estimate for the 2015 spring Chinook brood was 22,626 (± 3,600, 95% CI) fish. Emigration peaked during April 2017, when 28.4% of the 2015 brood migrated as smolts from the Twisp River (Figure 10).

To strengthen the validity of the Chinook estimates calculated from the Twisp River trap, we also estimated abundance by expanding PIT interrogations at the TWR PIT array. We found the

2015 brood Chinook captured between 1 September 2016 and 30 June 2017 to have an existing PIT tag rate of 0.85 percent. The PIT tag rate in conjunction with the flow/efficiency regression created for the TWR PIT antennas ($y = -0.00112806x + 1.251259012$; Table 7) was used to estimate that 25,870 (± 4,805, 95% CI) 2015 brood spring Chinook migrated past the TWR interrogation site between 1 July 2016 and 30 June 2017. There were no spring Chinook redds identified below the Twisp array in 2015, so no expansion for this area was necessary. This estimate was 14 percent higher than 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 fewer sub-yearling migrants, but more yearling emigrants than the screw trap. For consistency, all production tables include the population estimates created from the screw trap estimation method.

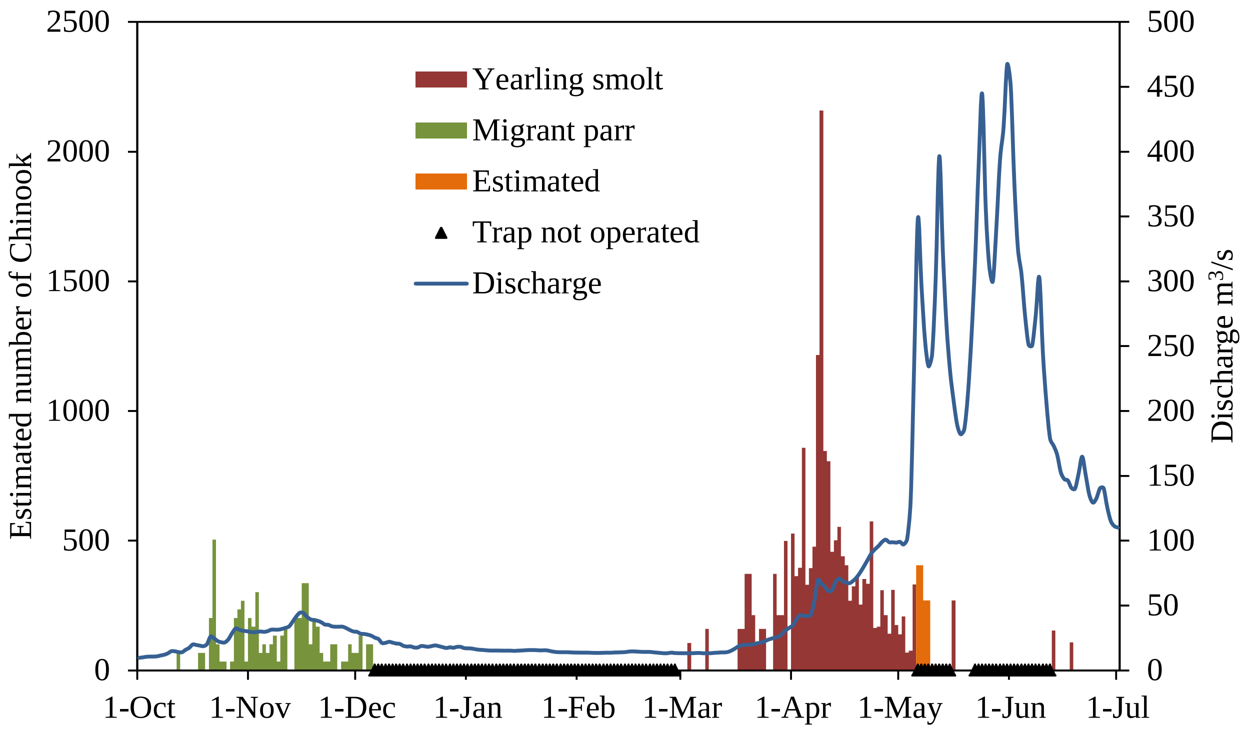

Figure 9. Estimated daily emigration of 2015 brood spring Chinook salmon from the Methow River by life stage.

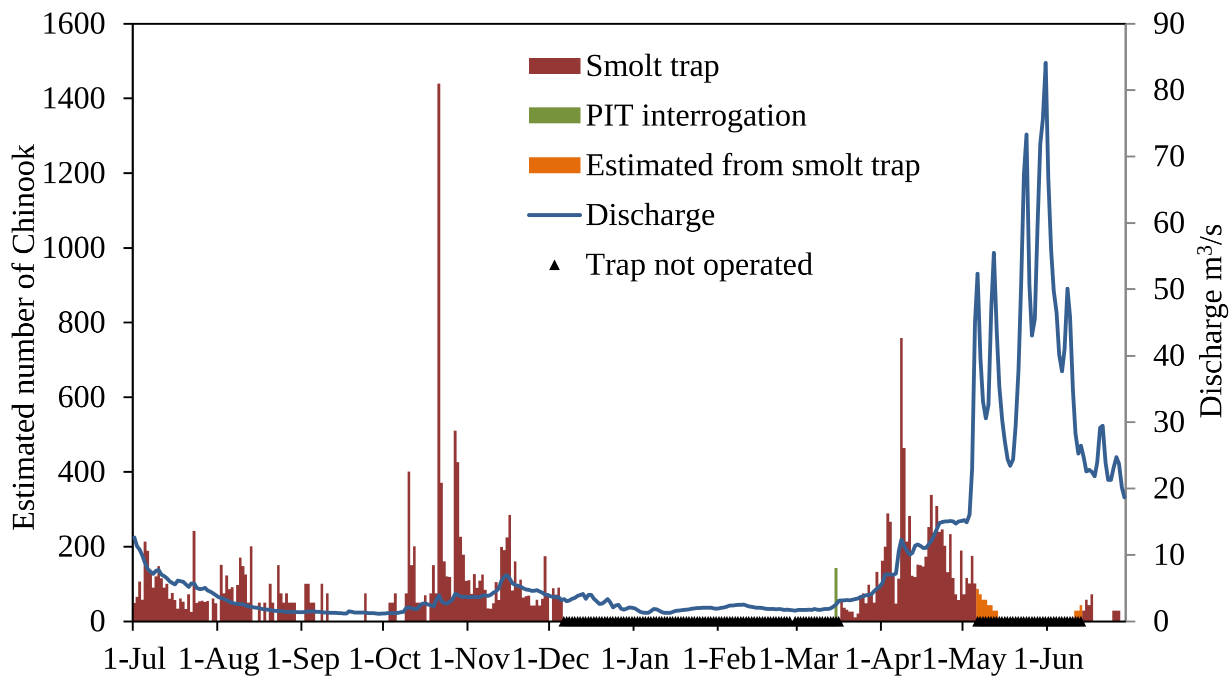

Figure 10. Estimated daily emigration of 2015 brood spring Chinook from the Twisp River by estimation method.

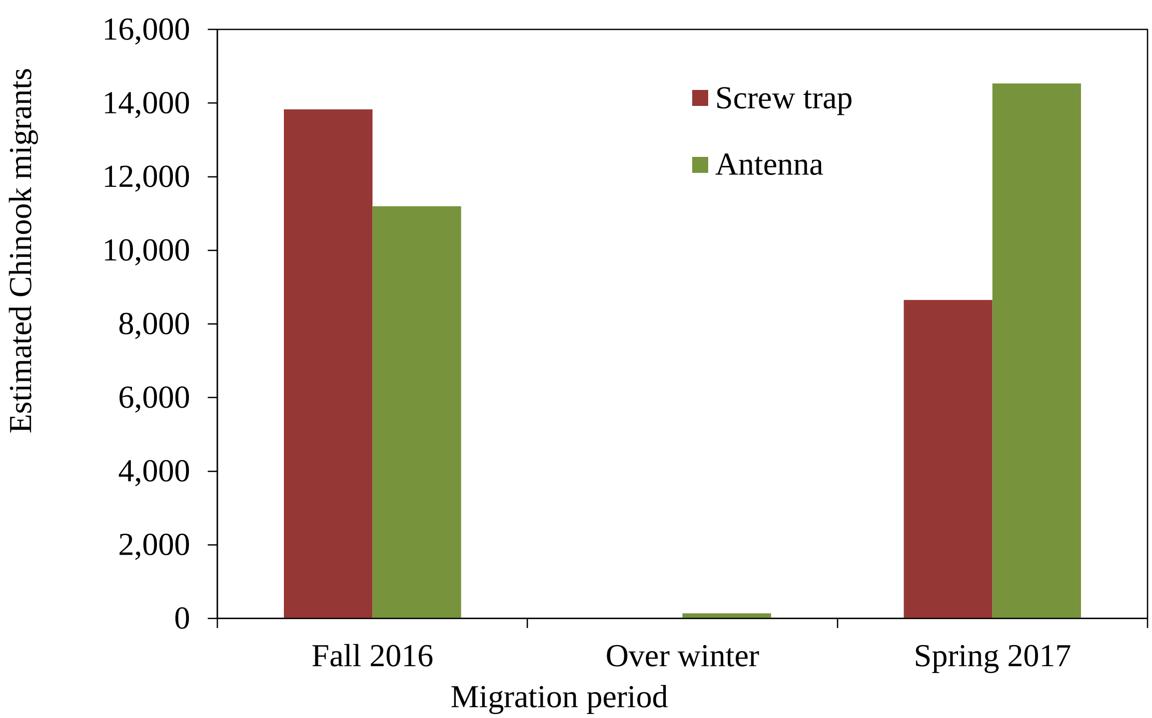

Figure 11. Estimated 2015 brood spring Chinook migration from the Twisp River by migration time and estimation method.

Table 5. Mark/recapture efficiency trials used to estimate emigration of 2015 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	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
YCW	09-Apr-17	Upper	124	2	1.61	64.7
YCH	21-Apr-17	Upper	337	9	2.67	82.2
YCH	25-Apr-17	Upper	204	3	1.47	97.0
	Flow model		3,178	80	2.50	

Table 6. Mark/recapture efficiency trials used to estimate emigration of 2015 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
YCW	04-Apr-17	Low	109	10	9.2	7.0
YCW	10-Apr-17	Low	132	16	12.1	10.3
YCH, YCW	19-Apr-17	Low	273	32	11.7	12.4
YCH	20-Apr-17	Low	200	25	12.5	13.4
YCH	23-Apr-17	Low	105	7	6.7	15.0
	Flow model		5,103	676	13.2	

<u>*2016 Brood Spring Chinook Salmon*</u>

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 2017, and a pooled efficiency was used to estimate fish passage during this time period (Table 8). To increase the sample size for the pooled estimate, we utilized 586 fish released above the Twisp trap instead of the 153 fish released above the Methow trap to calculate the pooled efficiency. Of the 586 Chinook released above the Twisp trap, seven of them were recaptured at the Methow trap providing a pooled efficiency of approximately 1.19%. Using this pooled efficiency, an estimated 13,227 (± 60,884, 95% CI) subyearling spring Chinook migrated past the trap in the fall of 2017.

Three mark/recapture trials were conducted at the Twisp trap site in the fall of 2017, 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 ($P < 0.01$, $r^2 = 0.57$; Table 9). The flow model regression ($y = 0.000908708x + 0.119169681$) was used to estimate that 15,241 (± 3,758, 95% CI) 2016 brood spring Chinook salmon parr emigrated past the Twisp trap between 1 July and 3 December 2017. There was a very sharp increase in river discharge and debris loading on 23 November which made daytime trap operation impossible. The trap was pulled for eleven hours during the day, but the TWR PIT tag array indicated significant fish movement during this time. Mark/detection trials performed at the Twisp PIT tag array (Table 7) were used to estimate that 5,815 (± 4,578, 95% CI) spring Chinook emigrated during the day on 23 November while the smolt trap was not operating. Summing these estimates, the total fall emigration estimate for the 2016 brood was 21,056 (± 5,923, 95% CI). There were no Chinook redds observed below the Twisp trap site in 2016, so no expansion to account for migrants originating from this area 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 downstream of TWR	Detected downstream and at TWR	Efficiency (%)	Discharge (m^3/s)
YCW	26-Mar-09	61	25	18	72.0	2.01
YCW	13-Apr-09	75	26	19	73.1	4.90
YCW	16-Apr-09	72	23	19	82.6	4.93
YCW	19-Apr-09	73	25	17	68.0	5.78
YCW	05-Apr-10	63	21	18	85.7	3.28
YCW	08-Apr-10	61	21	17	81.0	3.11
YCW	11-Apr-10	45	16	13	81.3	2.97
YCW	20-Apr-10	95	33	14	42.4	13.20
YCW	14-Apr-12	78	21	12	57.1	6.03
YCW	21-Apr-12	61	16	8	50.0	9.09
YCW	09 Apr-14	71	17	7	41.2	7.02
YCW	02-Apr-16	82	28	4	14.3	22.12
YCW	05-Apr-16	66	32	2	6.3	23.25
YCW	22-Apr-17	61	17	4	23.5	15.06
	Flow model	964	321	172	53.6	

Table 8. Mark/recapture efficiency trials used to estimate emigration of 2016 brood subyearling spring Chinook salmon (SBC) at the Methow River smolt trap in 2017.

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
SBC	03-Oct-17	Low	5	0	0.00	10.6
SBC	06-Oct-17	Low	4	0	0.00	10.8
SBC	10-Oct-17	Low	6	0	0.00	10.9
SBC	13-Oct-17	Low	7	0	0.00	11.0
SBC	16-Oct-17	Low	6	0	0.00	11.1
SBC	20-Oct-17	Low	41	0	0.00	13.5
SBC	23-Oct-17	Low	32	1	3.13	14.7
SBC	26-Oct-17	Low	11	0	0.00	13.5
SBC	29-Oct-17	Low	15	0	0.00	14.0
SBC	01-Nov-17	Low	20	0	0.00	14.4
SBC	04-Nov-17	Low	5	0	0.00	14.5
SBC	07-Nov-17	Low	12	0	0.00	13.6
SBC	10-Nov-17	Low	9	0	0.00	14.0
SBC	14-Nov-17	Low	18	0	0.00	14.3
SBC	17-Nov-17	Low	9	0	0.00	13.9
SBC	22-Nov-17	Low	12	0	0.00	19.8
SBC	24-Nov-17	Low	100	4	4.00	58.4
SBC	25-Nov-17	Low	100	1	1.00	49.3
SBC	27-Nov-17	Low	118	1	0.85	41.1
SBC	29-Nov-17	Low	41	0	0.00	35.0
SBC	02-Dec-17	Low	15	0	0.00	30.3
	Pooled		586	7	1.19	

Table 9. Mark/recapture efficiency trials used to estimate emigration of 2016 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	

<u>*Summer Steelhead*</u>

Because few migratory steelhead were captured, no mark/recapture trials were conducted with steelhead in 2017 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 22,526 (± 5,103, 95% CI) summer steelhead emigrated past the Methow River trap in 2017. An additional 141 migrants were estimated from redds located downstream of the trap in 2013 through 2016, which provides a total estimated migration of 22,667 (± 5,119, 95% CI) summer steelhead from the Methow River basin in 2017. Most 2017 migrants were age-2 fish (82.1%) from the 2015 brood (Table 10). The entire 2013 brood migration was estimated to be 19,278 (± 4,085, 95% CI) fish, including 642 migrants that were expected from the 27 redds located downstream of the Methow trap in 2013 (Table 14).

A single mark/recapture trial was conducted with wild summer steelhead at the Twisp site in 2017. Combining this group with historical trials, a significant relationship existed between river discharge and trap efficiency ($P < 0.01$, $r^2 = 0.53$; Table 11). The flow model regression ($y = -0.00029807x + 0.410559405$) was used to estimate that 5,926 (± 1,670, 95% CI) wild summer steelhead migrated past the Twisp River trap between 17 March and 30 June 2017. An additional 465 migrants were estimated from redds located downstream of the trap in 2013 through 2016, which provides a total estimated migration of 6,391 (± 1,734, 95% CI) summer steelhead from the Twisp River in 2017. Most 2017 migrants were age-2 fish (83.7%) from the 2015 brood (Table 10). Combining numbers from the last four years, the entire 2013 brood migration is estimated to be 5,715 (± 1,580, 95% CI) fish, which includes 327 expected migrants produced from eight redds downstream of the Twisp trap in 2013 (Table 14).

Table 10. Estimated number of steelhead emigrants from the Methow River basin in 2017 by age and brood.

Age	Brood	Percent of emigrants	Number
		Methow River trap	
1	2016	9.7	2,195
2	2015	82.1	18,609
3	2014	8.2	1,863
4	2013	0.0	0
Total		100.0	22,667
		Twisp River trap	
1	2016	6.5	414
2	2015	83.7	5,353
3	2014	9.8	624
4	2013	0.0	0
Total		100.0	6,391

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
SHR	10-Apr-17	Low	54	4	7.41	10.31
	Flow model		1,238	96	7.75	

2016 Brood Summer Chinook Salmon

Eight mark/recapture trials were conducted at the Methow trap with subyearling Chinook for the low position in the spring of 2017, but no significant relationship was found between flow and efficiency, so a pooled efficiency of approximately 1.11 percent was used to estimate Chinook emigration during that period (Table 12). Numerous mark/recapture trails were conducted with subyearling Chinook for the upper trapping position in 2017, but a significant relationship did not exist. However, a significant efficiency discharge relationship existed from release groups conducted during previous seasons (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 669,432 (± 468,739, 95% CI) wild summer Chinook migrated past the Methow trap in 2017. There were 215 summer Chinook redds located downstream of the Methow trap in 2016, so an estimated 159,920 (± 229,102 95% CI) fish migrated from redds located below the trap, thus bringing the total to 829,352 (± 521,732, 95% CI) wild 2016 brood summer Chinook migrants from the Methow River in 2017.

2015 Brood Coho Salmon

A total of eleven wild juvenile Coho migrants were captured at the Twisp site and five were captured at the Methow site between 1 July 2016 and 30 June 2017. Utilizing the same mark/recapture efficiency trial data used for spring Chinook at each site (see Tables 5-9), an estimated 296 (± 155, 95% CI) and 400 (± 348, 95% CI) wild 2015 brood Coho emigrated past the Twisp and Methow River traps, respectively.

Table 12. Mark/recapture efficiency trials used to estimate emigration of 2016 brood summer Chinook salmon (SBC) at the Methow River smolt trap in 2017.

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
SBC	03-Mar-17	Low	96	2	2.08	13.3
SBC	07-Mar-17	Low	83	1	1.20	13.3
SBC	18-Mar-17	Low	155	1	0.65	19.7
SBC	22-Mar-17	Low	131	2	1.53	21.2
SBC	25-Mar-17	Low	96	0	0.00	24.1
SBC	30-Mar-17	Low	130	2	1.54	32.0
SBC	03-Apr-17	Low	140	2	1.43	42.2
SBC	15-Jul-17	Low	70	0	0.00	44.1
	Pooled		901	10	1.11	
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

2015 Brood Spring Chinook Salmon

Yearling emigrants accounted for 38.2% of all 2015 brood spring Chinook salmon migrating from the Twisp River, and 77.9% of the overall emigrants from the Methow River basin (Table 13). The 2015 brood had more emigrants per redd than average in the Twisp River, but less than average for the Methow River.

Summer Steelhead

Since juvenile steelhead may emigrate as age-4 fish, completed emigration estimates have only been calculated for broods prior to 2014 (Table 14). The 2013 brood produced an estimated 24 and 41 emigrants from each redd in the Methow and Twisp River basins, respectively.

Table 13. Estimated egg-to-emigrant and emigrant-per-redd survival for Methow Basin spring Chinook. 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 (%)	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	8,653	22,626	4.3	190
Twisp	2016	46	209,262	21,056	--	21,056	--	--
Twisp	Mean 2003-2015	86	325,103	7,024	5,632	13,212	4.4	168
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	20,653	26,500	0.7	27
Methow	2016	361	1,426,641	13,227	--	13,227	--	--
Methow	Mean 2002-2015	765	2,900,219	10,410	25,376	34,299	1.2	46

Table 14. Estimated egg-to-emigrant and emigrant-per-redd survival of Methow Basin summer steelhead. 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 (%)	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	0	5,715	0.68	41
Twisp	2014	144	759,456	288	4,273	624	--	5,185	--	--
Twisp	2015	161	938,469	424	5,353	--	--	5,777	--	--
Twisp	2016	210	1,078,980	414	--	--	--	414	--	--
Mean 03-13		294	1,768,092	103	4,402	1,480	119	6,095	0.64	36
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	0	19,278	0.40	24
Methow	2014	878	4,630,572	1,008	11,569	1,863	--	14,440	--	--
Methow	2015	991	5,776,539	3,495	18,609	--	--	22,104	--	--
Methow	2016	682	3,504,116	2,195	--	--	--	2,195	--	--
Mean 03-13		1,111	6,585,415	1,642	12,795	3,038	304	17,778	0.35	20

Smolt to Adult Returns

The PTAGIS website (http://www.ptagis.org) was used to determine adult PIT tag detections at the first Columbia River adult ladder facility encountered for wild Chinook (Table 15) and at Wells Dam for wild steelhead (Table 16). 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	0	2	0.30
2013	2015	434	0	1	--	1	0.23
2014	2016	400	0	--	--	0	0.00
2003-2012 brood mean							0.52
Pooled 2003-2012 brood		7,285	7	38	10	55	0.75
			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	0	2	0.23
2013	2015	441	0	1	--	1	0.23
2014	2016	478	0	--	--	0	0.00
2003-2012 brood mean							0.63
Pooled 2003-2012 brood		4,779	5	20	2	27	0.56

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	0	1	0.37
2016	159	1	--	1	0.63
2006-2015 mean					1.10
Pooled 2006-2015	3,852	20	21	41	1.06
		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	0	1	0.23
2016	188	1	--	1	0.53
2006-2015 mean					0.99
Pooled 2006-2015	3,125	10	11	21	0.67

Discussion

River conditions at both the Methow and Twisp sites were generally favorable for trapping activities during the 2017 season. The Methow trap was not operated for 32 days between 6 May and 12 June because of high river discharge. The only other date in which the Methow trap did not operate was 2 July because of an on-going search and rescue operation at the trapping location. The Twisp trap was pulled from the river for 39 days between 6 May and 13 June because of high river discharge. Operating the traps during this time would make the traps susceptible to damage due to debris, 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 as it has during many previous trapping seasons.

Similar to conditions observed in 2016, river turbidity was abnormally high for much of the spring trapping period due to the additional sediment input from recent wildfire scars 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 2017. A hypothesis for this occurrence is that a significant number of fish actually migrated past the Methow 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. For example, there were 25 days during the month of April when fish present in the Twisp catch box were enumerated prior to sunset. These daytime captures accounted for around a fifth of the total wild spring Chinook and migrant steelhead captures during the same period. This is a slightly smaller proportion than what was observed in 2016, but still a very substantial component of the total migrant estimates. Turbidity levels were always higher at the Methow trap site than they were at the Twisp trap site. If the higher turbidity was indeed causing more fish to migrate during the daytime hours, then estimates of spring Chinook and steelhead abundance were likely underestimated at the Methow trap site.

On 18 December 2016, an ice flow occurred on the lower Twisp River that compromised nearly the entire in-river portion of the TWR PIT interrogation site. The site could not be repaired until 13 March 2017, when we were finally able to access and repair the broken equipment. The Twisp spring Chinook estimates have recently included an over-winter migration component that is calculated using the TWR PIT array. The absence of this data influenced the 2015 brood spring Chinook estimate for the Twisp River, but the extent of the impact is unknown. Conversely, the TWR PIT array was fully functional when operation of the Twisp trap ceased on 24 November because of high debris loads. An estimate of migrants was derived using the TWR PIT array which accounted for over a quarter of the total sub-yearling Chinook fall migration.

In a similar situation to that described above, the Methow trap cone had to be pulled early on the morning of 24 November due to increased debris levels. A similar fish emigration event may have occurred at the Methow trap site on this day, but there is no method of accurately estimating how many fish actually migrated past the Methow trap during this time. The reported sub-yearling portion of the 2016 brood spring Chinook estimate for the Methow River is likely lower than the actual number of migrants that passed the trap in the fall of 2017.

The 2017 trapping season provided opportunities to improve on flow/efficiency models at both trapping locations. For example, the model used to estimate yearling spring Chinook migrants at the Twisp trap site received five new data points, and extended the upper bounds of the existing regression model. The flow/efficiency model used in conjunction with the TWR PIT array to estimate emigration was completely recalculated this year. The regression used in historical estimates was formed using only the RRJ (Rocky Reach Juvenile Bypass) site as the sole indicator of downstream movement. The regression calculated this year used all PIT interrogation sites located downstream of TWR, which provided the model with much larger sample sizes. This also allowed for the incorporation of a wider range of river discharge in the regression.

Production estimates and associated variance estimates for the 2017 trapping season were made using the 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 2017 to determine the proportion of subyearling fish that were spring Chinook salmon. Spring Chinook salmon accounted for 91.8% 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
2017	Twisp	793	0	686	224	0	472
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
2017	Methow	471	0	164	360	1	48

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

2017 Methow Chinook salmon juvenile assignments

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Report, January 2018

Summary

In fall 2017, 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 34% of the spring type originated in the Twisp population.

Methods

We genotyped 170 juvenile Chinook salmon (WDFW collection code 17FA, 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 assessed with the assignment test in GENECLASS (Piry et al. 2004). The program uses 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

Results from GENECLASS indicated that most of the juveniles were spring run group (Figure 1 and Table 2). We plotted the negative log likelihood assignment values for the juveniles and for the adult spring and summer Chinook salmon collections (Figure 1). 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 14 juveniles assigned to the summer collection (plotted within or near the cluster formed by the Methow summer Chinook). Twelve 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 2. For instance, 17FA0007 assigned with 51% likelihood to Methow spring and with 49% likelihood to Twisp spring.

In summary, 14 smolts assigned with high likelihood to the Methow summer Chinook salmon collection and 156 smolts assigned to Methow or Twisp spring Chinook salmon collections.

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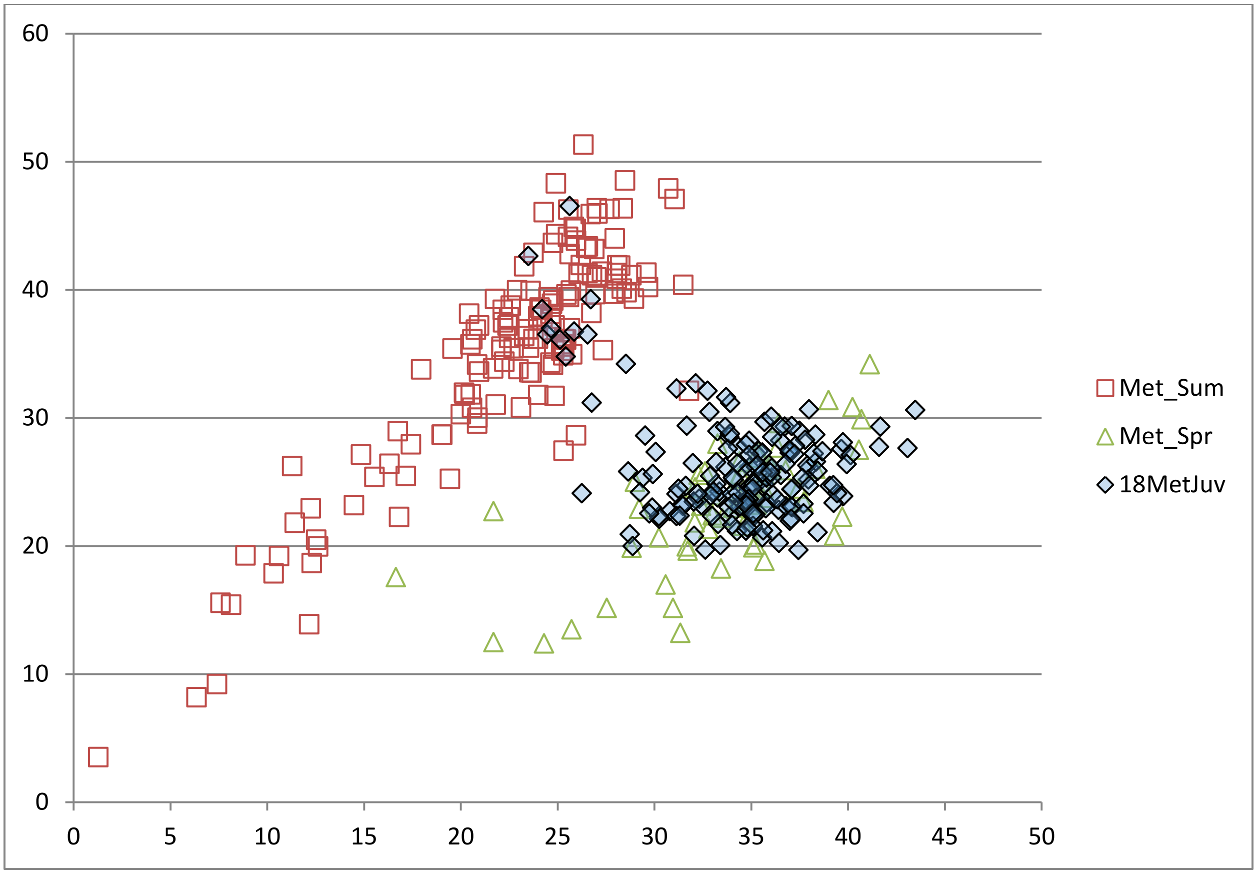

Figure 1. Graph of negative log likelihood assignment scores from GENECLASS. Methow juveniles (blue diamonds) are abbreviated Juv.

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

Code	Name	N
17FA	Methow juveniles - 2017	170
05HW	Methow spring	42
05HX	Twisp spring	42
93EC	GAPS Methow summer	143

Table 2. Juvenile assignments from GENECLASS. See Figure 1 for graphic of the negative log likelihoods of assignment from GeneClass. Abbreviations include Methow as “Met”, spring as “spr”, and summer as “sum”.

sample	assigned	score rel like	MetSum '-log(L)	MetSpr '-log(L)	TwispSpr '-log(L)	sample	assigned	score rel like	MetSum '-log(L)	MetSpr '-log(L)	TwispSpr '-log(L)
17FA001	MetSum	93.1	31.15	32.28	40	17FA051	TwispSpr	97.21	34.87	24.57	23.03
17FA002	MetSpr	99.98	37.13	23.01	26.74	17FA052	MetSpr	100	40.14	27.07	32.69
17FA003	MetSpr	99.52	31.14	24.05	26.37	17FA053	TwispSpr	99.92	36.08	28.51	25.42
17FA004	MetSpr	86.5	43.48	30.59	31.4	17FA054	MetSpr	99.27	32.33	23.67	25.8
17FA005	TwispSpr	100	33.9	22.3	17.25	17FA055	TwispSpr	98.3	29.4	25.31	23.55
17FA006	MetSpr	91.68	35.91	26.36	27.4	17FA056	Spring	51.2	36.79	23.07	23.09
17FA007	Spring	51.21	34.26	21.16	21.18	17FA057	TwispSpr	99.74	35.14	24.83	22.25
17FA008	MetSum	100	25.43	34.78	42.2	17FA058	MetSpr	97.81	34.89	28.21	29.86
17FA009	TwispSpr	99.99	37.5	28.97	24.77	17FA059	MetSpr	99.84	36.35	23.63	26.41
17FA010	MetSpr	100	36.1	24.03	32.01	17FA060	MetSpr	96.54	35.4	27.41	28.85
17FA011	TwispSpr	99.69	33.29	21.7	19.18	17FA061	MetSpr	99.97	34.64	23.99	27.58
17FA012	MetSpr	99.96	34.73	21.19	24.56	17FA062	MetSpr	98.4	35.78	25.32	27.11
17FA013	MetSpr	97.75	36.73	29.31	30.94	17FA063	TwispSpr	99.97	39.27	23.36	19.8
17FA014	Spring	50.43	36.41	22.81	22.8	17FA064	MetSpr	99.99	39.06	24.67	28.62
17FA015	MetSum	100	24.47	36.51	36.02	17FA065	Spring	61.12	36.09	21.14	21.34
17FA016	MetSpr	100	33.27	23.78	33.35	17FA066	MetSpr	100	34.02	21.63	27.21
17FA017	MetSpr	87.59	33.02	24.16	25.01	17FA067	MetSpr	100	35.24	23.72	32.99
17FA018	MetSpr	74.75	35.25	27.21	27.68	17FA068	MetSpr	99.96	38.34	26.57	29.93
17FA019	TwispSpr	99.73	39.75	23.87	21.31	17FA069	TwispSpr	99.99	33.87	28.53	24.7
17FA020	TwispSpr	100	33.26	28.96	23.55	17FA070	MetSpr	99.68	35.08	24.49	26.99
17FA021	MetSpr	99.98	36.5	28.22	31.82	17FA071	MetSpr	100	34.88	23.65	34.21
17FA022	MetSum	100	25.86	36.74	42.67	17FA072	MetSpr	100	36.54	29.32	34.5
17FA023	TwispSpr	99.94	33.35	24.23	21	17FA073	Spring	57.24	30.06	27.34	27.22
17FA024	MetSpr	99.96	38.31	28.68	32.05	17FA074	TwispSpr	100	35.57	27.28	21.49
17FA025	TwispSpr	99.93	37	21.97	18.82	17FA075	Spring	64.82	37.07	24.41	24.67
17FA026	TwispSpr	99.72	35.8	23.36	20.81	17FA076	MetSpr	98.96	37.99	30.65	32.63
17FA027	MetSpr	99.73	33.92	31.16	34.19	17FA077	TwispSpr	95.45	32.85	30.45	29.13
17FA028	MetSpr	100	32.63	19.71	24.88	17FA078	Spring	45.42	32.74	32.11	32.13
17FA029	MetSpr	100	31.43	23.2	30.1	17FA079	TwispSpr	99.99	37.96	25.18	20.94
17FA030	MetSum	100	24.2	38.49	43.64	17FA080	MetSpr	98.97	39.44	24.11	26.09
17FA031	MetSpr	99.98	30.25	22.11	25.75	17FA081	MetSpr	99.65	30.8	22.7	25.15
17FA032	TwispSpr	99.94	34.65	23	19.79	17FA082	MetSpr	100	32.44	23.17	33.02
17FA033	TwispSpr	100	34.33	27.74	23.42	17FA083	TwispSpr	100	26.26	24.12	18.88
17FA034	MetSpr	99.05	36.53	25.54	27.56	17FA084	MetSum	100	26.76	31.17	40.06
17FA035	TwispSpr	96.22	35.14	22.28	20.87	17FA085	MetSpr	99.97	32.04	23.45	26.92
17FA036	TwispSpr	79.12	33.2	24.82	24.24	17FA086	MetSpr	100	34.43	23.07	28.95
17FA037	MetSpr	99.61	35.41	24.98	27.39	17FA087	TwispSpr	98.88	31.98	26.45	24.5
17FA038	MetSpr	100	37.09	29.37	34.65	17FA088	MetSpr	100	37.08	23.05	30.99
17FA039	MetSpr	99.98	35.69	24.78	28.42	17FA089	MetSpr	77.17	31.24	24.45	24.98
17FA040	MetSpr	100	37	27.26	32.16	17FA090	MetSpr	100	30.24	22.31	29.54
17FA041	MetSum	100	24.67	36.98	35.86	17FA091	TwispSpr	76.96	31.67	29.37	28.85
17FA042	TwispSpr	99.47	38	26.12	23.84	17FA092	MetSpr	92.43	38.24	27.21	28.29
17FA043	MetSpr	99.09	35.58	20.67	22.7	17FA093	MetSpr	99.93	33.99	24.05	27.19
17FA044	MetSpr	99.93	37.91	26.28	29.43	17FA094	MetSpr	99.99	31.47	23.11	26.94
17FA045	TwispSpr	99.98	39.65	27.55	23.74	17FA095	TwispSpr	100	36.07	25.34	20.46
17FA046	TwispSpr	75.82	43.07	27.64	27.14	17FA096	TwispSpr	87.71	37.1	24.44	23.58
17FA047	TwispSpr	99.88	35.76	22.94	20.02	17FA097	TwispSpr	99.91	37.06	27.4	24.37
17FA048	Spring	57.4	34.91	26.15	26.27	17FA098	TwispSpr	99.87	35.69	29.67	26.79
17FA049	MetSpr	100	31.63	24.67	31.3	17FA099	MetSpr	100	33.84	23.01	28.19
17FA050	MetSpr	100	33.41	20.06	29.93	17FA100	TwispSpr	100	37.78	28.29	23.66

Table 2, continued.

sample	assigned	score rel like	MetSum '-log(L)	MetSpr '-log(L)	TwispSpr '-log(L)	sample	assigned	score rel like	MetSum '-log(L)	MetSpr '-log(L)	TwispSpr '-log(L)
17FA101	TwispSpr	96.37	37.7	23.29	21.86	17FA136	MetSpr	99.26	36.99	27.45	29.58
17FA102	TwispSpr	99.78	34.92	23.12	20.47	17FA137	MetSpr	100	38.01	24.72	29.07
17FA103	MetSpr	100	29.9	22.97	29.4	17FA138	TwispSpr	70.66	34.56	26.02	25.64
17FA104	MetSpr	100	35.23	22.45	33.12	17FA139	MetSpr	99.99	35.63	21.21	25.05
17FA105	MetSpr	92.98	34.72	23.58	24.7	17FA140	MetSpr	97.7	34.89	27.1	28.73
17FA106	MetSpr	100	37.64	25.3	30.31	17FA141	TwispSpr	100	33.19	26.54	21.77
17FA107	Spring	62.14	37.27	27.8	27.58	17FA142	TwispSpr	87.63	34.75	23.17	22.32
17FA108	TwispSpr	98.17	33.81	27.59	25.86	17FA143	MetSpr	72	35.61	25.74	26.15
17FA109	TwispSpr	100	38.43	25.86	20.55	17FA144	MetSpr	98.64	41.67	29.3	31.16
17FA110	MetSum	100	25.14	36.11	36.89	17FA145	MetSum	100	25.62	46.54	46.59
17FA111	MetSpr	89.08	29.53	28.61	31.52	17FA146	MetSum	77.27	32.14	32.67	36.1
17FA112	MetSpr	99.85	29.74	22.53	25.35	17FA147	MetSum	100	26.56	36.51	38.42
17FA113	MetSpr	99.97	36.08	26.08	29.56	17FA148	TwispSpr	99.92	36.04	30.09	27.01
17FA114	TwispSpr	99.9	34.1	25.15	22.14	17FA149	Spring	60.22	38.43	21.07	20.89
17FA115	MetSpr	100	29.27	24.17	31.49	17FA150	TwispSpr	100	38.68	27.38	22.82
17FA116	MetSpr	99.92	34.31	24.13	27.24	17FA151	TwispSpr	97.34	32.99	22.34	20.77
17FA117	MetSum	100	26.72	39.26	39.18	17FA152	MetSpr	100	34.1	23.35	31.29
17FA118	Spring	61.92	33.67	26.17	25.95	17FA153	TwispSpr	89.54	37.24	27.15	26.22
17FA119	MetSpr	99.46	35.09	21.56	23.82	17FA154	MetSpr	93.26	36.79	26.41	27.55
17FA120	MetSpr	99.98	33.05	24.26	28.01	17FA155	TwispSpr	91.77	41.61	27.73	26.68
17FA121	MetSpr	99.78	32.05	20.79	23.44	17FA156	MetSum	100	23.49	42.62	45.21
17FA122	Spring	69.19	32.88	25.45	25.1	17FA157	MetSpr	97.17	33.65	29.27	30.81
17FA123	MetSpr	93.26	33.91	28.76	29.9	17FA158	MetSpr	86.31	28.72	20.9	21.7
17FA124	TwispSpr	99.98	39.24	24.74	20.99	17FA159	MetSpr	99.97	29.92	25.6	29.27
17FA125	TwispSpr	99.49	35.25	26.17	23.88	17FA160	TwispSpr	100	33.71	31.6	26.35
17FA126	MetSpr	99.51	34.74	27.91	30.22	17FA161	MetSpr	99.8	32.24	24.04	26.74
17FA127	TwispSpr	99.93	37.44	19.68	16.51	17FA162	MetSpr	99.99	39.74	28.09	32.1
17FA128	MetSpr	100	39.93	26.38	32.29	17FA163	TwispSpr	99.41	28.66	25.81	23.59
17FA129	TwispSpr	99.95	31.15	22.32	19.02	17FA164	MetSpr	100	35.1	22.5	28.25
17FA130	TwispSpr	89.13	35.32	26.36	25.44	17FA165	MetSum	100	28.53	34.2	40.65
17FA131	MetSpr	99.17	32.91	23.93	26.01	17FA166	TwispSpr	98.71	28.88	19.98	18.1
17FA132	MetSpr	99.85	36.43	20.24	23.07	17FA167	TwispSpr	100	34.28	26.43	21.64
17FA133	TwispSpr	85.77	37.71	22.53	21.75	17FA168	TwispSpr	99.97	31.31	22.35	18.79
17FA134	MetSpr	98.93	37.06	22.1	24.07	17FA169	MetSpr	77.19	34.8	21.43	21.96
17FA135	MetSpr	96.55	34.06	25.33	26.77	17FA170	TwispSpr	99.48	36	25.74	23.46

Attachment B. In-stream PIT tagging of juvenile spring Chinook and steelhead in the Methow River basin in 2017.

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10 April 2018

To: Charlie Snow

From: Ben Goodman

Subject: 2017 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 2017, we conducted in-stream PIT tagging in the Twisp basin 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 (i.e., 2,500 total parr assuming that 1,250 will be age-1 parr). This memo summarizes the methods and results of our in-stream PIT tagging in 2017.

Methods

We used a combination of angling and electrofishing to collect spring Chinook Salmon and *O. mykiss* parr in 2017. 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 3-piece anode pole and stainless steel cable cathode. Electrofisher voltage and frequency were altered by date and location to maximize capture efficiency and minimize fish injury. 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 47), Little Bridge Creek (mouth to rkm 10), and Buttermilk Creek (rkm 1–4), Eagle Creek (rkm 1), South Creek (rkm 1), and War Creek (rkm 1). Angling effort occurred from 5 July to 8 September to target age-1 and age-2 *O. mykiss* 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 the summer steelhead released above 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 8) to the top of T7 (rkm 36). In tributaries and outside of the primary spawning reaches in the mainstem, angling effort was reduced. To reduce spatial bias in the sampling within these areas, 32 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), Little Bridge Creek (mouth to LBC4 [rkm 10]), and Buttermilk Creek (mouth to BM2 [rkm 4]). Electrofishing in the Twisp River basin began on 12 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 County PUD staff using a Generalized Random Tessellation Stratified (GRTS) design.

The GRTS design allows random site selection while ensuring that the sampling design is spatially balanced. Sampling sites were chosen from three spatial strata; 23% (N = 18) of the sites were downstream of the weir, 55% (N = 42) were upstream of the weir, and 22% (N = 17) were in tributaries. Within these strata, sampling sites were randomly 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. Three types of electrofishing sampling methods were used at sampling sites: single-pass, multiple-pass depletion, and recapture sampling. For all three methods, each electrofishing pass occurred in an upstream direction and all the accessible wetted area within the site was sampled with approximately equal effort per pass. Single-pass sites involved only a single electrofishing pass, whereas multiple-pass sites required a minimum of three consecutive electrofishing passes with each pass resulting in fewer fish captured. If more fish were captured on a given pass than on the previous pass during a depletion, then an additional pass was added at that site. A recapture pass was conducted at all depletion sites within 24 hours after the depletion sample in order to evaluate mark-recapture as an alternative method to estimate single pass capture efficiency.

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 in 2017, we captured a total of 3,426 wild *O. mykiss* parr, 326 residual hatchery-origin steelhead parr, and 939 wild Chinook Salmon parr during angling and electrofishing. Most wild Chinook Salmon and *O. mykiss* were tagged (Table 1) unless they were too small or other fish health concerns existed. Angling effort, angling catch, and electrofishing catch in 2017 were within the range of totals from previous years; however, electrofishing effort in 2017 was the greatest since GRTS sampling was initiated (i.e., 2014; Table 2). Wild steelhead fork length in the Twisp River basin was greater for those captured by angling (mean = 148 mm) than by electrofishing (mean = 98 mm) in 2017 (Figure 1; $P < 0.001$; Kolmogorov-Smirnov test).

Recapture passes were conducted at 20 sites in 2017 (14 depletion and 6 single-pass sites) and fish were recaptured at 18 of these sites (including only PIT-tagged fish that were originally tagged during the first pass at depletion sites or single-pass sites) for a total of 184 recaptures. The average number of recaptures per site was 9 fish (21%) in tributaries and 10 fish (25%) in the Twisp mainstem. For all species combined, recapture percentage varied from 0% in Eagle Creek to 50% in site 27500 (Table 3). Across sites, recapture rate was greatest for *O. mykiss* (26%), followed by Westslope Cutthroat Trout (25%), spring Chinook Salmon (24%), and Bull Trout (18%; Table 3). Of the 3,579 unique PIT-tagged fish captured during electrofishing, only three (two *O. mykiss* and one Bull Trout) were captured at multiple GRTS sites and all were recaptured the day following tagging, and within 400 m of the first capture site.

Table 1. Number of wild spring Chinook and *O. mykiss* parr PIT tagged by reach and capture method in the Twisp River basin in 2017. Section descriptions can be found in Section 2, Table 2.5 of this annual report.

Section	Angling			Electrofishing		
	Effort (angler hrs)	Chinook tagged	*O. mykiss* tagged	Effort (wand hrs)	Chinook tagged	*O. mykiss* tagged
T10	6.3	0	8	1.3	0	19
T9	5.5	0	14	1.8	0	67
T8	16.7	0	27	4.8	0	29
T7	35.8	0	154	5.5	155	89
T6	24.3	0	46	6.5	232	120
T5	30.7	1	61	7.1	121	215
T4	25.3	0	168	4.6	53	246
T3	31.0	0	206	8.7	169	466
T2	15.5	0	48	6.6	157	385
T1	11.0	0	56	5.3	48	160
LBC4	3.0	0	18	0.0	0	0
LBC3	9.0	0	51	0.7	0	98
LBC2	6.0	0	28	0.1	0	22
LBC1	12.0	0	90	1.5	0	219
BM2	4.7	0	59	1.9	0	126
BM1	6.0	0	72	0.3	3	37
EA2	0.0	0	0	1.3	0	9
WR1	0.0	0	0	0.1	0	12
SO1	0.0	0	0	0.2	0	1
Total	242.9	1	1,106	59.4	938	2,320

Table 2. Number 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 (angler hrs)	Chinook tagged	*O. mykiss* tagged	Effort (wand hrs)	Chinook tagged	*O. mykiss* 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
2017	242.9	1	1,106	59.4	938	2,320

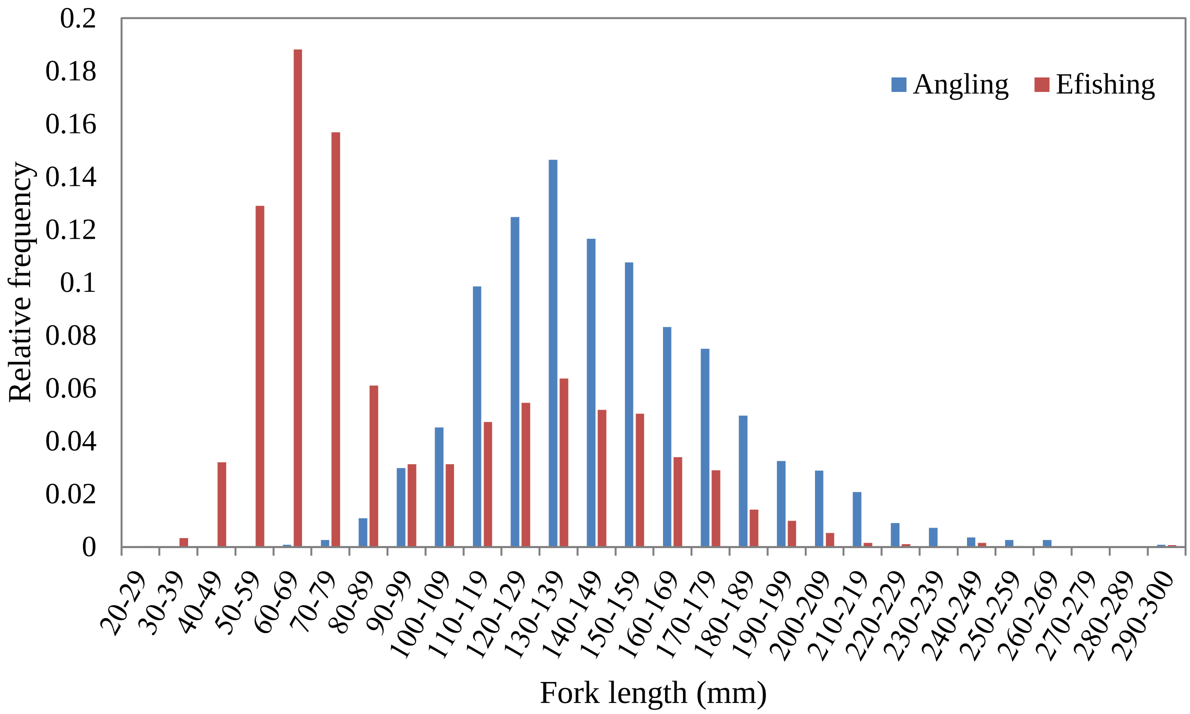

Figure 1. Relative frequency distribution of *O. mykiss* parr fork length by capture method in the Twisp River basin.

Table 3. Number of fish PIT-tagged during initial electrofishing passes (P_1) and the number recaptured during recapture passes (P_R) by site (site number equals river meters upstream from mouth) and species during GRTS sampling in the Twisp basin in 2017.

Site	Bull Trout			Cutthroat Trout			Chinook Salmon			*O. Mykiss*			All spp.		
	P_1	P_R	*%*	P_1	P_R	*%*	P_1	P_R	*%*	P_1	P_R	*%*	P_1	P_R	*%*
Twisp mainstem															
1100	1	0	*0*				7	1	*14*	25	6	*24*	33	7	*21*
2200							6	0	*0*	38	15	*39*	44	15	*34*
6400	1	0	*0*	1	0	*0*	46	13	*28*	76	17	*22*	124	30	*24*
11400	1	0	*0*				30	13	*43*	55	10	*18*	86	23	*27*
14700							5	2	*40*	45	16	*36*	50	18	*36*
16200	1	0	*0*				11	1	*9*	16	4	*25*	28	5	*18*
20600	1	1	*100*				6	2	*33*	22	2	*9*	29	5	*17*
23800	1	0	*0*				33	2	*6*	16	2	*13*	50	4	*8*
27500							3	1	*33*	1	1	*100*	4	2	*50*
29100	1	0	*0*	1	0	*0*	22	5	*23*	9	0	*0*	33	5	*15*
32500	3	0	*0*							13	0	*0*	16	0	*0*
37700	2	1	*50*							8	3	*38*	10	4	*40*
40300	19	2	*11*	2	0	*0*				38	10	*26*	59	12	*20*
42900	7	2	*29*	5	1	*20*				11	2	*18*	23	5	*22*
45700	9	3	*33*	8	4	*50*							17	7	*41*
Twisp tributaries															
500	1	0	*0*	3	0	*0*				3	0	*0*	7	0	*0*
1400										53	21	*40*	53	21	*40*
3500	3	0	*0*							23	3	*13*	26	3	*12*
3900										20	3	*15*	20	3	*15*
5000										37	15	*41*	37	15	*41*
Total	51	9	*18*	20	5	*25*	169	40	*24*	509	130	*26*	749	184	*25*

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 2017.

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From: Charles Frady

To: Charlie Snow

Date: 6 June 2018

Subject: Results of 2017 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 2017). 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 2017 brood. All age classes, mark types, and origins of adults and jacks apportioned to the Methow or Okanogan basin based on proportions of PIT-tagged in each basin. 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 4 June and 8 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 marked 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 2017 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:

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

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 2017, 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 2017 spring Chinook salmon migration to Wells Dam was monitored between 10 May and 27 June on the East Ladder and between 16 May and 27 June on the West Ladder. Overall, migration timing at Wells Dam was very similar between hatchery and wild fish (Table 1). Based on PIT tag detections at Wells Dam fish ladders, an estimated 50 fish were double counted and 102 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 4,942 fish. The run was composed primarily of hatchery fish (89.0%), 78.3% of which were adipose fin-clipped. After correcting for sex determination errors and accounting for fish retained for Methow Basin broodstock (*N* = 637), fish destined for the Okanogan Basin or Chief Joseph Hatchery (*N* = 1,421), and fish removed as surplus (*N* = 1,204) the remaining estimated escapement in the Methow River was 1,680 fish.

Table 1. Mean migration date of hatchery (H) and wild (W) spring Chinook to Wells Dam of the overall return for the 2006-2017 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
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
2017	H	1-June	5-June	8-June	13-June	19-June	8-June	760
2017	W	30-May	2-June	6-June	13-June	14-June	7-June	87

Redd Distribution, Spawn Timing, and Spawner Demographics

Spawning ground surveys were performed on foot between 1 August and 29 September. A total of 210 spring Chinook redds were constructed in the Methow basin in 2017 (Tables 2-4); the majority of redds were found in the Methow River subbasin (59.0%; *N* = 124; Table 2). The greatest number of redds within that subbasin were found in the 9 km reach downstream of Weeman Bridge (*N* = 35). On average, Methow Hatchery females spawned slightly earlier than wild females in the Chewuch subbasin but slightly later than wild females in the Methow subbasin (Tables 5-7). On average, wild females spawned between seven and 12 km further upstream than Methow Hatchery females, depending on subbasin (Tables 5-7).

Based on expanded redd counts, there were an estimated 464 spawners in the Methow River basin in 2017, of which 176 (37.9%) 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 46.8%, 42.6%, and 34.1% of the estimated spawning escapement in the Twisp, Chewuch, and Methow subbasins, respectively (see Tables 2-4).

A total of 62 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 69 of the 88 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 823,356 eggs were deposited in the Methow River basin in 2017 (Table 9).

Table 2. 2017 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	1	0.8	2	0	0	0	0[b]	2[b]
M14	4	3.2	9	0	2	3[a]	0	9
M13	4	3.2	9	0	2	2	2	9
M12	1	0.8	2	1	2	3		
M11	9	7.3	20	3	2	9[a]	12	8
M10	18	14.5	40	7	6	15[a]	22	18
M9	35	28.2	78	13	5	18	58	20
M8	3	2.4	7	2	0	2	7	0
M7	13	10.5	29	2	0	2	29	0
M6	4	3.2	9	1	1	2	5	4
M5,4	1	0.8	2	0	0	0	1[c]	1[c]
Total	93	75.0	207	29	20	56[a]	136	71
			Lost River					
L2	9	7.3	20	0	0	0	0[b]	20[b]
L1	0	0.0	0	0	0	0	0	0
Total	9	7.3	20	0	0	0	0	20
			Early Winters Creek					
EW5,4	0	0.0	0	0	0	0	0	0
EW3	3	2.4	7	1	0	1	7	0
EW2,1	0	0.0	0	0	0	0	0	0
Total	3	2.4	7	1	0	1	7	0
			Methow River tributaries					
HA2	0	0.0	0	0	0	0	0	0
HA1	0	0.0	0	0	0	0	0	0
MH1	2	1.6	4	3	0	3	4	0
Lsusp1	0	0.0	0	0	0	0	0	0
Susp1	3	2.4	7	0	0	0	4[d]	3[d]
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	14	11.3	31	2	0	2	31	0
Total	19	15.3	42	5	0	5	39	3
Grand total	124	100.0	276	35	20	62[a]	182	94

[a] Includes fish of unknown origin (unreadable scales).
[b] Expanded count based on H and W proportions from M14.
[c] Expanded count based on H and W proportions from M6.
[d] Expanded count based on H and W proportions from M11.

Table 3. 2017 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	1	1.6	2	1	0	1	2	0
C12	0	0.0	0	0	0	0	0	0
C11	0	0.0	0	0	0	0	0	0
C10	2	3.1	4	0	1	1	0	4
C9	1	1.6	2	1	1	2	8	7
C8	6	9.4	13	1	1	2		
C7	5	7.8	11	6	5	11	6	5
C6	15	23.3	33	5	6	12[a]	15	18
C5	11	17.2	24	8	5	13	15	9
C4	12	18.8	27	4	1	6[a]	19	8
C3	0	0.0	0	1	1	2		
C2	8	12.5	18	6	6	12	9	9
C1	3	4.7	7	3	0	3	7	0
Total	64	100.0	141	36	27	65[a]	81	60

[a] Includes fish of unknown origin (unreadable scales).

Table 4. 2017 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	2	9.1	4	0	0	0	0	4[a]
T7	2	9.1	4	0	0	0	0	4[a]
T6	11	50.0	24	1	0	1	10	14[a]
T5	6	27.3	13	6	0	6	13	0
T4	0	0.0	0	0	0	0	0	0
T3	1	4.5	2	2	0	2	2	0
T2	0	0.0	0	0	0	0	0	0
T1	0	0.0	0	1	0	0	0	0
Total	22	100.0	47	10	0	10	25	22

[a] Estimates based on recoveries of HOR and NOR spawners in T8,7, and 6 in 2016.

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 2017.

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
2017	H	101	10	18	251	7
2017	W	108	9	16	253	4
Mean	H	104	11	40	251	6
Mean	W	113	12	30	251	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 2017.

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
2017	H	95	10	14	251	6
2017	W	107	7	13	248	5
Mean	H	94	10	109	251	7
Mean	W	106	11	34	249	7

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 in 2017. No wild carcasses were recovered in the Twisp 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
2017	H	85	4	5	256	5
2017	W	- -	- -	- -	- -	- -
Mean	H	87	5	15	249	7
Mean	W	92	6	13	247	7

Table 8. Mean POH length (*N*; SD) by age and sex of spring Chinook salmon carcasses recovered during Methow Basin spawning ground surveys in 2017. These data include all measureable and aged Methow Hatchery fish regardless of their recovery location. No wild carcasses were recovered in the Twisp subbasin.

Stock	Origin	Mean length (POH; cm) of adult returns (*N*; SD)					
		Male			Female		
		Age-3 (2014 BY)	Age-4 (2013 BY)	Age-5 (2012 BY)	Age-3 (2014 BY)	Age-4 (2013 BY)	Age-5 (2012 BY)
MetComp	H	42 (*2*; 1)	65 (*1*; - -)	77 (*1*; - -)	- -	60 (*8*; 2)	- -
Methow / Chewuch	W	41 (*3*; 6)	62 (*12*; 7)	76 (*2*; 1)	- -	61 (*21*; 4)	72 (*6*; 5)
Twisp	H	40 (*1*; - -)	- -	- -	- -	60 (*5*; 2)	- -
Twisp	W	- -	- -	- -	- -	- -	- -

Table 9. Estimated egg deposition for spring Chinook salmon in the Methow Basin in 2017. 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.

Subbasin	Females with egg retention estimated	Mean fecundity	Mean egg retention (%)	Redds	Subbasin proportion (%)	Estimated egg deposition		
						2015	2016	2017
Chewuch	34	4,018	1.6	64	30.5	819,011	351,373	253,038
Methow	30	3,991	1.3	124	59.0	2,523,595	866,006	488,451
Twisp	5	3,755	0.9	22	10.5	524,425	209,262	81,867
Total				210		3,867,031	1,426,641	823,356

Natural Replacement Rates

Natural replacement rates (NRR) for the latest complete brood (2011) were less than 1.0 in all subbasins (Chewuch = 0.22; Methow = 0.11; Twisp = 0.55; Appendices A-C). All NRR values from the 2011 brood were lower than 2010. HRR values from the 2011 brood were between five and 104 times greater than corresponding NRR values within subbasins (Appendices A-C).

Stray Rates by Brood Year

Based on total expanded CWT recoveries, an estimated 19.5% of the 2011 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 = 31.7%) was greater than the 5% target. Based on total expanded CWT recoveries, an estimated 1.1% of the 2011 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 = 3.1%) was less than the 5% target. Based on total expanded CWT recoveries, an estimated 10.2% of the 2011 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 = 18.5%) was greater than the 5% target.

Stray Rates within the Methow Basin

A total of 60 coded wire tags (CWTs) were successfully decoded from the adult spring Chinook salmon collected during spawning ground surveys in the Methow River basin in 2017. These fish were expanded by tag-specific retention rates and stream-specific sample rates to account for 213 fish (Appendix G). As a percent of the spawning escapement, most within-basin strays were recovered in the Methow subbasin (Table 10-12; 5.5%, Chewuch releases). These values are based on stream-scale CWT expansions and only approximate total reach-scale escapement. Thus, the hatchery stock escapment totals in tables 10-12 will not sum to 100% of total hatchery escapement in the subbasin. 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).

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
2017	81	60	141	31.6	1.6	1.6	1.6	- -	11.7

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
2017	182	94	276	5.5	10.4	0.0	21.7	- -	8.8

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 escapement			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	- -	32.4
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
2017	25	22	47	0.0	0.0	30.3	10.2	- -	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

The 2017 run above Wells was low in numbers compared to recent years. Approximately 29% of the run was destined for Chief Joseph Hatchery and the Okanogan Basin, leaving roughly 3,500 fish returning to the Methow Basin. Broodstock collection and removal of surplus hatchery fish totaled 1,841 fish. There were nearly 1,700 fish remaining in the Methow Basin to make up the 2017 spawning population. However, only 210 redds were found during spawning ground surveys expanding out to 264 spawners. Though some surveys were not conducted due to poor air quality and National Forest closures due to the Diamond Creek fire, surveyors were able to return to the Lost River when conditions improved and were successful in documenting redds. It is not believed that surveyor efficiency was low in 2017, or that areas with substantial spawning were over-looked. The reaches surveyed in 2017 were consistent with previous years. The low numbers of spawners may be attributed to above average predation and pre-spawn mortality. Efforts should be made to better understand the various factors that may be influencing pre-spawn mortality and when and where the bulk of this mortality occurs. Alternatively, the apportioning of fish between Chief Joseph Hatchery, the Okanogan Basin, and the Methow Basin may have overestimated escapement to the Methow. With the current and ongoing returns of fish to Chief Joseph Hatchery and the Okanogan Basin, increased monitoring and reporting of PIT-tagged fish and the inception of spawning ground surveys for spring Chinook salmon in both the US and Canadian portions of the Okanogan Basin is imperative.

References

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Tonseth, M. 2016. Final Upper Columbia River 2017 BY salmon and 2018 BY steelhead hatchery program management plan and associated protocols for collection, rearing/release, and management of adult returns. Memo dated 14 April, 2017 to NMFS, HCP HC, and PRCC HSC.

Appendix A. Natural Replacement Rates (NRR) in the Chewuch subbasin for brood years 1992 to 2011 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age 1.1	Return age 1.2	Return age 1.3	Total expanded recruits (NOR)	NRR	HRR
1992	421.75	0	25	14	41.25	0.10	1.50
1993	184.34	2	69	21	95.53	0.52	1.00
1994	62.85	0	15	3	18.95	0.30	0.25
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	4.85
1998	7.00	11	23	19	62.69	8.96	12.60
1999	21.08	0	2	0	2.14	0.10	- -
2000	82.84	6	47	13	69.97	0.84	3.32
2001	2,493.22	0	205	49	264.42	0.11	3.77
2002	665.76	2	91	61	169.01	0.25	3.93
2003	489.60	0	15	33	53.14	0.11	0.59
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	4.80
2007	276.50	8	178	36	285.47	1.03	8.28
2008	252.00	22	81	16	152.38	0.60	5.26
2009	770.77	3	89	6	107.10	0.14	3.76
2010	494.78	2	187	25	271.76	0.55	4.47
2011	868.50	10	144	29	194.49	0.22	8.59

Appendix B. Natural Replacement Rates (NRR) in the Methow subbasin for brood years 1992 to 2011 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age 1.1	Return age 1.2	Return age 1.3	Total expanded recruits (NOR)	NRR	HRR
1992	924.26	0	44	43	92.38	0.10	- -
1993	759.56	5	79	32	119.66	0.16	1.93
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	3.34
1997	152.45	21	348	50	537.66	3.53	2.69
1998	23.00	16	34	2	60.75	2.64	12.60
1999	70.27	3	2	0	4.32	0.06	0.79
2000	639.39	5	197	39	256.60	0.40	3.32
2001	7,587.84	3	183	36	230.70	0.03	5.35
2002	1,729.65	0	96	93	209.12	0.12	5.24
2003	604.80	0	59	27	95.12	0.16	1.11
2004	820.82	13	163	35	248.46	0.30	3.75
2005	746.76	11	239	3	268.70	0.36	2.67
2006	1,069.72	33	363	199	775.03	0.72	9.38
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	3.74
2010	1,617.55	13	281	29	409.84	0.25	6.50
2011	1,823.00	8	153	25	197.87	0.11	11.40

Appendix C. Natural Replacement Rates (NRR) in the Twisp subbasin for brood years 1992 to 2011 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	5.37
1997	71.74	0	460	109	729.31	10.17	3.60
1998	11.00	24	72	21	138.15	12.56	1.91
1999	24.60	0	7	0	7.36	0.30	1.50
2000	256.27	37	264	17	339.31	1.32	2.10
2001	889.58	27	77	20	128.96	0.14	1.19
2002	241.09	0	47	35	90.85	0.38	8.00
2003	43.20	0	1	0	1.11	0.03	1.33
2004	340.55	8	48	9	75.82	0.22	2.50
2005	121.00	4	28	5	39.16	0.32	1.88
2006	165.00	19	179	61	337.90	2.05	8.86
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	179.95	0.72	4.97
2011	243.18	9	106	10	132.55	0.55	2.57

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
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	63	0	2	318	321	0	0	0	0	0	2	706	45.5%	45.6%
2002	94	3	59	174	299	0	0	0	1	3	1	633	47.7%	47.6%
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	41.7%	42.6%
2008	162	0	0	243	409	2	0	0	20	162	70	1,068	38.3%	50.2%
2009	76	2	0	144	116	0	0	0	5	4	10	357	32.5%	34.3%
2010	60	6	0	121	112	0	0	0	0	1	3	303	37.0%	37.5%
2011	378	2	0	108	122	0	0	1	4	1	11	627	19.8%	20.3%

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
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	244	2	38	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	1.7%	1.7%
2010	565	36	0	657	81	0	0	0	0	4	68	1,411	5.7%	6.0%
2011	2,941	0	0	409	39	3	0	0	2	7	88	3,489	1.1%	1.2%

Appendix F. Twisp River spring Chinook expanded CWT recoveries. Recoveries from captive brood program 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
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	0	46	3	32	36	0	0	0	0	0	3	120	30.0%	30.8%
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	18.9%	18.9%
2008	15	39	2	156	129	0	0	0	8	68	29	446	28.9%	37.8%
2009	11	29	0	58	23	0	0	0	0	1	1	123	18.7%	19.0%
2010	1	58	0	156	70	0	0	0	0	1	3	289	24.2%	24.6%
2011	0	8	0	45	6	0	0	0	0	0	0	59	10.2%	10.2%

Appendix G. Expanded coded wire tag (CWT) recoveries in 2017 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	2013	636707	Chewuch	Homed	40
Chewuch River	2013	55717	Okanogan (Riverside)	Out-of-Basin	9
Chewuch River	2013	200109	Columbia (CJH)	Out-of-Basin	6
Chewuch River	2013	636640	Methow	Within-Basin	2
Chewuch River	2013	55710	Okanogan (Riverside)	Out-of-Basin	2
Chewuch River	2013	55720	Methow	Winthrop	2
Chewuch River	2014	636757	Chewuch	Homed	4
Chewuch River	2014	636688	Twisp	Within-Basin	2
Early Winters Creek	2013	55720	Methow	Winthrop	7
Methow H. Outfall	2013	636640	Methow	Homed	3
Methow H. Outfall	2013	55720	Methow	Winthrop	1
Methow River	2012	636284	Methow (MVP)	Homed	4
Methow River	2013	636707	Chewuch	Within-Basin	15
Methow River	2013	55717	Okanogan (Riverside)	Out-of-Basin	15
Methow River	2013	636623	Methow	Homed	11
Methow River	2013	636640	Methow	Homed	11
Methow River	2013	55718	Methow	Winthrop	11
Methow River	2013	200109	Columbia (CJH)	Out-of-Basin	9
Methow River	2013	55720	Methow	Winthrop	8
Twisp River	2013	636613	Twisp	Homed	9
Twisp River	2013	55718	Methow	Winthrop	5
Twisp River	2014	636688	Twisp	Homed	5
WNFH outfall	2013	55718	Methow	Winthrop	16
WNFH outfall	2013	55720	Methow	Winthrop	16

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	2017
Ballard C.G. - Lost River	M15	0	0	0	6	4	1	0	8	3	1	4	5	1	2	1
Lost River - Gate Creek	M14	4	9	7	17	12	17	11	32	23	20	31	27	6	16	4
Gate Creek - Early Winters Creek	M13	0	14	0	5	3	13	1	34	9	13	15	25	2	5	4
Early Winters Creek - Mazama Bridge	M12	6	9	10	20	13	9	10	14	15	6	10	12	13	5	1
Mazama Bridge - Suspension Bridge	M11	7	10	12	24	15	17	14	50	22	21	17	24	10	17	9
Suspension Bridge - Weeman Bridge	M10	34	51	45	36	19	31	44	63	26	24	21	62	84	25	18
Weeman Bridge - Along Highway 20	M9	105	104	136	173	84	94	138	332	156	161	97	200	294	75	35
Along Highway 20 - Wolf Creek	M8	2	3	5	9	2	4	11	8	0	7	0	5	14	2	3
Wolf Creek - Foghorn Dam	M7	20	16	19	59	10	13	11	67	37	48	26	66	68	16	13
Foghorn Dam - Winthrop Bridge	M6	19	17	18	46	12	20	12	71	54	74	26	67	19	15	4
Winthrop Bridge – MVID diversion	M5	5	0	7	0	Ns	2	3	9	3	2	0	1	10	1	1
MVID diversion – Twisp Bridge	M4	Ns	0	0	0	Ns	1	Ns	1[a]	0	1	0	1	3	0	Ns
Twisp Bridge – Upper Burma Bridge	M3,2	Ns	Ns	Ns	Ns	Ns	Ns	Ns	4[a]	Ns	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	9
Lost River Bridge - Confluence	L1	0	5	1	2	0	2	4	5	4	3	4	3	1	1	0
Klipchuck C,G. - Early Winters Bridge	EW5	0	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	0
Highway 20 Bridge - Diversion dam	EW3	3	10	0	9	3	2	7	26	3	5	3	7	5	4	3
Diversion dam - Highway 20 Bridge	EW2	1	0	0	1	0	0	0	1	0	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	0
Various reaches of Gold Creek + Foggy Dew Creek	GDN4-1,FD1	Ns	Ns	0	0	1	0	0	5	1	Ns	Ns	Ns	Ns	Ns	Ns
Suspension Creek (Entire length)	Susp1	19	12	7	36	0	7	9	31	16	17	11	37	25	6	3
Little Suspension Creek (Entire length)	Lsusp1	Ns	Ns	Ns	Ns	Ns	Ns	Ns	0	5	2	0	7	0	0	0
Methow Hatchery Outfall (Entire length)	MH1	13	9	8	75	7	10	14	50	38	55	33	79	19	2	2
Winthrop NFH Outfall(Entire length)	WN1	11	8	5	21	3	25	17	55	44	33	10	81	39	29	14
Hancock Cr. (Kumm Rd. to Wolf Cr. Rd.)	HA2	Ns	Ns	Ns	Ns	Ns	Ns	Ns	19	2	9	1	12	0	0	0
Hancock Cr. (Wolf Cr. Rd. to Confluence)	HA1	Ns	Ns	Ns	Ns	Ns	Ns	Ns	1	0	1	1	3	4	1	0
Wolf Creek (Rd 5505 access - footbridge)	W3,2	0	Ns	Ns	Ns	Ns	Ns	5	30	0	4	1	14	0	0	0
Wolf Creek (footbridge - Confluence)	W1	2	0	0	0	0	0	0	3	0	3	0	2	3	0	0
Upper Methow River subbasin total		252	287	294	569	199	278	323	935	472	520	336	763	654	231	124

[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	2017
Chewuch Falls - 30 Mile Bridge	C13	Ns	Ns	0	Ns	0	2	2	2	8	4	3	5	2	0	1
30 Mile Bridge - Road Side Camp	C12	0	0	3	1	5	4	10	32	35	12	20	24	12	5	0
Road Side Camp - Andrews Creek	C11	0	0	1	1	1	3	4	9	8	8	3	6	1	1	0
Andrews Creek - Lake Creek	C10	0	0	7	9	0	7	4	10	14	7	13	18	6	3	2
Lake Creek - Buck Creek	C9	2	0	0	0	0	1	0	0	0	1	1	2	0	0	1
Buck Creek - Camp 4 C.G.	C8	14	10	5	10	7	7	7	8	18	14	6	14	10	6	6
Camp 4 C.G. - Chewuch Campground	C7	25	2	16	32	9	16	11	24	17	22	14	17	17	9	5
Chewuch C.G. - Falls Creek C.G.	C6	16	19	33	54	23	21	30	37	25	42	29	51	33	14	15
Falls Creek C.G. - Eightmile Creek	C5	18	27	32	22	8	12	14	15	23	18	17	23	21	9	11
Eightmile Creek - Boulder Creek	C4	49	20	44	63	9	19	26	82	45	66	34	44	36	12	12
Boulder Creek - Chewuch Bridge	C3	3	0	10	5	0	0	0	5	0	0	0	0	0	2	0
Chewuch Bridge - WDFW Land	C2	51	29	55	51	13	21	29	52	27	41	30	31	61	22	8
WDFW Land - Confluence	C1	26	10	11	25	4	7	6	9	5	1	1	4	7	1	3
Eightmile Creek Bridge - Confluence	EM1	0	Ns	0	Ns	Ns	0	0	0	0	0	0	Ns	Ns	Ns	Ns
Black Lake - Confluence	LK2,1	0	0	Ns	Ns	Ns	Ns	Ns	1[a]	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Chewuch River subbasin total		204	117	217	273	79	120	143	286	225	236	171	239	206	84	64

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	2017
Road's End C.G. - South Creek Bridge	T10	0	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	0
Poplar Flats C.G. - Mystery Bridge	T8	0	1	0	3	0	0	0	11	3	6	3	5	5	0	2
Mystery Bridge - War Creek Bridge	T7	1	24	5	19	7	18	5	21	7	19	20	25	17	15	2
War Creek Bridge - Buttermilk Bridge	T6	8	62	24	39	14	24	11	54	40	74	46	66	56	14	11
Buttermilk Bridge - Little Bridge Cr.	T5	7	26	10	15	9	26	3	35	8	24	7	27	30	14	6
Little Bridge Creek - Twisp Weir	T4	1	9	3	3	0	7	3	9	0	6	2	3	4	0	0
Twisp Weir - Upper Poorman Bridge	T3	1	5	8	2	0	2	1	9	1	4	4	7	5	3	1
Up. Poorman Br. - Lower Poorman Br.	T2	0	8	4	2	0	2	1	5	3	3	0	3	2	0	0
Lower Poorman Bridge - Confluence	T1	0	4	1	4	0	0	0	0	0	3	2	1	0	0	0
Twisp River subbasin total		18	139	55	87	30	79	24	145	63	139	85	138	119	46	22

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
2017	0.056	0.555	0.000	0.000	0.028	0.000	0.028	0.000	0.000	0.000	0.111	0.056	0.000	0.166	0.000	81	0.115	0.693	0.192	61	0.082	0.125

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
2017	0.000	0.114	0.000	0.029	0.314	0.029	0.000	0.000	0.000	0.029	0.342	0.000	0.000	0.143	0.000	182	0.050	0.750	0.200	94	0.204	0.236

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	0.133	0.534	0.133	0.133	0.000	0.000	0.000	0.000	0.000	29	0.143	0.714	0.143	60	0.496	0.604
2017	0.000	0.000	0.000	0.000	0.000	0.000	0.100	0.700	0.000	0.100	0.100	0.000	0.000	0.000	0.000	25	0.462	0.538	0.000	22	0.431	0.447

Appendix N. Spring Chinook run escapement and hatchery activites at Wells Dam and in the Methow Basin. Double Count (reascensions) and fallback estimates at Wells Dam are calculated using detections of pit-tagged fish through Wells Dam and at locations downstream of Wells Dam. Wells Dam totals are estimates post spring-summer Chinook segregation via ladder passage video review. Totals of hatchery surplus at Winthrop NFH (WN) include some transfers from Methow Hatchery (MH) if transfers were conducted during the broodstock collection or tribal surplus period. Spring Chinook spawning ground surveys have not been conducted in the Okanogan Basin so all wild fish returning to Wells Dam are assumed to have originated from the Methow Basin.

Brood year	Estimated double counts at Wells Dam		Estimated fallback below Wells Dam		Wells Dam totals based on trapping and video review		Broodstock retained at Wells Dam		Estimated run escapement				Local broodstock retained			Hatchery surplus		Redd-based spawning escapement					
									Methow Basin		Okan/CJH		Met.			Methow		Chewuch		Methow		Twisp	
	H	W	H	W	H	W	H	W	H	W	H	W	MH-H	WN-H	MH-W	MH	WN	H	W	H	W	H	W
2006	--	--	--	--	4,055	310	163	10	3,782	300	110	0	192	391	0	--	24	378	135	942	128	100	65
2007	--	--	--	--	1,929	202	113	23	1,638	179	178	0	89	340	0	--	0	203	74	545	152	65	40
2008	116	18	43	6	2,503	423	28	50	2,346	373	129	0	211	417	6	--	0	166	86	412	172	126	40
2009	50	9	149	28	4,051	753	19	115	3,656	638	376	0	177	376	5	--	53	500	271	1,480	261	97	32
2010	160	8	102	8	7,415	1,151	18	155	6,338	996	1,059	0	142	458	11	--	1,850	341	155	1,331	290	96	156
2011	257	24	663	71	7,256	965	11	111	7,139	854	106	0	273	427	5	--	1,538	499	370	1,391	432	85	159
2012	191	25	371	56	4,624	663	2	53	4,619	610	3	0	120	469	8	--	1,619	243	94	641	103	135	64
2013	329	23	112	79	4,898	603	2	46	4,752	557	144	0	61	501	1	--	2,617	226	89	505	113	117	39
2014	67	4	291	31	9,508	1,038	0	94	9,488	944	20	0	11	517	35	369	4,848	267	166	1,131	250	157	92
2015	5	1	83	100	9,202	790	3	96	9,199	694	0	0	51	445	0	681	5,458	152	134	749	154	54	110
2016	2	0	42	54	4,553	658	1	68	4,180	590	372	0	56	416	17	156	2,941	61	101	287	159	29	60
2017	49	1	42	60	4,393	549	19	67	2,953	482	1,421	0	122	466	8	98	1,111	81	61	182	94	25	22

Attachment D. Summary of summer steelhead spawning ground surveys and escapement estimates conducted in the Methow River basin in 2017.

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From: Charles Frady

To: Charlie Snow

Date: 30 May 2018

Subject: Results of 2017 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 HOR 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 (OBMEP 2018) 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 2017). 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 2017, 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 not subjected to local selective fisheries in 2017 as numbers of returning adults were not sufficient to allow a fishery. 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 broodstock collections were subtracted from the estimated escapement to each basin to determine the number of steelhead available for natural spawning. Pre-spawn mortality was assumed to be 10% for HOR and NOR steelhead in both the Okanogan and Methow Basins (NOAA, personal communication). No estimates were made of natural predation 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. 2018). 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, blue = HOR male, pink = 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 can be used for spawn timing analyses and to determine redd distribution of HOR and NOR steelhead.

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 2017, 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. 2018). 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 2017 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 mapped and all pertinent data for each redd was recorded/logged (e.g., date, GPS coordinates).

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), 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:

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

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 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 2013 and 2014 brood fish and the release location of tagged fish was recorded during release monitoring.

None of the 2013 or 2014 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

<u>*Run Composition*</u>

Stock assessment and collection of the 2017 brood Wells Hatchery steelhead broodstock occurred at Wells Dam between 3 August and 15 November 2016. During that time, a total of 4,368 steelhead passed Wells Dam. Of those fish, 387 (8.9%) were sampled for hatchery marks or were scale sampled to determine origin. Of the sampled fish, 144 HOR steelhead were retained for broodstock purposes from Wells Dam ladder traps. 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 2017 brood was 4,364 fish (Table 1). Analysis of scale samples and observations of hatchery marks indicate that NOR fish comprised 21.4% of the steelhead run to Wells Dam (78.6% HOR). Based on biological sampling of steelhead during broodstock collection, identification of hatchery marks, and coded-wire-tags from fish retained for broodstock, only 3.4% 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 2017 brood return was not great enough to allow selective sport fisheries in the Methow, Okanogan, and Similkameen rivers, or the mainstem Columbia River. However, a total of 60 HOR and 45 NOR steelhead were removed in the CCT Chief Joseph snag fishery. Both HOR and NOR 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 151 and 469 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 surplus removal, an estimated 1,431 HOR and 469 NOR steelhead were available for natural spawning in the Methow River basin (see Table 1), resulting in a basin pHOS estimate of 0.75 prior to spawning.

Table 1. Escapement and disposition of the 2017 brood summer steelhead passing Wells Dam. HOR (*N* = 144) fish removed for broodstock at Wells Dam are not included in the escapement estimate above Wells Dam. Tributary 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 2016 through 14 June 2017.

Area	Description (Variable)	Number
Wells Dam	Wells Dam fish count (DCPUD raw data)	5,145
	Wells Dam HOR total (based on trapping)	4,041
	Wells Dam NOR total (based on trapping)	1,104
	Estimated double counted fish (HOR)	257
	Estimated fallback fish (HOR)	317
	Adjusted Wells Dam HOR total	3,467
	Estimated double counted fish (NOR)	59
	Estimated fallback fish (NOR)	148
	Adjusted Wells Dam NOR total	897
Above Wells Dam	Local HOR fish	3,418
	Stray HOR fish	49
	Hatchery fish removed in WDFW fishery	0
	HOR fish removed in CCT fisheries	60
	Above Wells HOR run estimate	3,407
	NOR fish	897
	NOR fish removed in WDFW fishery	0
	NOR fish removed in CCT fisheries	45
	Above Wells NOR run estimate	852
Okanogan Basin	HOR run escapement estimate	1,105
	HOR fish removed in WDFW fishery	0
	HOR fish collected for broodstock	2
	HOR pre-spawn mortality estimate (10%)	110
	HOR spawn escapement estimate	993
	NOR run escapement estimate	178
	NOR fish removed in WDFW fishery	0
	NOR fish collected for broodstock	10
	NOR pre-spawn mortality estimate (10%)	17
	NOR spawn escapement estimate	151
Methow Basin	HOR run escapement estimate	1,977
	HOR fish removed in WDFW fishery	0
	HOR fish collected for broodstock	46
	HOR fish removed as excess	341
	HOR pre-spawn mortality estimate (10%)	159
	HOR spawn escapement estimate	1,431
	NOR run escapement estimate	604
	NOR fish removed in WDFW fishery	0
	NOR fish collected for broodstock	82
	NOR pre-spawn mortality estimate (10%)	53
	NOR spawn escapement estimate	469

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

PIT-tagged steelhead were detected between 16 March and 11 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 84.8%. However, some adults could have bypassed the TWR array in the new side channel adjacent to the array. Ten NOR steelhead were retained for broodstock. A total of 18 HOR steelhead were removed as surplus at the weir and no HOR steelhead were retained for broodstock. In 2017, no observations were made of anchor-tagged HOR steelhead on redds, so comparisons of spawn timing and spawner distributions of HOR and NOR fish were not made.

Redd surveys in the Twisp River basin were conducted from 13 March to 31 May. Redd surveys in the Mainstem Methow River from the MRW array upstream of Winthrop downstream to Pateros were conducted from 3 March to 2 May. Early, prolonged high flow precluded surveyors ability to effectively document steelhead redds in 2017, so all subbasin redd totals should be considered minimum values. Based on PIT-based escapement estimates (Truscott et al. 2018), an estimated 533 steelhead redds were created in the Methow River basin in 2017 (Table 4). Historic redd counts for each of the subbasins are listed in Appendices B1-B4.

Based on biological sampling during 2017 run evaluation at Wells Dam, the age distribution of HOR steelhead was skewed towards 2-salt fish (94.7%); NOR steelhead were also skewed towards 2-salt fish (81.7%). Based on scale analysis, 44.3% (N = 43) of the steelhead sampled at the Twisp River weir were NOR (Table 5). Using expanded redd counts by tributary, and the mean fecundity from Wells Hatchery broodstock by salt age and origin, an estimated 3,309,930 were deposited in the Methow Basin (Table 6). This estimate may be biased towards hatchery (ad-clipped) fish and not representative of actual spawners since the majority of fish used to calculate means were from Wells Hatchery broodstock.

Table 2. Twisp River mainstem and tributary census redd counts by section number and survey year. Ns = not surveyed. Data from Goodman et al. 2018.

Stream reach	Code	Length (km)	2010	2011	2012	2013	2014	2015	2016	2017
			Twisp River mainstem							
Road's End C.G. - South Creek Bridge	T10	4.6	0	Ns	Ns	Ns	Ns	Ns	Ns	Ns
South Creek Bridge - Poplar Flats C.G.	T9	3.2	3	0	0	0	0	2	0	0
Poplar Flats C.G. - Mystery Bridge	T8	3.2	4	0	0	1	1	2	1	0
Mystery Bridge - War Creek Bridge	T7	6.9	18	8	5	8	4	9	2	6
War Creek Bridge - Buttermilk Bridge	T6	7.4	97	43	43	21	36	30	3	13
Buttermilk Bridge - Little Bridge Creek	T5	5.9	62	33	26	18	25	10	4	7
Little Bridge Creek - Twisp weir	T4	3.8	27	13	5	7	3	10	1	6
Twisp weir - Upper Poorman Bridge	T3	3.5	70	46	20	46	30	44	7	38
Up. Poorman Br. - Lower Poorman Br.	T2	5.0	35	30	12	23	23	18	1	21
Lower Poorman Bridge - Confluence	T1	2.9	13	4	11	7	12	11	2	10
Twisp River mainstem total		46.4	329	177	122	131	134	136	21	101
			Twisp River tributaries							
Little Br. Cr. (Road's End - Vetch Cr.)	LBC4	1.3	0	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Little Br. Cr. (Vetch Cr. - 2nd Culvert)	LBC3	3.0	1	0	3	0	0	0	1	0
Little Br. Cr. (2nd Culvert - 1st Culvert)	LBC2	2.4	3	0	0	1	0	0	0	0
Little Br. Cr. (1st Culvert - Confluence)	LBC1	2.4	4	0	7	4	1	13	0	0
MSRF pond outfalls[1]	MSRF1	0.1	1	3	0	3	6	12	11	4
War Creek (log jam barrier - Conf.)	WR1	0.5	0	0	0	0	0	0	0	0
Eagle Creek (Rd 4430 - Confluence)	EA1	0.3	0	0	0	0	0	0	0	0
W. Fork Buttermilk Creek	BMW1	3.1	Ns	Ns	Ns	Ns	1	0	0	0
Buttermilk Cr. (Fork - Cattle Guard)	BM2	2.1	3	0	1	0	0	0	0	0
Buttermilk Cr. (Cattle Guard - Conf.)	BM1	2.0	1	0	0	0	2	0	0	0
South Creek (Falls - Confluence)	SO1	0.6	0	Ns	Ns	Ns	0	0	0	0
Twisp River tributary total		14.7	13	3	11	8	10	25	12	4

[1] Methow Salmon Recovery Foundation pond outfall.

Table 3. 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. 2018) using 1.33 fish per redd. Mainstem Methow HOR and NOR estimates reflect removal of fish for broodstock and adult management. Ns = not surveyed. * Poor survey conditions and limited surveys.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Methow River (MRW PIT array – Red Barn)	MRW8	24		
Methow River (Red Barn – Halderman Hole)	MRW7	13		
Methow River (Halderman Hole – Braids)	MRW6	12		
Methow River (Braids – Carlton Bridge)	MRW5	Ns		
Methow River (Carlton Bridge – WDFW Access)	MRW4	2*	192	63
Methow River (WDFW Access – Upper Burma Br.)	MRW3	Ns		
Methow River (Upper Burma Br. – Lower Burma Br.)	MRW2	0*		
Methow River (Lower Burma Bridge – Pateros)	MRW1	Ns		
Chewuch River (CRW PIT array to – Confluence)	CRW1	0	--	--
Methow Hatchery outfall	MH1	15	--	--
Winthrop NFH Outfall	WN1	55	--	--
1890's channel	18N	1	--	--
Beaver Creek (above PIT antenna)	Beaver	22	13 (1-33)	16 (2-37)
Beaver Creek (below PIT antenna)	BV1	Ns	--	--
Libby Creek (above PIT antenna)	Libby	17	7 (0-21)	15 (2-32)
Gold Creek (above PIT array)	Gold	20	12 (2-29)	15 (2-33)
Total		181	--	--

Table 4. 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 are back-calculated from escapement totals (Truscott et al. 2018) using 1.33 fish per redd. Twisp totals reflect removal of both HOR and NOR values at the Twisp weir.

Location	Estimated Redds	Spawners		
		HOR	NOR	Total
Upper Methow River	101	100 (58-153)	34 (14-63)	134 (72-216)
Chewuch River	111	68 (36-105)	80 (50-121)	148 (86-226)
Twisp River	140[a]	122 (76-167)	65 (34-100)	187 (110-267)
Lower Methow River	181	--	--	--
Total	533	--	--	--

[a] Not from Table 2 redd counts.

Table 5. Summary of adult steelhead sampled at the Twisp weir in 2017, 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	2	27	4	0	33	26
	M	None	0	7	3	0	10	7
	Total NOR		2	34	7	0	43	33
HOR	F	CWTO	0	23	3	0	26	23
		HFN	0	1	0	0	1	1
		None	0	0	1	0	1	1
	Total F		0	24	4	0	28	25
	M	Ad-only	0	1	0	0	1	1
		CWTO	0	19	2	0	21	7
		HFN	0	3	0	0	3	2
		None	0	1	0	0	1	1
	Total M		0	24	2	0	26	11
	Total HOR		0	48	6	0	54	36
Grand total			2	82	13	0	97	69

Table 6. Estimated 2017 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 (4,381; 3.4), HOR 2-salt (6,782; 60.7), NOR 1-salt (4,198; 6.6), NOR 2-salt (5,691; 29.3). NOR fecundities are from WNFH broodstock. Twisp redd total is from Table 4.

Area	Redds	% of redds	Estimated egg deposition						
			2011	2012	2013	2014	2015	2016	2017
U. Met.	101	18.9	2,394,516	1,548,633	1,647,444	1,086,444	1,562,172	477,834	627,210
Chew.	111	20.8	693,972	184,224	1,211,707	1,075,896	1,189,116	822,080	689,310
Twisp	140	26.3	1,187,880	759,924	835,660	759,456	938,469	1,078,980	869,400
L. Met.	181	34.0	1,062,840	909,606	1,140,079	1,708,776	2,086,782	1,125,222	1,124,010
Total	533	100.0	5,339,208	3,402,387	4,834,890	4,630,572	5,776,539	3,504,116	3,309,930

<u>*Natural Replacement Rate (NRR)*</u>

A total of 368 steelhead were trapped and sampled at Wells Dam, of which 83 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 (N = 1,045) after excluding fish that ascended the fish ladders multiple times. Expanded return at age was based on scale analysis of NOR fish sampled during trapping, resulting in an estimated total of 740 NOR steelhead returning to the Methow Basin prior to broodstock collection, estimated fallback, and Columbia River fishery-related mortality (Table 7). The NRR of the Methow Basin steelhead population was below replacement (i.e., < 1.0) in each of the sixteen brood years examined (Table 8). A plot of NRR verses run escapement suggests that high spawner escapement reduces overall productivity rates in the Methow Basin (Figure 1).

Table 7. 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 2017.

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	
2017	1,045	83	0.0794	0	165	493	72	10	740
2016	2,094	86	0.0499	19	867	462	135	0	1,483
2015	2,394	116	0.0580	35	311	1,090	242	17	1,695
2014	2,231	147	0.0659	12	839	668	61	0	1,580
2013	1,210	70	0.0579	46	337	321	153	0	857
2012	1,643	94	0.0572	15	471	662	15	0	1,163
2011	2,045	120	0.0587	13	642	717	76	0	1,448
2010	2,070	115	0.0556	59	762	601	44	0	1,466
2009	1,217	127	0.1044	72	471	283	36	0	862
2008	1,283	132	0.1029	15	679	192	22	0	908
2007	631	52	0.0824	0	214	204	29	0	447
2006	765	124	0.1621	6	159	332	45	0	542
2005	861	104	0.1208	10	276	324	0	0	610
2004	1,161	116	0.0999	14	642	159	7	0	822
2003	821	27	0.0329	0	0	511	70	0	581
2002	900	18	0.0200	35	212	319	71	0	637
2001	553	26	0.0470	15	302	75	0	0	392
2000	435	41	0.0943	24	166	102	16	0	308
1999	242	29	0.1198	7	55	109	0	0	171

Table 8. 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	2,120	0.2455
2011	3,443	2014	2015	2016	2017	2018	857	0.2489

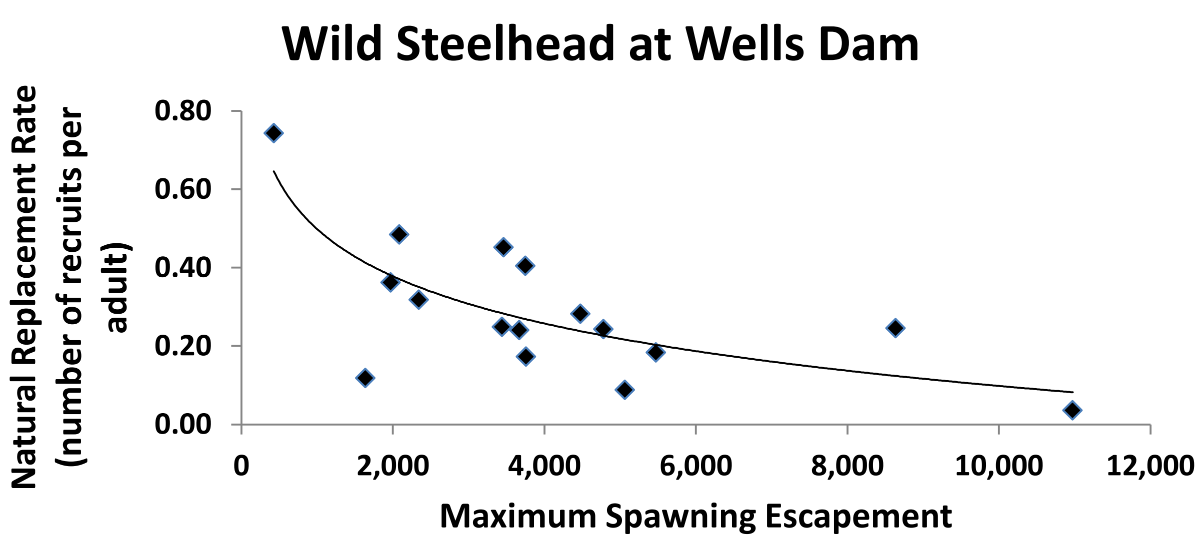

Figure 1. Methow Basin steelhead run escapement (HOR + NOR; x-axis) verses natural replacement rate (NRR; y-axis) for parent brood years 1996-2011.

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 2013 brood, stray rates for Methow Basin steelhead releases averaged 6.1% across two release locations (Methow and Twisp; Table 9). 2014 brood adult returns were essentially zero, with only two PIT-tagged fish returning to or above Wells Dam precluding stray rate estimation.

Table 9. Detection of adult HOR summer steelhead released from Wells Hatchery into Methow Basin tributaries. Detections of 2014 brood releases are considered incomplete because they include only 1-salt returns. Detections in the Lower Methow / Wells pool are not considered strays for the Methow or Twisp 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	Okan. Basin	Total	% stray
2013	Columbia	0	0	0	1	5	71[a]	5	2	84	14.1
2013	Methow	9	0	2	0	15	10	1	0	37	8.1
2013	Twisp	0	13	0	1	5	6	0	0	25	4.0
2014	Columbia	0	0	0	0	0	1	0	0	1	N/A
2014	Methow	0	0	0	0	0	0	0	0	0	N/A
2014	Twisp	1	0	0	0	0	0	0	0	1	N/A

[a] Includes two returns to Wells tailrace.

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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 plus winter counts from DCPUD raw data. 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. Hatchery fish retained for broodstock in the Methow Basin includes 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). Estimated maximum spawning escapement has been adjusted for 10% pre-spawn mortality (NOAA, personal communication).

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	0	- -	- -	2,264	77	1,285	23	75	0	5	0	- -	- -	- -	- -	1,971	69	1,135	20
1999	2,943	242	383	29	- -	- -	- -	- -	- -	- -	- -	- -	1,485	151	829	44	- -	- -	- -	- -	- -	- -	- -	- -	1,337	136	747	40
2000	3,448	435	334	41	- -	- -	- -	- -	- -	- -	- -	- -	1,806	279	1,009	82	10	10	0	11	- -	- -	- -	- -	1,618	242	909	64
2001	6,167	553	323	26	- -	- -	- -	- -	8	0	- -	- -	3,385	373	1,893	110	12	0	18	0	- -	- -	- -	- -	3,038	336	1,687	99
2002	18,241	900	374	18	- -	- -	- -	- -	23	0	- -	- -	10,350	624	5,789	183	- -	- -	581	9	- -	- -	- -	- -	9,321	562	4,685	157
2003	8,962	821	274	27	- -	- -	- -	- -	455	9	- -	- -	4,775	556	2,668	163	254	13	120	2	- -	- -	1	4	4,072	489	2,294	142
2004	9,388	1,161	325	120	- -	- -	- -	- -	298	4	- -	- -	5,084	734	2,840	216	336	10	385	1	- -	- -	11	5	4,276	652	2,202	189
2005	9,098	861	346	69	- -	- -	- -	- -	292	1	- -	- -	4,907	560	2,741	164	679	9	528	3	- -	- -	15	3	3,808	496	1,981	142
2006	6,901	765	324	91	- -	- -	- -	- -	237	1	- -	- -	3,677	476	2,054	140	683	8	492	5	- -	- -	10	3	2,697	422	1,399	119
2007	6,702	631	345	46	- -	- -	- -	- -	523	2	79	4	3,338	410	1,865	120	- -	- -	- -	- -	- -	- -	4	7	3,006	369	1,676	102
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	2,576	729	1,419	208
2009	9,148	1,236	300	75	148	19	409	54	444	5	277	27	4,391	748	2,453	220	636	11	446	5	8	8	5	11	3,375	656	1,804	184
2010	24,091	2,120	279	88	583	50	1,207	103	1,068	17	719	48	11,736	1,284	6,556	377	4,002	48	3,110	16	322	12	4	13	6,679	1,102	3,103	314
2011	11,728	2,085	272	55	206	40	633	273	1,131	19	173	29	5,402	1,181	3,018	347	2,913	53	899	15	141	33	0	16	2,116	987	1,909	285
2012	11,164	1,732	259	67	495	89	628	250	551	6	180	19	5,249	921	2,932	271	1,302	20	400	5	135	46	10	5	3,435	770	2,273	235
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	2,731	494	1,552	152
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	90	92	42	16	1,526	1,002	1,057	309
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	1,526	1,113	1,033	330
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	2,224	942	1,599	292
2017	4,185	1,104	144	0	257	59	317	148	0	0	60	45	1,976	603	1,104	177	0	0	0	0	387	82	2	10	1,431	469	993	151

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.