MONITORING AND EVALUATION OF THE WELLS HATCHERY AND METHOW HATCHERY PROGRAMS

2018 ANNUAL REPORT

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Prepared by:

The Washington State Dept. of Fish and Wildlife
Charlie Snow
Charles Frady
David Grundy
Benjamin Goodman
and
Alf Haukenes

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

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Section 1: Introduction

The Public Utility District No. 1 of Douglas County (Douglas PUD) funds hatchery programs to compensate for inundation of spawning habitat and lost harvest opportunities related to the construction of the Wells Hydroelectric Project (Wells Hatchery steelhead and summer Chinook Salmon inundation programs) 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. Additionally, Douglas PUD operates a program 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).

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. Two fundamental objectives of this strategy are that 1) hatchery programs will increase the number of fish returning to the spawning grounds, which will therefore 2) increase the number of wild fish produced. 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 thirteenth annual report, summarizing data collected during 2018 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 2017). Data collection in 2018 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 M5-M8, WN1) and steelhead (WN1) spawning ground surveys conducted by U.S. Fish and Wildlife Service personnel. All data presented in this report should be considered preliminary. Final data will be published in comprehensive reports or journal articles.

Section 2: Summary of Methods

Data collection and fish sampling conducted in 2018 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 HCP Hatchery Committees and Priest Rapids Coordinating Committee Hatchery Subcommittee (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 2018 were described in full in annual broodstock collection protocols (Tonseth 2017, 2018). Spring Chinook Salmon and steelhead collection at Wells Hatchery attempted to include 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), Methow Hatchery (spring Chinook Salmon), Wells Dam (spring Chinook Salmon and steelhead), Wells Hatchery outlet channel (summer Chinook Salmon and steelhead), and through Methow River angling (steelhead), 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 3 June and 7 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
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 (e.g., smolt-to-adult returns) 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 species at 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, ideally, a linear regression model relating discharge and capture efficiency could be developed for each species at 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 for each species. 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 were captured through backpack electroshocking in the Twisp subbasin to estimate over-winter (parr to smolt) and smolt to adult survival. Juvenile steelhead were captured through electroshocking or angling to evaluate the metrics above, and to evaluate productivity of adult spawners as part of the Twisp River Relative Reproductive Success Study (Bonneville Power Administration project No. 2010-033-00). 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	Trout Creek – Rattlesnake Creek	M17	126.7	123.5	3.2
	Rattlesnake Creek – Ballard C.G.	M16	123.5	121.2	2.3
	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 conservation steelhead	24	48,000	0.01	549	87	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. 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 2018 brood Methow Hatchery spring Chinook occurred concurrently with run-at-large evaluation at Wells Dam between 7 May and 26 June, 2018. During this time, a total of 124 wild origin fish were retained for broodstock, representing 20.5% of the estimated wild fish escapement above Wells Dam during the trapping period (*N* = 604). 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 (WNFH) 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 1 June and 28 June, 2018. Trapping occurred Monday through Friday between 5:00 am and 1:30 pm. During this time, no spring Chinook were trapped. Historically, most spring Chinook held for broodstock 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
2018	106	2[a]	1	103	0	8	1	0	7	0	110
Mean	49	1	1	47	0	160	6	31	119	3	167
						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
2018	18	0	0	18	0	0	0	0	0	0	18
Mean	15	1	0	14	0	17	1	1	15	0	29

[a] Includes facility morts at Wells Hatchery.

Length and Age at Maturity

Annual sample sizes within ages and sexes are often 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	-	-	-

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	F	-	-	-	-	-	-	-	-	-
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
2016	H	F	-	-	-	76	24	5	86	8	2
2016	W	F	-	-	-	76	31	4	88	14	7
Mean	H	F	66	1	-	76	72	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

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						
1999	H	M	51	67	5	78	44	4	88	1	-
1999	W	M	-	-	-	76	14	5	100	2	10
2000	H	M	51	40	4	73	59	7	-	-	-
2000	W	M	-	-	-	-	-	-	-	-	-
2001	H	M	60	1	-	81	10	5	-	-	-
2001	W	M	-	-	-	-	-	-	-	-	-
2002	H	M	48	7	6	79	88	6	100	1	-
2002	W	M	-	-	-	-	-	-	-	-	-
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
2016	H	M	-	-	-	75	17	5	91	4	5
2016	W	M	-	-	-	73	27	7	93	8	8

Table 3.2. Continued.

Brood	Origin	Sex	Age-3			Age-4			Age-5		
			Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Methow / Methow Composite spring Chinook						
Mean	H	M	53	26	4	75	52	6	92	5	6
Mean	W	M	52	4	5	75	25	6	96	5	7
					Twisp spring Chinook						
1998	H	F	-	-	-	77	2	2	77	4	16
1998	W	F	-	-	-	-	-	-	-	-	-
1999	H	F	-	-	-	-	-	-	-	-	-
1999	W	F	-	-	-	79	13	3	89	3	2
2000	H	F	-	-	-	75	38	4	-	-	-
2000	W	F	-	-	-	-	-	-	91	3	1
2001	H	F	-	-	-	77	7	2	93	2	10
2001	W	F	-	-	-	80	7	1	88	1	-
2002	H	F	-	-	-	75	5	3	-	-	-
2002	W	F	-	-	-	-	-	-	-	-	-
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	-

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					
2015	H	F	-	-	-	-	-	-	96	1	-
2015	W	F	-	-	-	79	9	3	89	1	-
2016	H	F	-	-	-	76	5	2	-	-	-
2016	W	F	-	-	-	73	2	2	94	1	-
Mean	H	F	-	-	-	75	10	4	89	2	9
Mean	W	F	-	-	-	77	7	4	90	2	2
1998	H	M	-	-	-	80	3	1	87	1	-
1998	W	M	-	-	-	-	-	-	98	1	-
1999	H	M	50	24	4	-	-	-	-	-	-
1999	W	M	-	-	-	-	-	-	-	-	-
2000	H	M	52	1	1	72	23	11	-	-	-
2000	W	M	45	1	-	-	-	-	98	2	1
2001	H	M	63	2	3	79	4	6	-	-	-
2001	W	M	53	2	2	75	22	5	-	-	-
2002	H	M	46	4	5	-	-	-	-	-	-
2002	W	M	-	-	-	-	-	-	-	-	-
2003	H	M	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	-	-	-

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					
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	-	-	-
2016	H	M	-	-	-	-	-	-	-	-	-
2016	W	M	-	-	-	81	3	9	-	-	-
Mean	H	M	51	5	3	72	7	6	87	1	-
Mean	W	M	48	4	3	73	9	6	97	1	1

Sex Ratio and Fecundity

For the 2016 brood, the sex ratio favored female fish in both the Methow Composite and Twisp programs. Of the female fish retained, fecundity of the 2016 brood was higher for natural origin fish than for hatchery origin fish in both programs. Overall fecundities of the 2016 brood were above the value used in broodstock protocol calculations for hatchery (3,663) and natural origin (4,181) Methow Composite females. Similarly, fecundity of Twisp hatchery and natural origin females was above the value used in broodstock protocols (3,379 and 4,014, 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

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
Methow Composite spring Chinook										
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
2016	21	32	3,701	0.66:1	35	45	4,563	0.78:1	0.73:1	4,192
Mean	92	83	3,835	1.19:1	23	26	4,131	1.01:1	1.05:1	3,911
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
2016	0	5	3,630	-	3	3	4,566	1.00:1	0.38:1	3,981
Mean	9	10	3,720	0.92:1	7	7	4,322	1.10:1	0.94:1	3,923

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 61% 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 (e.g., Tonseth 2017) have increased the proportion of progeny with lower ELISA OD values retained at Methow Hatchery. For the 2016 brood, most females were in the below-low and low categories except for two wild females, one in each of the moderate and high categories (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

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											
1997	H	29.6	29.4	50.9	53.0	11.2	15.1	8.3	2.5	169	119
1997	W	20.0	22.2	60.0	66.7	10.0	11.1	10.0	0.0	10	9
1998	H	76.3	78.4	0.0	0.0	10.5	10.8	13.2	10.8	38	37
1998	W	69.1	69.1	11.8	11.8	0.0	0.0	19.1	19.1	68	68
1999	H	64.6	59.3	29.0	33.3	3.2	3.7	3.2	3.7	31	27
1999	W	88.2	88.2	0.0	0.0	0.0	0.0	11.8	11.8	17	17
2000	H	80.6	78.3	16.1	18.9	1.1	1.4	2.2	1.4	93	74
2000	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2001	H	60.8	75.3	10.0	11.8	4.2	2.3	25.0	10.6	120	85
2001	W	90.0	90.0	10.0	10.0	0.0	0.0	0.0	0.0	10	10
2002	H	57.5	72.2	32.3	24.6	1.6	0.0	8.6	3.2	257	126
2002	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2003	H	39.4	34.0	32.9	34.0	6.6	6.4	21.1	25.6	76	47
2003	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2004	H	45.2	66.7	13.7	20.2	11.0	13.1	30.1	0.0	146	99
2004	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	1	1
2005	H	89.7	89.7	6.3	6.3	0.0	0.0	4.0	4.0	126	126
2005	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	2	2
2006	H	81.6	87.9	18.4	12.1	0.0	0.0	0.0	0.0	158	140
2006	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	3	3
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

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						
2015	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	38	38
2016	H	35.5	90.0	64.5	10.0	0.0	0.0	0.0	0.0	31	10
2016	W	69.0	69.0	28.6	28.6	2.4	2.4	0.0	0.0	42	42
Mean	H	61.0	70.3	27.8	22.4	4.0	3.0	7.2	4.3	83	60
Mean	W	86.4	86.6	9.6	9.9	1.0	1.1	3.0	2.4	28	28
					Twisp spring Chinook						
1992	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1992	W	0.0	0.0	77.8	77.8	11.1	11.1	11.1	11.1	9	9
1993	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1993	W	4.3	4.3	52.2	52.2	26.1	26.1	17.4	17.4	23	23
1994	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1994	W	25.0	25.0	50.0	50.0	0.0	0.0	25.0	25.0	4	4
1996	H	61.5	61.5	23.1	23.1	0.0	0.0	15.4	15.4	13	13
1996	W	77.8	77.8	11.1	11.1	11.1	11.1	0.0	0.0	9	9
1997	H	36.4	36.4	36.4	36.4	18.2	18.2	9.0	9.0	11	11
1997	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1998	H	50.0	50.0	33.3	33.3	0.0	0.0	16.7	16.7	6	6
1998	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1999	H	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1999	W	81.2	80.0	6.3	6.7	0.0	0.0	12.5	13.3	16	15
2000	H	81.6	81.6	18.4	18.4	0.0	0.0	0.0	0.0	38	38
2000	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	3	3
2001	H	85.7	100.0	0.0	0.0	0.0	0.0	14.3	0.0	7	6
2001	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	8	8
2002	H	80.0	80.0	20.0	20.0	0.0	0.0	0.0	0.0	5	5
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

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					
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
2016	H	40.0	40.0	60.0	60.0	0.0	0.0	0.0	0.0	5	5
2016	W	33.4	33.4	33.3	33.3	33.3	33.3	0.0	0.0	3	3
Mean	H	66.9	62.8	23.0	20.4	6.0	3.0	4.0	3.3	11	10
Mean	W	75.8	76.7	14.8	14.8	5.1	4.1	4.3	4.3	9	8

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 2000-2016 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 (broods 2015 and 2016). Acclimation time averaged 28 days for the Chewuch River releases (Chewuch Acclimation Pond) and 162 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 2016 brood, Twisp River Acclimation Pond releases achieved 102% of the release goal of 30,000 smolts specified in broodstock collection protocols (Tonseth 2016; Table 3.6). Releases into the Methow River achieved 114% of the release goal of 133,249 smolts specified for Methow Composite stock release in the broodstock collection protocols (Table 3.5). Brood year 2016 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)	Mark rate	Total released
			Chewuch River spring Chinook		
1992	18-Apr-94	3	634331, 634332, 634848, 634850, 635121, 635123, 635124, 635133, 635138, 635139, 635140	0.97-1.0	40,881
1993	17-Apr-95	18	634127, 635161 635350	0.98	284,165
1994	21-Apr-96	31	635132, 635415, 635416, 635863, 635903, 635905	0.99	11,854
1996	15-Apr-98	21	630233	0.97	91,672
1997	19-Apr-99	27	630614	0.98	132,759
1998	17-Apr-00	36	631024	0.95	435,670
2000	16-Apr-02	18	630776	0.95	266,392
2001	23-Apr-03	26	631384, 631440, 631494	0.98	261,284
2002	14-Apr-04	22	631976	0.98	254,238
2003	18-Apr-05	39	632566, 632569	0.98-0.99	127,614
2004	18-Apr-06	27	632899	0.98	204,906
2005	16-Apr-07	27	633294	0.99	232,811
2006	17-Apr-08	31	633884	0.97	154,381
2007	21-Apr-09	29	634294, 634471	0.99	126,055
2008	15-Apr-10	38	635099	0.97	260,344
2009	25-Apr-11	34	635076, 635078, 635491, 635492, 635494, 635495	0.95-0.97	149,863
2010	23-Apr-12	29	635197	0.99	88,788
2011	18-Apr-13	37	635664	0.98	93,372
2013	16-Apr-15	28	636707	0.98	60,860
2014	21-Apr-16	31	636761, 636757	0.97	71,768
2015	18-Apr-17	20	636903	0.97	65,621
2016	18-Apr-18	35	637050, 637067	0.93	65,405
			Methow River spring Chinook		
1993	15-Apr-95	227	635410, 635551	0.98-0.99	210,849
1994	22-Apr-96	29	635417	0.99	4,477
1995	15-Apr-97	350	636037, 636038, 636039, 636040, 636041, 636042, 636043	0.98-0.99	28,878
1996	15-Apr-98	300	630130, 630246, 630248, 636315	0.98	202,947
1997	15-Apr-99	300	630613	0.96	332,484
1999	17-Apr-01	171	630377, 630380	0.98-0.99	180,775
2001	21-Apr-03	82	630976, 631179, 631477	0.88-0.99	130,887
2002	14-Apr-04	42	631524, 631891	0.98	181,235

Table 3.5. Continued.

Brood	Release date	Days acclimated	CWT code (s)	Mark rate	Total released
			Methow River spring Chinook		
2003	18-Apr-05	169	632568	0.95	48,831
2004	18-Apr-06	169	631187, 632694 (subyearling release)	0.95-1.0	107,398
2005	16-Apr-07	153	633281, 633395	0.97-0.99	156,633
2006	16-Apr-08	168	633866	0.98	211,717
2007	21-Apr-09	152	634293, 634674	0.96-0.99	119,407
2008	15-Apr-10	137	634866	0.99	201,290
2009	18-Apr-11	139	635077, 635079, 635080, 635299, 635493, 635496, 635497, 635499	0.96-0.97	347,993
2010	23-Apr-12	146	635687, 636064, 636065, 636066, 636067, 636068	0.98-1.0	339,540
2011	15-Apr-13	135	636409, 636410, 636411, 636412, 636413, 636414, 636415	0.95-0.98	396,085
2012	15-Apr-14	139	636284	0.98	196,188
2013	15-Apr-15	136	636606, 636640, 636623	0.99	161,145
2014	18-Apr-16	139	636773, 636759, 636687	0.99	157,206
2015	19-Apr-17	140	637015, 637016	0.98-0.99	59,260
2016	18-Apr-18	139[a]	637071, 637178	0.96	152,411

[a] On-station release only.

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)	Mark rate	Total released
1992	15-Apr-94	3	634849, 634851, 635122, 635125, 635134, 635135, 635136, 635137, 635141	0.94-0.99	35,853
1993	17-Apr-95	20	635329, 635609	0.96-0.99	116,749
1994	21-Apr-96	36	634515, 635418, 635419, 635420	0.99	19,835
1996	15-Apr-98	26	636114, 636316, 636317	0.96-0.97	76,687
1997	15-Apr-99	30	630434	0.97	26,714
1998	17-Apr-00	36	631041	0.97	15,470
1999	17-Apr-01	36	630378, 630379, 630381	0.99	67,408
2000	23-Apr-02	0	630182, 630994	0.99	75,704
2001	21-Apr-03	27	631068, 631478	0.97	57,471
2002	13-Apr-04	27	631076, 631077, 631582, 631694, 631695	0.95-0.99	58,074
2003	18-Apr-05	35	632499, 632564, 632567, 632565	0.95-0.97	136,998
2004	22-Apr-06	28	631508 (subyearling release), 632878, 632988	0.97-1.0	100,260
2005	16-Apr-07	34	633483	0.96	27,658
2006	21-Apr-08	41	633687, 634068	0.96-0.97	45,892
2007	25-Apr-09	10	634673, 634675	0.98-0.99	54,096
2008	15-Apr-10	43	635085	0.97	78,656
2009	25-Apr-11	36	635498, 635506, 635509	0.96-0.97	67,031
2010	23-Apr-12	35	635584	0.97	81,380
2011	18-Apr-13	35	636179	0.98	18,190

Table 3.6. Continued.

Brood	Release date	Days acclimated	CWT code (s)	Mark rate	Total released
			Twisp River spring Chinook		
2012	22-Apr-14	31	636464	0.97	48,924
2013	15-Apr-15	37	636613	0.99	31,333
2014	15-Apr-16	31	636688	0.98	36,316
2015	18-Apr-17	22	636996	0.99	40,351
2016	18-Apr-18	36	637070	0.94	30,566

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 2018 into the Chewuch, Methow, and Twisp rivers attained between 92% and 97% of the target fork lengths prior to release (Table 3.7). Coefficient of variation (CV) in length for 2016 brood releases was above the target value of nine for Chewuch releases (11.7) and Twisp releases (10.9), but below nine for Methow releases (8.4).

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

Table 3.7. Continued.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
				Chewuch River spring Chinook				
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
2016	125.7	14.7	11.7	24.1	10.0	41.7	18.8	1.21
Target	136.0	- -	9.0	30.3	- -	- -	15.0	1.20
				Methow River spring Chinook				
1993	134.8	- -	- -	28.5	- -	- -	15.9	1.16
1994	132.0	- -	- -	31.2	- -	- -	14.5	1.36
1995	134.9	- -	- -	32.2	- -	- -	14.1	1.31
1996	128.2	- -	- -	25.0	- -	- -	18.1	1.19
1997	126.5	- -	- -	24.7	- -	- -	18.3	1.22
1998	133.9	6.7	5.0	28.3	5.6	19.8	16.0	1.18
1999	151.0	14.3	9.5	40.9	13.1	32.0	11.0	1.19
2000	131.3	6.8	5.2	26.8	4.8	17.9	16.9	1.18
2001	132.8	- -	- -	28.4	- -	- -	16.0	1.21
2002	132.5	12.5	9.4	28.7	8.1	28.2	15.8	1.23
2003	135.0	10.9	8.1	28.4	6.5	22.9	16.0	1.15
2004	137.3	7.3	5.3	32.1	5.7	17.8	14.1	1.24
2005	130.8	13.9	10.6	27.4	9.3	33.9	17.0	1.22
2006	127.6	15.8	12.4	25.3	12.0	47.4	17.9	1.22
2007	130.8	14.0	10.7	27.0	9.3	34.4	16.8	1.21
2008	125.9	12.2	9.7	24.0	7.0	29.2	18.9	1.20
2009	124.2	16.0	12.9	22.9	7.1	31.0	19.8	1.20
2010	128.8	13.8	10.7	26.9	8.7	32.3	16.9	1.26
2011	142.8	16.1	11.3	33.6	13.8	41.1	14.4	1.15
2012	132.2	11.0	8.3	27.2	8.6	31.6	17.1	1.18
2013	141.1	12.5	8.9	33.6	9.5	28.4	13.5	1.19
2014	130.7	11.5	8.8	26.8	8.1	30.4	17.0	1.20
2015	133.2	10.4	7.8	28.0	8.5	30.4	16.2	1.19
2016	133.5	11.2	8.4	30.3	8.4	27.8	15.0	1.27
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

Table 3.7. Continued.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
				Twisp River spring Chinook				
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
2016	124.5	13.6	10.9	24.6	8.9	36.2	18.4	1.28
Target	135.0	- -	9.0	30.2	- -	- -	15.0	1.23

Survival Estimates

In-hatchery survival of the 2016 brood Methow Composite and Twisp program fish exceeded target values (Wells HCP HC 2007; Table 3.8). Overall (all-year average) mean survival in all 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

Table 3.8. Continued.

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
Methow Composite spring Chinook									
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
2016	94.8	96.4	97.5	100.0	99.9	99.2	98.1	99.3	95.6
Mean	98.2	97.7	95.2	99.2	99.2	98.9	94.2	97.6	87.8
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
2015	100.0	100.0	98.8	99.7	87.5	87.3	87.1	100.0	85.8
2016	100.0	100.0	97.4	100.0	99.7	98.3	97.7	99.8	95.1
Mean	96.5	94.4	94.4	99.5	98.7	98.2	92.3	95.6	86.5
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 2018 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 4 December 2018 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 one occasion for a total of 25 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 265 wild yearling spring Chinook emigrants between 1 March and 30 June at the Methow River trapping location, with peak capture on 17 April ($N = 31$). No mortality of captured Chinook was observed. We PIT tagged and releases 255 of the 265 wild Chinook emigrants captured. We also captured 17,426 hatchery Chinook at the Methow River trap, which included spring and summer races. Overall mortality of the hatchery Chinook captured totaled one fish (<0.01%). We captured 19 emigrant Chinook parr between 1 October and 4 December with peak capture ($N = 2$) occurring on multiple dates. We DNA sampled all 19 of the fall-captured parr, and genetic analysis indicated that 18 (94.7%) of the sampled parr were spring Chinook, and one (5.3%) was a summer Chinook (Attachment A). All 19 parr were PIT tagged prior to release 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 ($y = -2.57\text{E-}05x + 0.161723324$) to determine estimates for the low trapping position in 2018. For the upper trapping position, we were able to conduct two mark/recapture trials with hatchery Chinook. Adding these groups to the previous years' model resulted in a significant relationship ($P < 0.01$, $r^2 = 0.66$; Table 5) and the regression ($y = -2.28\text{E-}05x + 0.254115208$) was used for the upper position in 2018. Using both these flow models, the estimated number of yearling spring Chinook emigrants was 12,732 (± 2,298; 95% CI). When combined with the estimate of parr that emigrated past the trap in 2017 (13,227 ±

60,884, 95% CI), we estimated that 25,959 (± 60,927; 95% CI) 2016 brood wild spring Chinook migrated from the Methow River basin between 1 October 2017 and 30 June 2018 (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.

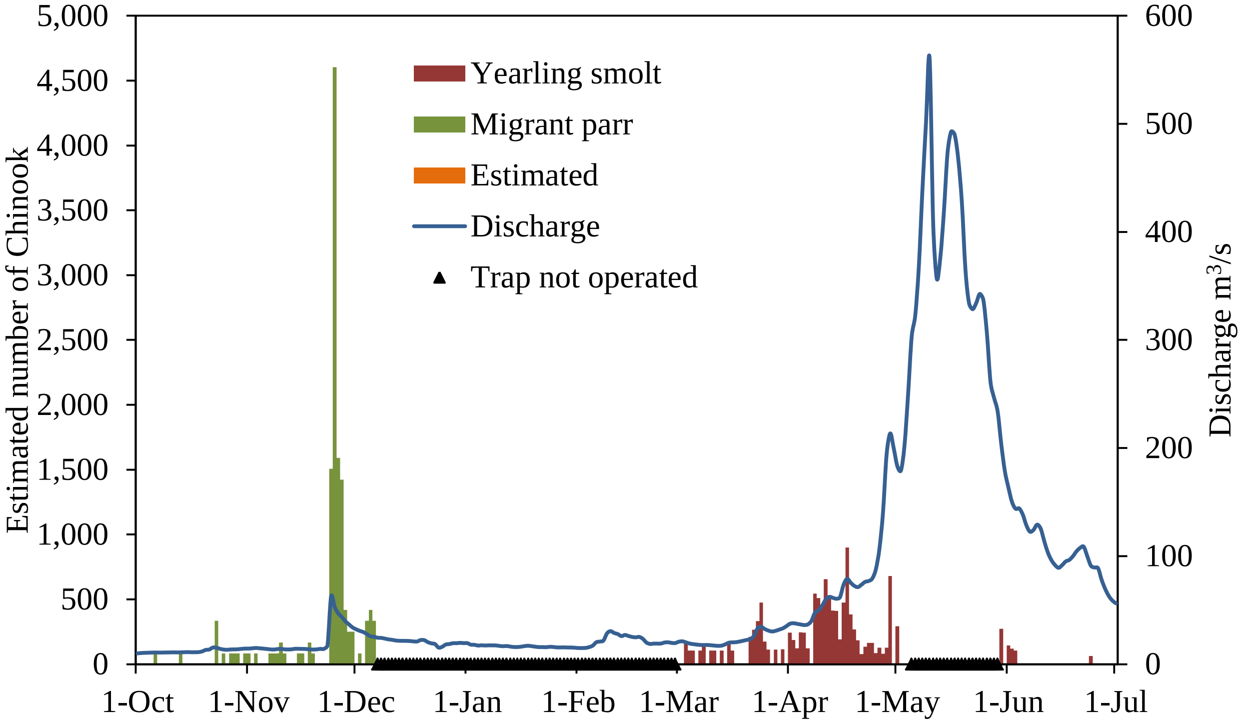

Figure 3.1. Daily emigration of 2016 brood spring Chinook from the Methow River by life stage.

Twisp Trap

Trapping at the Twisp River trap site (rkm 2) occurred between 9 March and 3 December 2018 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 26 days in 2018 because of high flow and debris. We captured 492 wild yearling spring Chinook emigrants at the Twisp trap between 9 March and 30 June. Peak capture occurred on 8 April (*N* = 49; Figure 3.2). We PIT tagged 480 wild yearling emigrants and released 475 after subtracting four mortalities and one shed tag. Overall mortality of wild yearling Chinook totaled four of the 492 fish captured (0.81%). We also captured 3,401 hatchery spring Chinook and a single mortality of these fish occurred (0.03%).

We captured 249 subyearling spring Chinook between 9 March and 3 December at the Twisp trap with peak capture occurring on 3 November (*N* = 22). Although many subyearling Chinook were too small for PIT tagging, we implanted 168 PIT tags into Chinook parr and no mortalities or shed tags occurred (Attachment A).

Four mark/recapture trials were conducted with Chinook smolts at the Twisp trap in the spring of 2018, one with hatchery spring Chinook, one with wild spring Chinook, and two with both hatchery and wild fish. Combining these groups with historical trials, a significant relationship existed between river discharge and trap efficiency ($P < 0.01$, $r^2 = 0.67$). Using the flow model regression parameters ($y = -0.000351573x + 0.514895270$) derived from these trials, we estimated that 3,554 (± 486; 95% CI) smolts emigrated from the Twisp River between 9 March and 30 June 2018. There were no spring Chinook redds identified below the Twisp trap in 2016, so no expansion for this area was necessary. An estimated 21,056 (± 5,923; 95% CI) 2016 brood spring Chinook Salmon parr emigrated from the Twisp River in the fall of 2017 (Attachment A). In addition to the smolt trap estimates, mark/detection trials performed at the Twisp PIT tag array were used to estimate that 1,327 (± 272; 95% CI) spring Chinook emigrated between 4 December 2017 and 8 March 2018 when the smolt trap was not operating. Adding all emigrants totals, an estimated 25,937 (± 5,949; 95% CI) 2016 brood spring Chinook emigrated from the Twisp River, resulting in an estimated 564 smolts produced from each 2016 brood redd (Table 3.9).

No mark/recapture trials were conducted at the Twisp trap site in the fall of 2018 because of low fish abundance. However, a significant efficiency discharge relationship existed from release groups conducted during previous seasons ($P < 0.01$, $r^2 = 0.57$). We used the regression ($y = 0.000908708x + 0.119169681$) from this model to estimate that 6,179 (± 1,522; 95% CI) 2017 brood spring Chinook Salmon parr emigrated past the Twisp trap between 1 July and 3 December 2018 (Attachment A). The trap operated for the entire fall period, so adding estimated migrants using the Twisp PIT tag array was not needed in the fall of 2018. 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. Egg deposition values are derived from within-year redd survey and run composition sampling data (Attachment C). 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

Table 3.9. Continued.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants			Egg to emigrant (%)	Emigrants per redd
				Age-0	Age-1	Total		
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	3,554	25,937	12.4	564
Twisp	2017	22	81,867	6,179	--	6,179	--	--
Twisp	Mean 2003-2016	83	316,828	8,104	5,484	14,121	5.0	196
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	12,732	25,959	1.8	72
Methow	2017	210	823,356	1,507	--	1,507	--	--
Methow	Mean 2003-2016	738	2,801,980	10,627	24,533	33,743	1.2	48

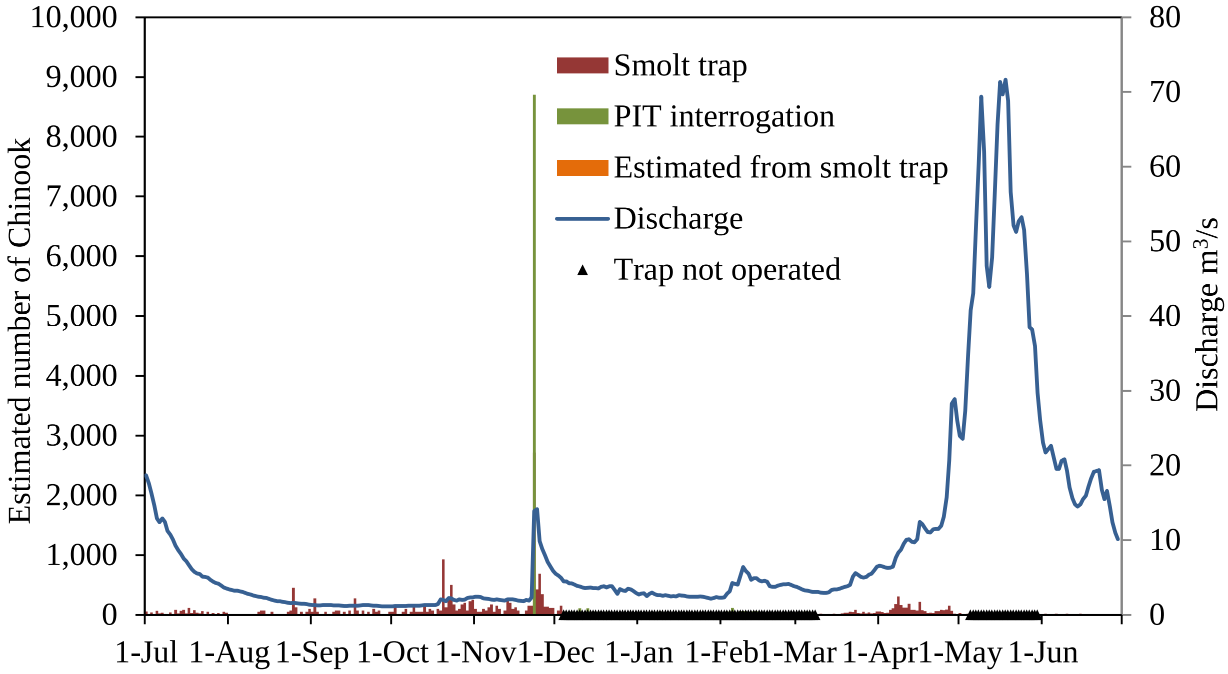

Figure 3.2. Daily emigration of 2016 brood spring Chinook (YCW) from the Twisp River by estimation method.

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, no estimate of post-release tag loss is incorporated into the survival estimate, and 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 2018 (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 and 2017 (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 eight years (2010-2017 tag years) for which emigration is complete (Table 3.11). Standard error (SE) values generated for individual estimates of some groups were high but mean values were similar among release locations.

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 to Rocky Reach Dam 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	39	4.4	0.21	0.05
2018	187	--	--	--	--
Mean 2010-2017		30	3.7	0.24	0.09
		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	0.26	0.12
2017	176	3	1.7	0.25	0.22
2018	110	--	--	--	--
Mean 2010-2017		16	3.0	0.19	0.10

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	--	--	--	--
2018	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 30 July and 26 September 2018 (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 250 spring Chinook redds were constructed in the Methow Basin in 2018, lower than the overall mean number of redds found in the 2003-2017 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 2018 spawning year, the majority of redds were found in the Methow River and tributaries (54.0%). The Chewuch and Twisp rivers accounted for 26.0% and 20.0% 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
2018	112	4	3	8	8	50	65	250
Mean	324	7	26	25	16	77	171	646

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* = 54; 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 sections T6 and T5 (82.0%) and in section C6 of the Chewuch River (29.2%). Spawning was observed in Methow River tributaries (e.g., Early Winters Creek, Lost River), but no spawning tributaries have been identified in the Chewuch or Twisp River watersheds (Table 3.13).

Table 3.13. Spawning distribution (redd counts) and proportion of redds within primary tributaries and reaches of the Methow Basin in 2018.

Methow				Twisp				Chewuch			
Reach	Redds	Redds/ km	% within basin	Reach	Redds	Redds/ km	% within basin	Reach	Redds	Redds/ km	% within basin
M17	1	0.3	0.7	T10[a]	ns	0.0	ns	C13	0	0.0	0.0
M16	1	0.4	0.7	T9[a]	ns	0.0	ns	C12	1	0.2	1.5
M15	2	0.5	1.5	T8	1	0.3	2.0	C11	0	0.0	0.0
M14	4	0.8	3.0	T7	2	0.3	4.0	C10	3	0.8	4.6
M13	1	0.2	0.8	T6	22	3.0	44.0	C9	0	0.0	0.0
M12	5	1.6	3.7	T5	19	3.2	38.0	C8	5	2.1	7.7
M11	6	1.5	4.4	T4	0	0.0	0.0	C7	12	2.4	18.5
M10	18	3.5	13.3	T3	6	1.7	12.0	C6	19	3.3	29.2
M9	54	6.0	40.0	T2	0	0.0	0.0	C5	10	2.7	15.4
M8	1	0.5	0.8	T1	0	0.0	0.0	C4	8	2.2	12.3
M7	10	5.6	7.4					C3	0	0.0	0.0
M6	5	1.9	3.7					C2	7	0.9	10.8
Lost R.	8	1.2	5.9					C1	0	0.0	0.0
Early Winters Cr.	4	0.2	3.0								
Hatchery outfalls	11	13.8	8.1								
Other tributaries[b]	4	0.3	3.0								
Total	135	2.9			50	1.3			65	1.2	

[a] Prevented from surveying above Poplar Flats due to Crescent Fire.

[b] Includes Hancock Springs, Suspension Creek, Little Suspension Creek, and Wolf Creek.

Spawn Timing

Fish were actively spawning in two of the three subbasins by the week starting on 12 August, and peak redd counts occurred earlier in the Methow subbasin than the Chewuch subbasin (Table 3.14; Figure 3.3). Redds were likely documented later than actual spawning in the Twisp River as surveyors were prevented from accessing the river upstream of Buttermilk Bridge until 8 September due to wildfire activity. 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 2018.

Subbasin	Week starting date (Sunday)									Total
	29-Jul	5-Aug	12-Aug	19-Aug	26-Aug	2-Sep	9-Sep	16-Sep	23-Sep	
Chewuch	0	0	0	1	10	29	22	3	0	65
Methow	0	1	2	20	45	37	20	9	1	135
Twisp	0	0	1	0	9	35	4	1	0	50

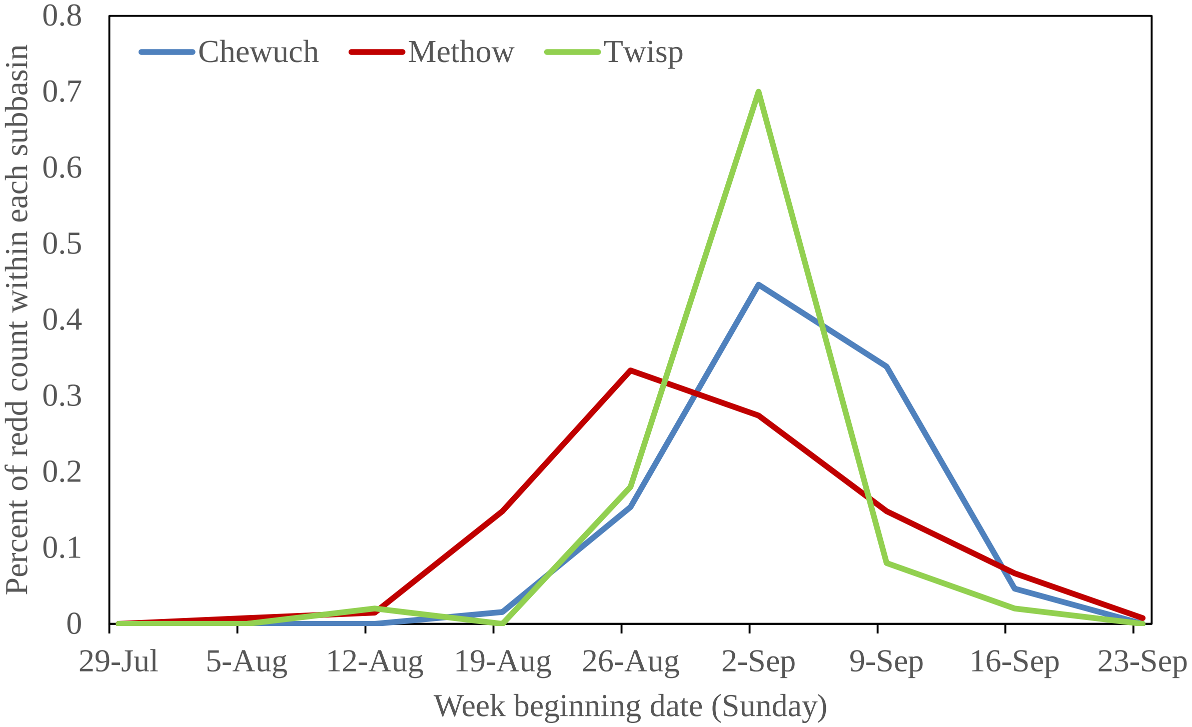

Figure 3.3. Percent of completed spring Chinook redds by subbasin and week of detection in 2018.

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 2018 FPR value (1.99), there were an estimated 500 spawners in the Methow River basin, of which 265 (53.0%) were estimated to be wild (NOR) fish (Tables 3.15 and 3.16). Estimated spawning escapement does not include hatchery or wild fish collected for broodstock. Wild fish comprised 69.0%, 50.0%, and 46.9% of the estimated spawning escapement in the Twisp, Methow, and Chewuch subbasins, respectively (Attachment C).

Table 3.15. Estimated spawning escapement by stream in the Methow River Basin in 2018.

Survey stream	Redds	Estimated spawning escapement		
		H	W	Total
Chewuch River	65	69	61	130
Early Winters Creek	4	8	0	8
Hancock Creek	0	0	0	0
Lost River	8	0	16	16
Methow River	108	113	103	216
MH outfall	3	6	0	6
Suspension Creek	4	0	8	8
Twisp River	50	31	69	100
WNFH outfall	8	8	8	16
Wolf Creek	0	0	0	0
Total	250	235	265	500

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. Surveyors (WDFW and USFWS) sampled 32.4% of the overall Methow Basin estimated spawning population in 2018 (Table 3.16, Attachment C).

Egg retention was estimated for 84 of the 96 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 966,908 eggs were deposited in the Methow River basin in 2018 (Table 3.17).

Table 3.16. Carcass recoveries and expanded count by tributary and reach from Methow Basin spring Chinook surveys in 2018.

Reach	Redds		Estimated spawning escapement	Carcasses				
	Count	Subbasin Prop. (%)		Recoveries			Expanded count	
				H	W	Total	H	W
Methow River mainstem								
M17	1	0.7	2	1	1	2	1	1
M16	1	0.7	2	0	1	1	0	2
M15	2	1.5	4	2	1	3	3	1
M14	4	3.0	8	1	1	2	4	4
M13	1	0.8	2	1	0	1	2	0
M12	5	3.7	10	3	2	5	6	4
M11	6	4.4	12	2	2	4	6	6
M10	18	13.3	36	1	6	7	5	29
M9	54	40.0	108	14	11	25	63	47
M8	1	0.8	2	2	1	3		
M7	10	7.4	20	7	3	10	14	6
M6	5	3.7	10	6	1	7	9	1
M5,4	0	0.0	0	0	0	0	0	0
Total	108	80.0	216	40	30	70	113	103
Lost River								
L2	4	3.0	8	0	1	1	0	8
L1	4	2.9	8	0	0	0	0[a]	8[a]
Total	8	5.9	16	0	1	1	0	16
Early Winters Creek								
EW5,4	0	0.0	0	0	0	0	0	0
EW3	4	3.0	8	1	0	1	8	0
EW2,1	0	0.0	0	0	0	0	0	0
Total	4	3.0	8	1	0	1	8	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	3	2.2	6	0	0	0	6[b]	0[b]
Lsusp1	0	0.0	0	0	0	0	0	0
Susp1	4	3.0	8	0	1	1	0	8
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	8	5.9	16	1	1	2	8	8
Total	15	11.1	30	1	2	3	14	16
Grand total	135	100.0	270	42	33	75	135	135

[a] Expanded count based on H and W proportions from L2.

[b] Expanded count based on H and W proportions from previous years' data.

Table 3.16. Continued.

Reach	Redds		Estimated spawning escapement	Carcasses				
				Recoveries			Expanded count	
	Count	Subbasin Prop. (%)		H	W	Total	H	W
			Chewuch River mainstem					
C13	0	0.0	0	0	0	0	0	0
C12	1	1.5	2	0	0	0	1[a]	1[a]
C11	0	0.0	0	0	0	0	0	0
C10	3	4.6	6	1	1	2	3	3
C9	0	0.0	0	0	0	0	0	0
C8	5	7.7	10	4	3	7	6	4
C7	12	18.5	24	4	8	12	8	16
C6	19	29.2	38	10	15	25	15	23
C5	10	15.4	20	6	2	8	15	5
C4	8	12.3	16	4	1	5	13	3
C3	0	0.0	0	0	0	0	0	0
C2	7	10.8	14	4	3	7	8	6
C1	0	0.0	0	0	0	0	0	0
Total	65	100.0	130	33	33	66	69	61
			Twisp River mainstem					
T10[a]	ns	ns	ns	ns	ns	ns	ns	ns
T9[a]	ns	ns	ns	ns	ns	ns	ns	ns
T8	1	2.0	2	0	0	0	0	2[b]
T7	2	4.0	4	0	2	2	0	4
T6	22	44.0	44	1	3	4	11	33
T5	19	38.0	38	6	8	14	15	23
T4	0	0.0	0	0	1	1		
T3	6	12.0	12	0	0	0	5[c]	7[c]
T2	0	0.0	0	0	0	0	0	0
T1	0	0.0	0	0	0	0	0	0
Total	50	100.0	100	7	14	21	31	69

[a] Prevented from surveying above Poplar Flats due to Crescent Fire.

[b] Expanded count based on H and W proportions from T7.

[c] Expanded count based on H and W proportions from T5/4.

Table 3.17. Estimated egg deposition for spring Chinook in the Methow Basin in 2018. 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 (Attachment C).

Subbasin	Females with egg retention estimated	Mean fecundity	Mean egg retention (%)	Redds	Subbasin proportion (%)	Estimated egg deposition		
						2016	2017	2018
Chewuch	42	3,784	0.40	65	25.5	351,373	253,038	244,976
Methow	34	3,787	0.60	140	54.9	866,006	488,451	526,999
Twisp	8	3,901	0.06	50	19.6	209,262	81,867	194,933
Total	84			255		1,426,641	823,356	966,908

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 3.18). Average age-4 returns across river basins ranged from 72 – 78% for hatchery fish and 74 – 79% 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 3.18).

Table 3.18. Proportion of adult returns by total age of the 1998-2012 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

Table 3.18. Continued.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Methow spring Chinook			
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
2012	H	0.09	0.90	0.01	2,313
2012	W	0.06	0.81	0.13	222
Mean	H	0.16	0.78	0.07	1,059
Mean	W	0.09	0.74	0.16	210
		Chewuch spring Chinook			
2001	H	0.1	0.87	0.03	707
2001	W	0.00	0.81	0.19	254
2002	H	0.08	0.78	0.15	633
2002	W	0.01	0.59	0.39	153
2003	H	0.04	0.79	0.18	56
2003	W	0.00	0.31	0.69	48
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

Table 3.18. Continued.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Chewuch spring Chinook			
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
2012[a]	H	--	--	--	--
2012	W	0.00	0.85	0.15	120
Mean	H	0.17	0.78	0.06	506
Mean	W	0.04	0.74	0.23	185
		Twisp spring Chinook			
1998	H	0.18	0.68	0.14	22
1998	W	0.21	0.62	0.18	117
1999	H	0.13	0.83	0.03	60
1999	W	0.00	1.00	0.00	7
2000	H	0.12	0.88	0.00	147
2000	W	0.12	0.83	0.05	318
2001	H	0.12	0.86	0.02	42
2001	W	0.22	0.62	0.16	124
2002	H	0.26	0.7	0.04	210
2002	W	0.00	0.57	0.43	82
2003	H	0.06	0.92	0.02	134
2003	W	0.00	1.00	0.00	1
2004	H	0.31	0.63	0.07	225
2004	W	0.12	0.74	0.14	65
2005	H	0.24	0.67	0.09	45
2005	W	0.11	0.76	0.14	37
2006	H	0.00	0.39	0.60	238
2006	W	0.07	0.69	0.24	259
2007	H	0.24	0.76	0.00	37
2007	W	0.04	0.89	0.07	118
2008	H	0.33	0.65	0.02	360
2008	W	0.13	0.81	0.06	77

Table 3.18. Continued.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Twisp spring Chinook			
2009	H	0.16	0.82	0.02	121
2009	W	0.16	0.73	0.10	33
2010	H	0.46	0.52	0.02	288
2010	W	0.12	0.74	0.14	142
2011	H	0.24	0.66	0.10	59
2011	W	0.07	0.85	0.08	125
2012	H	0.12	0.88	0.00	40
2012	W	0.05	0.95	0.00	50
Mean	H	0.20	0.72	0.08	135
Mean	W	0.09	0.79	0.12	104

Length at Maturity

Length at maturity of Methow Composite hatchery-origin spring Chinook was similar to wild spring Chinook from the Methow and Chewuch Rivers for the long-term mean (1992-2012 broods; Table 3.19). Length at maturity of hatchery-origin 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 3.19. Mean post-eye to hypural plate (POH) length (cm) of adult Chinook Salmon by sex, age, origin, and release location (hatchery fish) or stream of recovery (wild fish). Adult data for Twisp wild fish includes those found on spawning ground surveys, retained for broodstock at the Twisp weir, and fish collected at Wells Dam for which stock was determined through genetic assessment. Wild fish collected from Fulton Dam are included in the Chewuch groups.

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

Table 3.19. 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										
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
2012	H	42	3	7	60	18	4	77	3	1
2012	W	40	7	3	61	17	7	75	1	--
Mean	H	41	33	--	60	59	--	72	8	--
Mean	W	43	3	--	60	17	--	75	5	--
Methow River females										
1992	W	--	--	--	--	--	--	74	4	6
1993	H	--	--	--	59	61	3	73	16	6
1993	W	--	--	--	63	15	2	--	--	--
1994	H	--	--	--	63	2	6	--	--	--
1995	H	--	--	--	65	56	3	--	--	--
1995	W	--	--	--	61	7	3	74	1	--
1996	H	--	--	--	62	66	3	74	8	3
1996	W	--	--	--	64	2	6	73	12	6
1997	H	--	--	--	63	283	3	70	19	4

Table 3.19. 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	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
2012	H	--	--	--	61	42	4	70	1	--
2012	W	55	1	--	59	31	6	68	3	5
Mean	H	49	3	--	61	114	--	69	11	--
Mean	W	55	1	--	60	25	--	71	7	--
					Chewuch River males					
1992	H	--	--	--	58	15	5	--	--	--
1992	W	--	--	--	--	--	--	77	4	7
1993	H	40	16	2	58	18	4	75	6	3

Table 3.19. 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										
1993	W	--	--	--	61	8	3	--	--	--
1996	H	42	3	3	60	5	4	70	1	--
1996	W	--	--	--	--	--	--	69	11	2
1997	H	42	24	4	62	109	5	71	7	8
1997	W	--	--	--	61	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
2012	H[c]	--	--	--	--	--	--	--	--	--
2012	W	--	--	--	60	11	5	77	1	--
Mean	H	40	23	--	59	47	--	71	8	--
Mean	W	42	2	--	60	20	--	74	5	--
Chewuch River females										
1992	H	--	--	--	59	22	3	--	--	--

Table 3.19. 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								
1992	W	--	--	--	--	--	--	73	1	--
1993	H	--	--	--	60	24	3	71	7	3
1993	W	--	--	--	60	16	3	--	--	--
1994	H	--	--	--	65	2	3	--	--	--
1995	W	--	--	--	--	--	--	74	3	3
1996	H	--	--	--	62	10	3	75	2	4
1996	W	--	--	--	65	3	2	68	6	1
1997	H	60	1	--	63	174	4	72	5	5
1997	W	--	--	--	62	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
2012	H[c]	--	--	--	--	--	--	--	--	--

Table 3.19. 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					
2012	W	--	--	--	60	24	4	75	3	3
Mean	H	58	2	--	60	84	--	69	11	--
Mean	W	56	1	--	60	23	--	70	7	--
					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	--	--	--

Table 3.19. 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										
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	--	--	--
2011	W	43	4	4	56	36	4	--	--	--
2012	H	47	1	--	61	4	4	--	--	--
2012	W	45	2	16	62	7	6	62	1	--
Mean	H	41	12	--	57	11	--	72	1	--
Mean	W	40	5	--	57	18	--	72	3	--
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	--

Table 3.19. 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								
2005	W	--	--	--	61	8	6	74	2	0
2006	H	--	--	--	61	32	3	68	1	--
2006	W	--	--	--	62	32	4	70	11	4
2007	H	--	--	--	59	4	4	--	--	--
2007	W	--	--	--	63	11	4	74	4	2
2008	H	--	--	--	60	65	3	70	1	--
2008	W	--	--	--	58	16	4	73	3	3
2009	H	--	--	--	59	27	3	73	1	--
2009	W	--	--	--	58	6	5	62	2	4
2010	H	--	--	--	59	44	4	72	3	3
2010	W	--	--	--	60	31	4	71	9	4
2011	H	--	--	--	59	16	3	70	2	6
2011	W	--	--	--	61	40	3	73	4	2
2012	H	--	--	--	59	11	4	--	--	--
2012	W	--	--	--	59	13	3	--	--	--
Mean	H	--	--	--	60	23	--	69	2	--
Mean	W	--	--	--	61	17	--	71	4	--

[a] Includes Methow Composite mixed release group spawning ground recoveries in the Methow subbasin only.

[b] Includes Methow Composite mixed release group spawning ground recoveries in the Chewuch subbasin only.

[c] No hatchery releases in 2012.

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 3.20).

Table 3.20. 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 2000-2012). 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
2012	2,112	187	3	0	0	0	17	9	2,328	1.1
Mean	599	279	1	0	0	7	27	36	950	7.5
				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

Table 3.20. Continued.

Brood	Hatchery	Spawning ground	Ocean fishery			Freshwater fishery			Total	Harvest %
			Comm.	Sport	Tribal	Comm.	Sport	Tribal		
				Twisp spring Chinook						
2004	35	124	0	0	0	2	0	19	180	11.7
2005	11	34	0	0	0	0	0	0	45	0.0
2006	42	181	0	0	0	0	0	25	248	10.1
2007	18	19	0	0	0	0	0	0	37	0.0
2008	56	285	0	0	0	8	68	29	446	23.5
2009	40	81	0	0	0	0	1	1	123	1.6
2010	59	226	0	0	0	0	1	3	289	1.4
2011	8	51	0	0	0	0	0	0	59	0.0
2012	15	25	0	0	0	0	0	0	40	0.0
Mean	31	82	0	0	0	1	4	6	125	8.7
				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
2012				No releases this brood year						
Mean	93	262	0	0	0	4	20	16	395	8.2

Migration Timing

The 2018 spring Chinook migration to Wells Dam was monitored between 7 May and 12 July 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 CWTs 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 3.21), although several groups had low sample sizes. Although the recent (2010-2018) 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 3.21. 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 2018. Totals do not include fish of unknown origin or age. Totals (all) does include fish of unknown age.

Age	Origin	Percentile					Mean	*N*
		10	25	50	75	90		
3	H	29-May	1-Jun	4-Jun	7-Jun	13-Jun	4-Jun	137
3	W	27-May	30-May	2-Jun	6-Jun	8-Jun	2-Jun	9
4	H	25-May	29-May	2-Jun	8-Jun	14-Jun	3-Jun	987
4	W	25-May	39-May	3-Jun	8-Jun	14-Jun	3-Jun	199
5	H	28-May	28-May	4-Jun	11-Jun	18-Jun	5-Jun	16
5	W	2-Jun	2-Jun	2-Jun	4-Jun	4-Jun	3-Jun	2
All	H	26-May	30-May	3-Jun	8-Jun	14-Jun	3-Jun	1,199
All	W	25-May	29-May	3-Jun	8-Jun	14-Jun	3-Jun	211

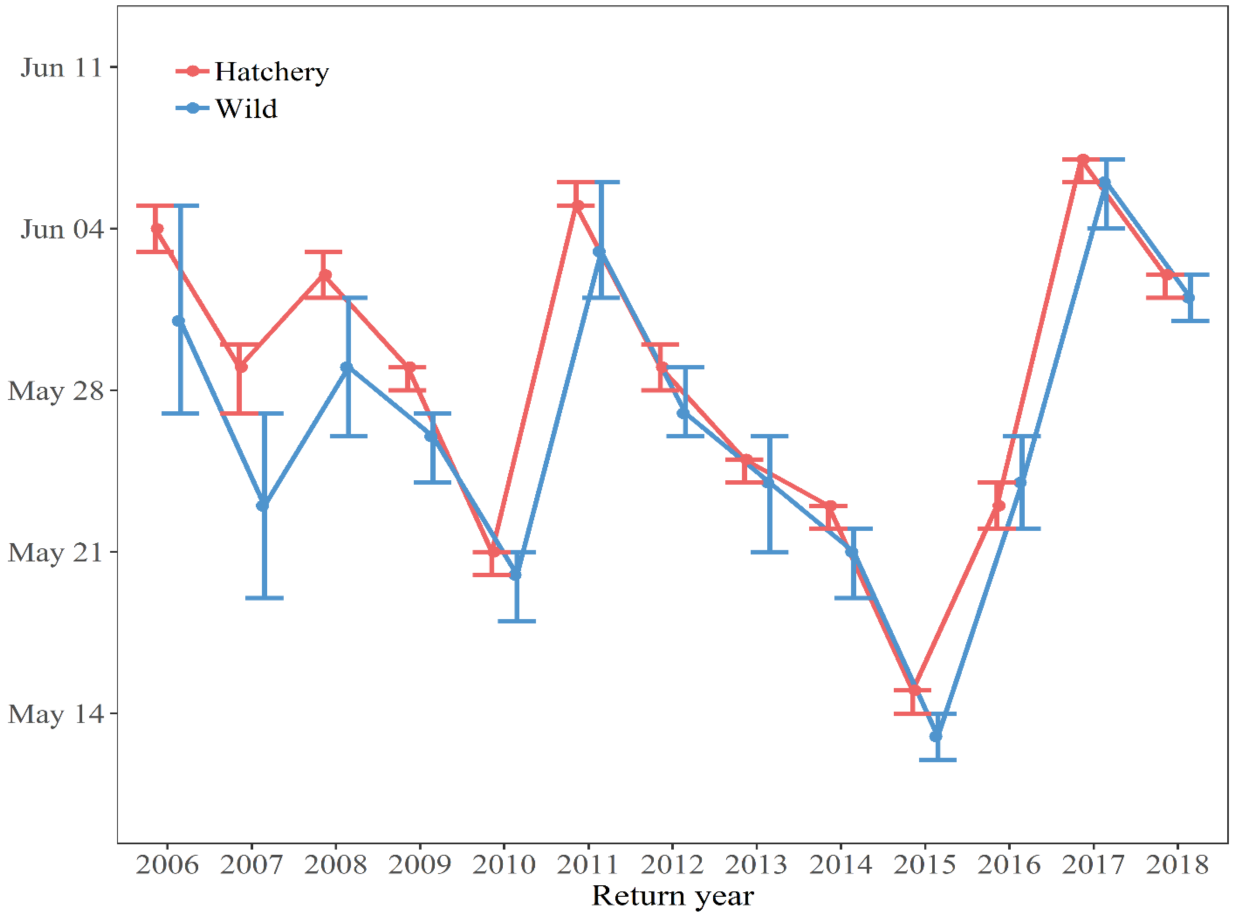

Figure 3.4. Mean (center point) +/- 95% CI (bars) arrival date at Wells Dam of hatchery and wild spring Chinook by return year.

Straying

Targets for recipient population 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 is 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 based on CWT recoveries averaged over 30% for each release location overall (Table 3.22). Conversely, adult returns from Methow River (on-station) releases rarely strayed into non-target recipient populations, averaging less than 3% overall (Table 3.22). 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 3.23).

Table 3.22. Straying by Methow Hatchery spring Chinook released as yearling smolts by brood year, release location, and recipient area based on CWT recoveries.

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
2012			No releases this brood year		
Mean	396	141	5	146	32.18
		Methow River releases			
1993	191	1	0	1	0.52
1994	1	0	0	0	0.00
1995	122	0	0	0	0.00
1996	501	8	0	8	1.60
1997	716	1	0	1	0.14
1998	924	- -	- -	0	0.00
1999	144	7	0	7	4.86
2000	32	- -	- -	0	0.00
2001	503	23	0	23	4.57
2002	603	26	2	28	4.64
2003	52	0	0	0	0.00
2004	304	33	0	33	10.86
2005	326	10	1	11	3.37
2006	1,707	106	1	107	6.27
2007	515	10	0	11	2.14
2008	1,206	39	0	39	3.23
2009	761	13	2	15	1.97

Table 3.22. Continued.

Brood year	Total return	Recipient (stray) area			% stray
		Stream	Hatchery	Total	
		Methow River releases			
2010	1,411	81	36	117	8.29
2011	3,489	39	0	39	1.12
2012	2,328	14	0	14	0.60
Mean	817	23	2	23	2.59
		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
2012	40	6	10	16	40.00
Mean	119	25	18	43	31.14

Table 3.23. Contribution (%) to tributary spawning escapements by return year from Methow Basin spring Chinook Salmon releases. Contribution was calculated from CWT recoveries as the estimated sum of hatchery Chinook from a release-site in each return-year divided by the estimated total escapement of all Chinook in the recipient tributary in each 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
2017	0.0	0.0	5.5	0.0	31.6
2018	0.0	0.0	2.3	0.0	29.5
Mean %	0.1	0.1	11.6	0.9	26.8
			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

Table 3.23. Continued.

Return year	Recipient tributary				
	Chiwawa R.	Entiat R.	Methow R.	Twisp R.	Chewuch R.
			Methow River releases		
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
2015	0.0	0.6	36.4	5.0	6.5
2016	0.0	0.0	22.3	2.7	5.7
2017	0.0	0.0	10.4	0.0	1.6
2018	0.0	0.0	9.2	0.0	1.5
Mean %	0.0	0.3	22.9	1.0	5.0
			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
2017	0.0	0.0	0.0	30.3	1.6
2018	0.0	0.0	0.0	19.2	0.0
Mean %	0.0	0.1	2.7	36.9	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 0.22%, 0.42%, and 0.25%, respectively for Twisp, Methow, and Chewuch river releases (Table 3.24). Smolt to adult return of 2012 brood fish was well above the overall mean value for the Methow release group but well under for the Twisp release group. There were no hatchery releases in the Chewuch River in 2012. HRR values (harvest included), calculated as the number of adult returns divided by the number of adult broodstock, were nearly three times greater than average for 2012 brood Methow releases (Table 3.24). Only the Methow release group had an overall mean HRR value above the target value of 4.5 (Table 3.24).

Table 3.24. 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, fish not utilized, and strays.

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
2012	33	48,924	40	0.082	1.2	40	0.082	1.2
Mean	35	52,485	115	0.219	3.2	104	0.198	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

Table 3.24. Continued.

Brood year	Number of broodstock	Smolts released	Harvest included			Harvest not included		
			Adults	SAR (%)	HRR	Adults	SAR (%)	HRR
			Methow spring Chinook					
1998	181	435,670	2,281	0.524	12.6	1,359	0.312	7.5
1999	182	180,775	144	0.080	0.8	135	0.075	0.7
2000	256	266,392	851	0.319	3.3	819	0.307	3.2
2001	94	130,887	503	0.384	5.4	499	0.381	5.3
2002	115	181,235	603	0.333	5.2	597	0.329	5.2
2003	47	48,831	52	0.106	1.1	52	0.106	1.1
2004	81	65,146	304	0.467	3.8	281	0.431	3.5
2005	122	156,633	326	0.208	2.7	326	0.208	2.7
2006	182	211,717	1,707	0.806	9.4	1,519	0.717	8.3
2007	90	119,407	515	0.431	5.7	512	0.429	5.7
2008	137	175,699	1,206	0.686	8.8	921	0.524	6.7
2009	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
2012	152	196,711	2,328	1.181	15.3	2,299	1.169	15.1
Mean	144	195,500	922	0.417	5.8	817	0.380	5.2
			Chewuch spring Chinook					
1992	26	40,881	39	0.095	1.5	39	0.095	1.5
1993	115	284,165	115	0.040	1	109	0.038	0.9
1994	12	11,854	3	0.025	0.3	3	0.025	0.3
1995	-	-	-	-	-	-	-	-
1996	95	91,672	37	0.040	0.4	34	0.037	0.4
1997	68	132,759	330	0.249	4.9	118	0.089	1.7
2001	187	261,284	705	0.270	3.8	703	0.269	3.8
2002	161	254,238	632	0.249	3.9	627	0.247	3.9
2003	94	127,614	55	0.043	0.6	55	0.043	0.6
2004	165	204,906	194	0.095	1.2	185	0.090	1.1
2005	170	232,811	307	0.132	1.8	303	0.130	1.8
2006	152	154,381	730	0.473	4.8	649	0.420	4.3
2007	98	126,055	811	0.643	8.3	793	0.629	8.1
2008	203	260,344	1,068	0.410	5.3	814	0.313	4.0
2009	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
2012			No releases this brood year					
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 two most recent 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 3.25). 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 3.25).

Table 3.25. 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)	0.36 (18)
2016*	5,001	0.676 (0.048)	17.5 (0.28)	0.02 (1)
Mean[1]	6,328	0.720	18.3	0.65
		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)

Table 3.25. Continued.

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*))
		Twisp River Acclimation Pond release		
2015*	5,001	0.740 (0.046)	21.7 (0.40)	0.30 (13)
2016*	4,996	0.654 (0.050)	16.2 (0.27)	0 (0)
Mean[1]	4,354	0.702	16.0	0.48
		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)	0.36 (18)
2016*	4,968	0.696 (0.052)	17.1 (0.33)	0.04 (2)
Mean[1]	7,004	0.707	19.5	0.46

[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 (2012 brood) was < 1 in all three subbasins and less than the overall median NRR values in the Chewuch and Twisp subbasins (Table 3.26).

Table 3.26. 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

Table 3.26. Continued.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
			Chewuch River				
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
2012	337	0	103	18	126	0.4	--
Median	335	2	81	19	107	0.5	4.0
			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
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
2012	744	14	180	29	232	0.3	15.3
Median	744	5	103	29	209	0.3	4.5

Table 3.26. Continued.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
			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
2012	199	3	48	0	53	0.3	1.2
Median	165	5	48	12	91	0.4	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 (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 2003-2018, mean PNI was higher in the Twisp Basin than in the Methow or Chewuch river basins (Table 3.27). However, mean values for all basins are low and indicate that most genetic selection pressure on progeny produced from naturally spawning adults comes from the hatchery environment (Table 3.27).

Table 3.27. The proportionate 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 within each tributary and spawning year. Stray hatchery-origin fish were included under the WNFH category because we assumed their genetic lineage was most similar to that category for modeling purposes.

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
2018	0.33	0.20	0.47	0.59	0.11	0.39	0.50	0.54	0.25	0.06	0.69	0.74
Mean	0.55	0.11	0.34	0.29	0.54	0.23	0.23	0.27	0.46	0.04	0.50	0.45

Precocial Maturation Rates

Yearling spring Chinook (BY 2016; *N* = 300; 170 males) were sampled prior to release on 16 April, 2018 with overall male precocity rate of 44% (Figure 3.5). Histogram results of pre-release gondal somatic index (GSI) sampling of 2016 brood Methow Hatchery spring Chinook illustrating the bimodal distribution of log10 transformed gonadal weights used to identify maturing males from non-maturing males are presented for raceway 8 and pond 13 combined (Figure 3.5), and separately for pond 13 (Figure 3.6) and raceway 8 (Figure 3.7). Both groups were fed with EWOS-brand feed. Closer inspection revealed that fish in pond 13 (the large acclimation pond) exhibited a much higher precocity rate (60%; Figure 3.6) than in raceway 8 (20%; Figure 3.7). Hatchery staff reported difficulty in keeping the CV for size under control in pond 13 due to the extremely low rearing density in the pond. We hypothesize that the low rearing density in pond 13 resulted in high CV for fish size (length), resulting in the higher precocity levels. Alternatively, but believed to be less likely, pond 13 is outdoors, not covered like the raceways and this may have affected precocity. Early maturation of males from the 2016 brood was higher than the mean male maturation rate of the last 4 broods sampled (Table 3.28).

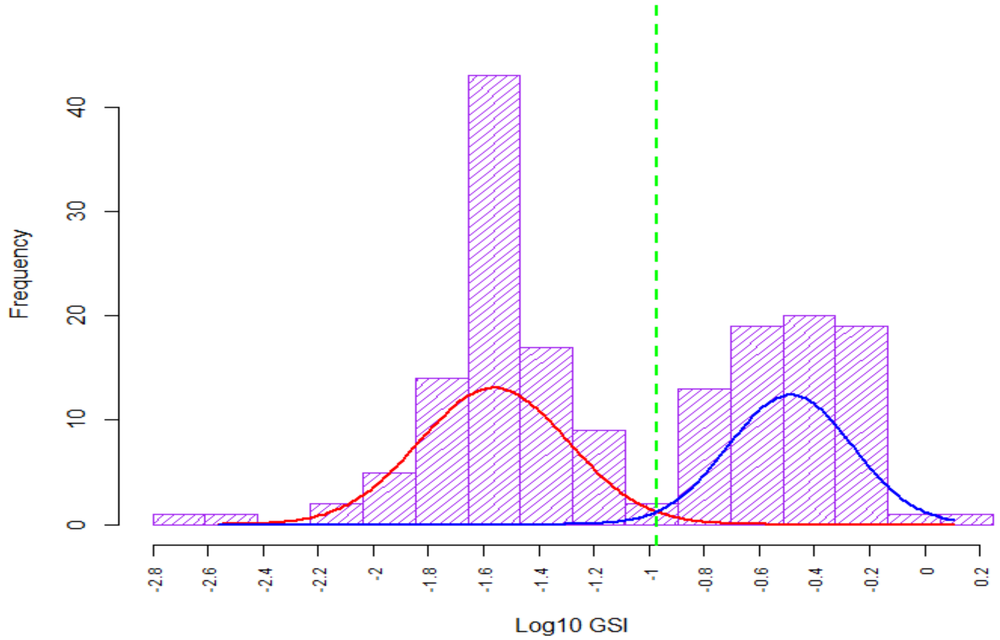

Figure 3.5. Brood year 2016 male log10 GSI results for rearing pond 13 and raceway 8. Both groups were fed EWOS-brand food and the model-generated precocity cutoff (dotted vertical line) was -0.8812507.

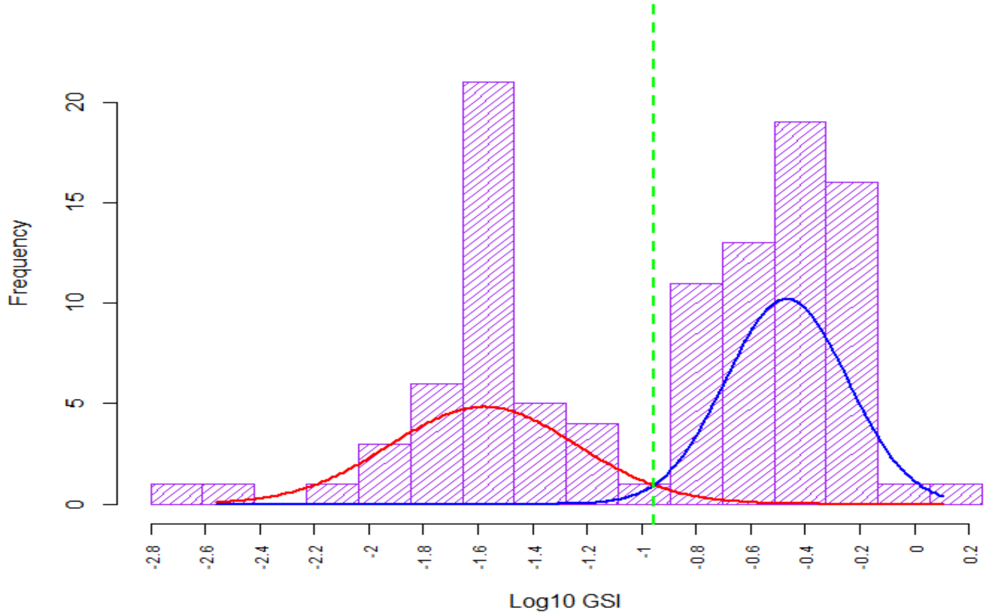

Figure 3.6. Brood year 2016 male log10 GSI results for rearing pond 13, receiving EWOS-brand food during rearing. The model-generated precocity cutoff (dotted vertical line) was -0.8638049.

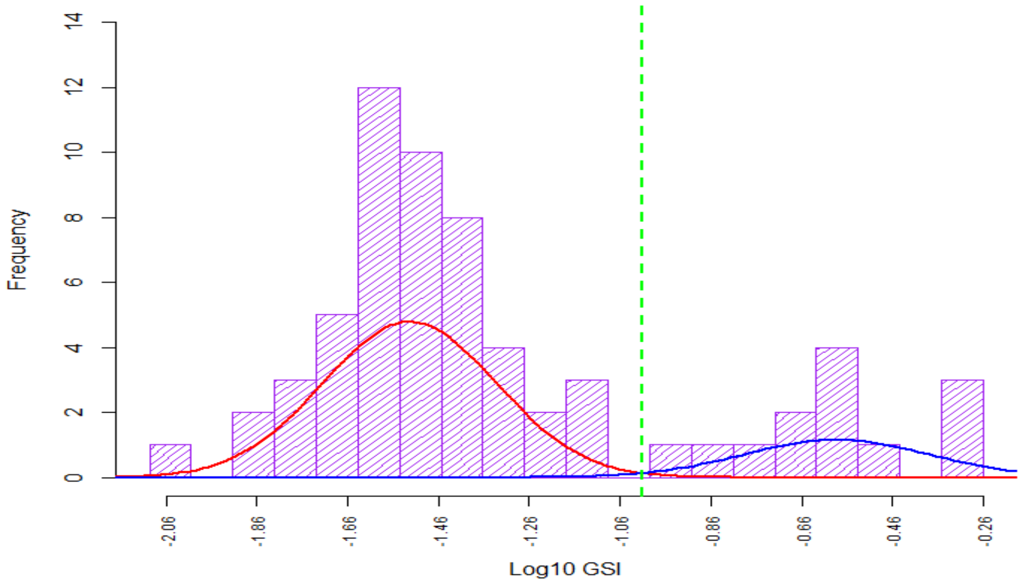

Figure 3.7. Brood year 2016 male log10 GSI results for raceway 8, receiving EWOS-brand food during rearing. The model-generated precocity cutoff (dotted vertical line) was -0.9176248.

Table 3.28. Early maturation rate of juvenile male spring Chinook Salmon prior to release from Methow Hatchery. Early maturation was determined through analysis of log10-transformed GSI values of male fish.

Brood year	Sample date	Sampled			Male early maturation rate (%)
		Male	Female	Total	
2012	4/14/2014	172	128	300	53.4
2014	4/12/2016	149	151	300	17.4
2015	4/17/2017	149	151	300	7.3
2016	4/16/2018	170	130	300	44.7
Mean		160	140	300	30.7

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 (2016 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. Because of the relatively short rearing period for subyearling program fish, ELISA sampling is not conducted on adult females spawned for that program.

4.1: Broodstock Collection and Sampling

Trapping of the 2016 brood of Wells Hatchery summer Chinook Salmon occurred between 5 July and 7 September, 2016. During this time a total of 1,588 hatchery origin and 81 wild origin fish were collected. The overall collection represented 11.7% 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. Collections of adult fish included 861 surplus fish provided to local tribes (Table 4.1), and overall pre-spawn mortality totaled 22 (2.7%) of the fish remaining on-station after tribal surplus fish were removed.

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
2016	81	4	0	77	0	1,588	18	19	690	0	861	767

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 2016 return year, age-4 and age-5 fish were 33.7% and 63.1% 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
Hatchery origin													
2016	M	77	7	10	80	141	6	88	181	8	89	7	11
2016	F	76	1	--	83	89	5	88	250	4	92	7	3
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	--	--	--

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							
2016	M	--	--	--	88	31	7	98	8	8	--	--	--
2016	F	--	--	--	86	22	4	91	18	4	--	--	--

Sex Ratio and Fecundity

The long-term mean sex ratio of fish retained for broodstock (excludes released fish) favored females (Table 4.3), and the sex ratio of the 2016 brood was similar to these values. Of the 2016 brood female Chinook sampled, overall fecundity (4,085) was less than the long-term mean fecundity (Table 4.3). By origin, mean fecundity values for hatchery (4,183) and wild females (4,552) were less than those used to estimate broodstock collection quotas in the broodstock collection protocols.

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

Table 4.3. Continued.

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
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
2016	350	360	4,088	0.97:1	39	43	3,944	0.90:1	0.97:1	4,085
Mean	452	466	4,428	0.96:1	53	50	4,437	1.06:1	0.98:1	4,450

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 almost all females from the 2016 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	Low	Med	High	Total number
	<0.099	0.099 - 0.199	0.20 - 0.449	> 0.450	
1993	100.0	0.0	0.0	0.0	132
1994	97.2	1.7	0.0	1.1	181
1995	78.8	12.9	1.8	6.5	170
1996	99.0	0.5	0.0	0.5	196
1997	88.6	7.6	1.1	2.7	185
1998	91.7	5.5	1.8	0.9	109
1999	99.1	0.9	0.0	0.0	106
2000	87.9	8.8	3.3	0.0	91
2001	99.3	0.0	0.0	0.7	139
2002	93.9	2.4	0.0	3.7	82
2003	94.9	2.0	2.0	1.0	99
2004	95.0	5.0	0.0	0.0	20
2005	98.9	0.5	0.0	0.5	190
2006	100.0	0.0	0.0	0.0	167

Table 4.4. Continued.

Return year	Below-low	Low	Med	High	Total number
	<0.099	0.099 - 0.199	0.20 - 0.449	> 0.450	
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
2016	99.0	0.0	1.0	0.0	103
Mean	95.9	2.8	0.5	0.8	158

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 95.7% 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 2016 brood fish were similar, with subyearling program fish slightly below the release goal (-3%) and yearling program fish above the release goal (+11%; 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
2016	7191	0.986	24-May-17	470,247	6988, 7136, 7137, 6939	0.995	18-Apr-18	356,240
Mean	--	0.976	--	434,161	--	0.957	--	336,716

Juvenile Size and Condition at Release

Size-at-release (FPP) targets for DCPUD program fish are described in Hillman et al. (2017). The 2016 brood yearling program fish were larger than their target FPP goal of 10, and had a fork length coefficient of variation (CV) below the release goal of 7.0, indicating that length-at-release variability was low. Length-at-release of the 2016 brood subyearling program fish was also fairly uniform with a CV at release (7.4) near the release goal of 7.0 (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 2008-2016 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
2016	165.2	9.9	6.0	49.6	8.7	17.6	9.1	1.10
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

Table 4.6. Continued.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
				Wells subyearling Chinook Salmon				
2001	116.9	7.6	6.5	20.6	4.8	23.5	21.9	1.29
2002	108.1	8.0	7.4	14.7	3.6	25.0	30.9	1.16
2003	115.4	7.2	6.2	18.9	4.4	23.5	24.0	1.23
2004	109.5	6.1	5.6	15.0	2.8	18.7	30.2	1.14
2005	108.5	7.4	6.8	14.3	3.6	25.3	31.7	1.12
2006	111.0	10.3	9.3	14.9	- -	- -	30.4	1.09
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
2016	82.0	6.1	7.4	7.0	1.4	20.4	64.6	1.27
Target	- -	- -	<7.0	- -	- -	- -	50.0	- -

Survival Estimates

In-hatchery survival from fertilization to release of the 2016 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 post-ponding period. 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
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
2016	97.0	96.9	88.3	100.0	97.3	97.0	96.9	--	85.6
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

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 subyearling									
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	--	75.9
2016	--	--	92.8	90.9	--	--	77.2	--	65.1
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 2011 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 are 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
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	0.003	0.210	0.695	0.092	0.000	0.000	850
2007	Yearling	0.005	0.074	0.354	0.543	0.025	0.000	1,017
2008	Subyearling	0.094	0.346	0.513	0.048	0.000	0.000	412
2008	Yearling	0.003	0.087	0.557	0.345	0.009	0.000	3,461
2009	Subyearling	0.000	0.268	0.631	0.100	0.001	0.000	1,138

Table 4.8. Continued.

Brood year	Release type	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Total
2009	Yearling	0.002	0.039	0.411	0.538	0.010	0.000	2,640
2010	Subyearling	0.012	0.315	0.627	0.046	0.000	0.000	959
2010	Yearling	0.016	0.037	0.535	0.393	0.020	0.000	1,896
2011	Subyearling	0.011	0.214	0.728	0.046	0.000	0.000	1,072
2011	Yearling	0.002	0.026	0.478	0.467	0.028	0.000	3,929
Mean	Subyearling	0.020	0.165	0.629	0.182	0.003	0.000	455
Mean	Yearling	0.008	0.041	0.385	0.516	0.050	0.001	2,034

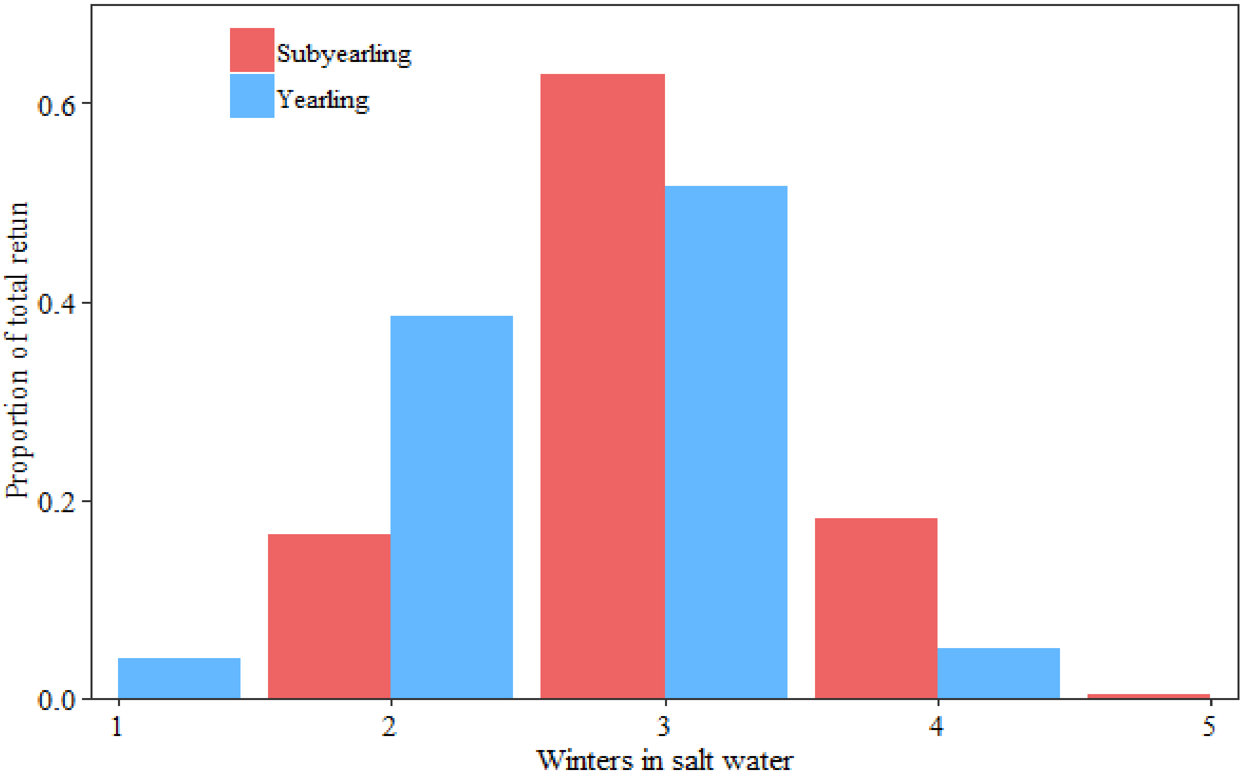

Figure 4.1. Mean salt water age of Wells Hatchery summer Chinook Salmon from the 1992-2011 broods released as subyearling or yearling program fish. Adult returns are from broodstock, spawning ground, or freshwater sport, commercial, and tribal fisheries.

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	--	--	--

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
Subearling program													
2010	M	56	26	3	63	35	6	--	--	--	--	--	--
2010	F	61	1	--	66	85	4	68	9	6	--	--	--
2011	M	59	3	3	67	68	4	72	3	2	--	--	--
2011	F	55	20	4	63	53	5	64	2	1	--	--	--
Mean	M	57	23	5	66	24	6	76	4	4	78	1	0
Mean	F	64	3	5	68	34	3	73	16	4	75	5	3
Yearling program													
1993	M	41	22	5	59	2	11	73	145	7	78	16	6
1993	F	--	--	--	60	5	4	75	127	4	78	53	6
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	--	--	--

Table 4.9. Continued.

		Mean length (POH; cm) of adult returns											
Brood	Sex	Age-3			Age-4			Age-5			Age-6		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
						Yearling program							
2010	M	--	--	--	62	142	4	70	34	6	72	2	1
2010	F	--	--	--	66	53	4	72	75	4	83	1	--
2011	M	--	--	--	64	84	4	71	126	4	--	--	--
2011	F	42	1	--	61	173	4	69	85	5	--	--	--
Mean	M	45	16	3	62	148	5	72	106	6	77	11	6
Mean	F	--	--	--	66	74	4	75	178	25	78	25	5

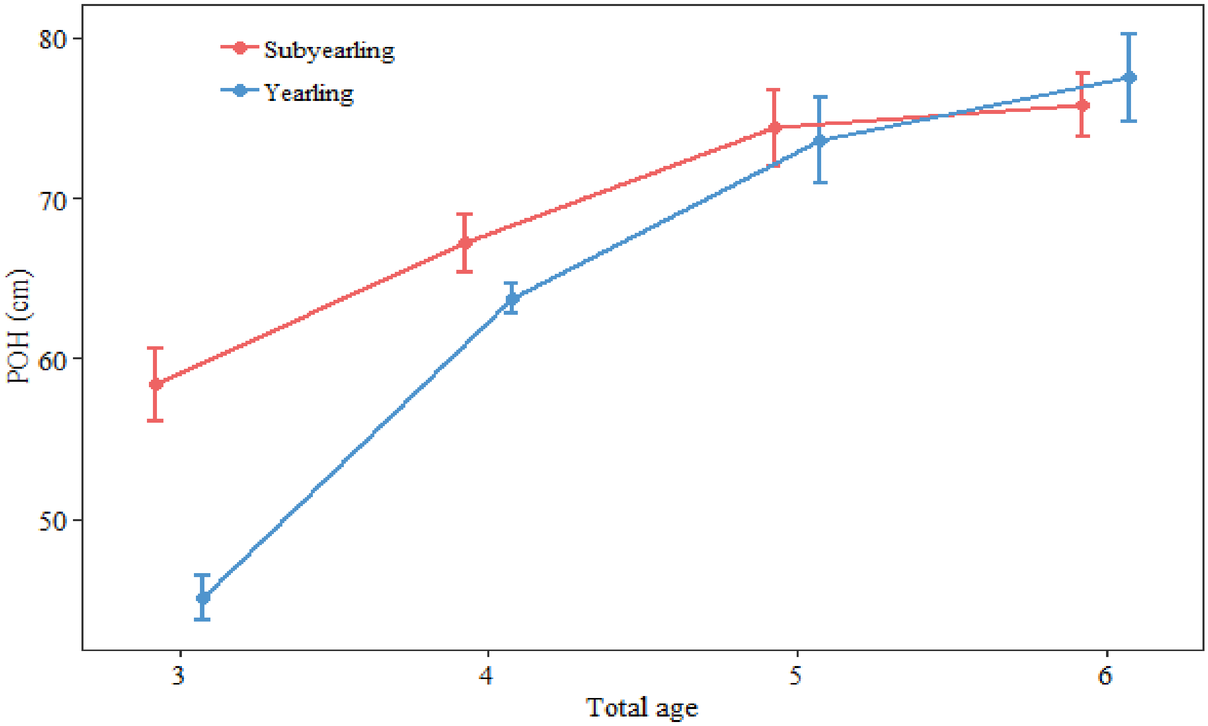

Figure 4.2. Mean (+/- 95% CI) POH length (cm) of adult returns of summer Chinook Salmon released as subyearling or yearling fish from the 1992-2011 broods.

Contribution to Fisheries

As a segregated harvest program, most returning adult fish from Wells Hatchery summer Chinook Salmon releases are considered surplus fish available for harvest as long as annual broodstock collection targets have been met. Harvesting surplus fish should provide a benefit to sport, commercial, and subsistence fisheries, and reduce escapement of surplus fish to spawning grounds already supplemented with progeny from endemic broodstocks. Based on expanded CWT recoveries, the proportion of the total adult return by brood has increased over time, while the proportion of fish on spawning grounds has generally decreased over time (Table 4.10; Figure 4.3). These results suggest that management of the Wells summer Chinook adult returns align with the conservation and harvest augmentation objectives for the program described in Hillman et al. (2017).

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

Brood year	Broodstock		Freshwater commercial		Freshwater sport		Freshwater tribal		Ocean fisheries		Spawning ground		Total
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*
							Subyearling program						
1993	22	54	0	0	0	0	3	7	16	39	0	0	41
1994	8	57	0	0	0	0	3	21	3	21	0	0	14
1995	67	53	1	1	0	0	3	2	53	42	2	2	126
1996	288	42	2	0	5	1	3	0	309	45	79	12	686
1997	47	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	308	24	57	4	158	12	282	22	432	33	61	5	1,298
2008	217	38	4	1	56	10	124	22	148	26	23	4	573
2009	637	39	46	3	249	15	177	11	489	30	35	2	1,632
2010	464	32	41	3	150	10	302	21	456	32	23	2	1,437
2011	224	13	83	5	196	11	556	31	692	39	25	1	1,776
Mean	205	33	21	2	76	8	123	13	249	38	37	5	712
							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

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*
							Yearling program						
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	614	44	45	3	159	11	194	14	386	27	13	1	1,410
2008	2,054	38	104	2	717	13	535	10	1,900	35	108	2	5,417
2009	1,631	28	168	3	726	12	1,098	19	2,071	36	112	2	5,806
2010	653	20	135	4	322	10	773	24	1,295	40	22	1	3,199
2011	694	9	346	5	1,303	17	1,497	20	3,696	48	103	1	7,639
Mean	614	44	45	3	159	11	194	14	386	27	13	1	1,410

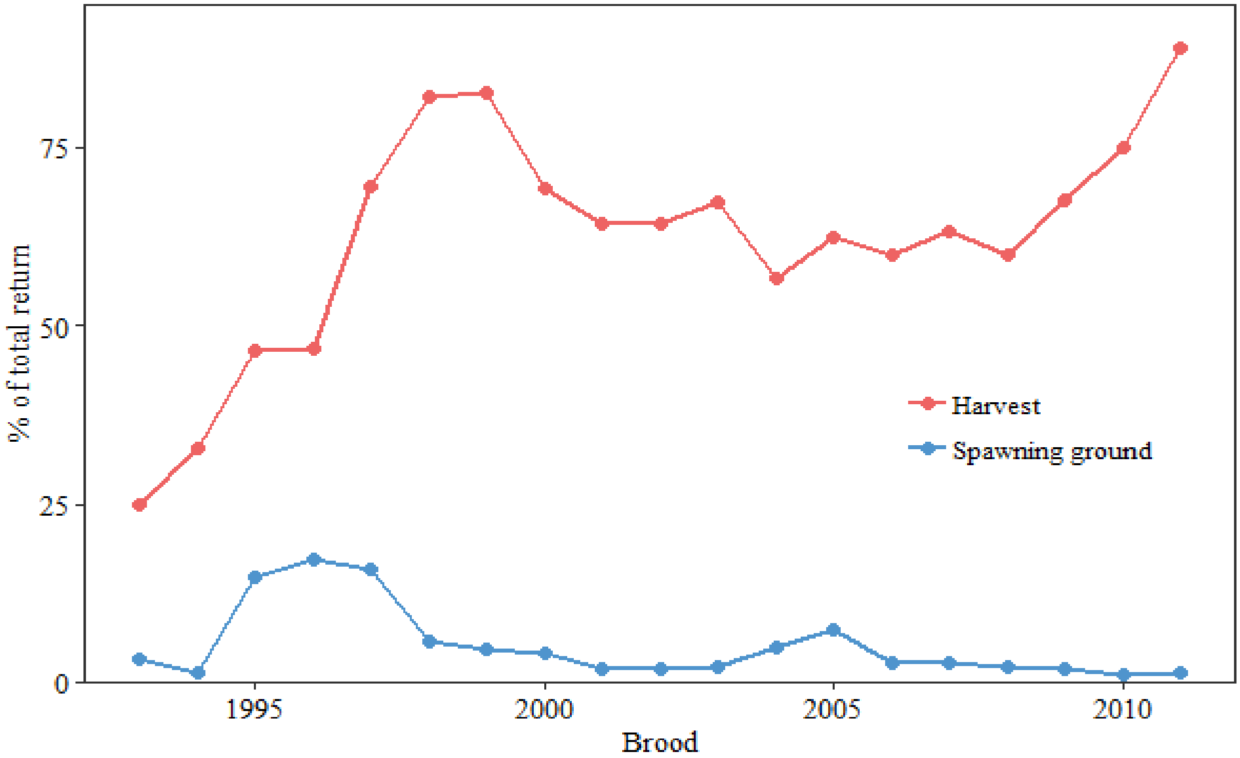

Figure 4.3. Percent of the total adult return from subyearling and yearling releases in the harvest and spawning ground categories for the 1993-2011 broods.

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 1992-2011 broods averaged 6.75%, 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 (combined) by brood year and recipient stray category.

Brood year	Total brood return	Recipient category			% stray
		Stream	Hatchery	Total	
1992	835	61	13	74	8.86
1993	1,668	56	31	87	5.22
1994	156	2	5	7	4.49
1995	1,246	185	27	212	17.01
1996	2,268	388	50	438	19.31
1997	11,003	1,760	129	1,889	17.17
1998	10,486	604	43	647	6.17
1999	2,122	97	15	112	5.28
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	2.27
2004	4,324	210	4	214	4.95
2005	4,055	298	24	322	7.94
2006	7,303	191	167	358	4.90
2007	2,709	75	115	190	7.01
2008	5,990	131	356	487	8.13
2009	7,438	190	136	326	4.38
2010	4,636	45	33	78	1.68
2011	9,415	128	94	222	2.36
Mean	4,686	248	62	310	6.75

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	61	11.4	0	0	0	0	0	0
1998	0	0	42	6.2	12	4.5	0	0	3	0.1	0	0
1999	0	0	6	0.6	0	0	0	0	0	0	16	11.5
2000	0	0	40	3.3	110	8.3	0	0	8	0.1	124	26.4
2001	0	0	509	18.4	329	7.2	21	0.3	0	0	332	33.7
2002	42	8.4	532	11.5	310	5.1	0	0	11	0.1	173	29.7
2003	65	9.4	146	3.7	25	1.0	0	0	21	0.2	87	20.8
2004	0	0	47	2.1	47	1.6	7	0.2	6	0.1	25	6.0
2005	11	3	83	3.2	69	1.5	9	0.2	14	0.2	83	15.8
2006	0	0	48	1.8	13	0.2	0	0	0	0	32	7.6
2007	3	1.2	58	4.3	3	0.1	0	0	0	0	22	11.6
2008	11	3.4	102	5.2	70	1.9	7	0.2	6	0.1	46	9.3
2009	3	1.2	134	7.6	78	1.8	0	0	0	0	0	0
2010	10	2.3	71	2.8	71	2.5	4	0.1	6	0.1	98	8.8
2011	0	0	32	1.1	12	0.2	5	0.1	0	0	40	3.1
2012	0	0	95	3.2	29	0.6	0	0	0	0	38	2.9
2013	0	0	93	2.6	0	0	0	0	0	0	63	3.7
2014	0	0	0	0	22	0.3	0	0	0	0	31	2.8
2015	6	1.5	55	1.4	5	0.1	0	0	4	0.1	8	0.6
2016	0	0	12	0.5	0	0	0	0	0	0	39	4.3
2017	0	0	0	0	0	0	0	0	0	0	0	0
Mean	7	1.4	100	3.8	60	2.3	3	0.1	4	0.1	60	9.5

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 1.2% and 0.2%, 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 (21.3) than for subyearling releases (2.6). 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 (2011 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	1,410	0.442	7.9
2008	Yearling	191	336,881	5,417	1.608	28.4
2009	Yearling	164	350,000	5,806	1.659	35.4
2010	Yearling	203	350,218	3,199	0.913	15.8
2011	Yearling	196	289,998	7,639	2.634	39.0
Mean	Yearling	187	331,822	3,994	1.192	21.3
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

Table 4.13. Continued.

Brood	Program	Broodstock	Released	Adult returns	SAR (%)	HRR
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	1,298	0.260	3.9
2008	Subyearling	279	427,131	573	0.134	2.1
2009	Subyearling	254	464,137	1,632	0.352	6.4
2010	Subyearling	323	442,821	1,437	0.325	4.4
2011	Subyearling	297	492,777	1,776	0.360	6.0
Mean	Subyearling	262	431,182	712	0.161	2.6

Section 5: Wells Hatchery Summer Steelhead

This section focuses on the most recent brood for which releases were completed during the report year (2017 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, the Twisp River Weir, angling, 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 2017 brood of Wells Hatchery summer steelhead occurred between 3 August and 15 November 2016 at the Wells Dam fish ladders. During this time a total of 128 hatchery origin fish were retained, representing 3.9% of the estimated hatchery fish returning to Wells Dam during the trapping period. In addition to fish collected at Wells Dam, broodstock were also collected from the Twisp River weir (10 wild), the Methow Hatchery outfall channel (1 hatchery), the Wells Hatchery volunteer channel (16 hatchery), the Winthrop National Fish Hatchery (WNFH) outfall channel (4 hatchery) and through angling in the Methow River (11 hatchery). Additional hatchery fish were collected from all locations and transferred to other facilities (i.e., Winthrop National Fish Hatchery), or removed as surplus to spawning escapement needs. Overall, pre-spawn mortality totaled 8.8% of the total hatchery and natural origin fish spawned from all sources (Table 5.1).

Within-season adjustments to spawning protocols for the Twisp program required that wild adult fish collected at the Twisp River weir (*N* = 10, Table 5.1), be transferred to WNFH and spawned with the Methow conservation program broodstock being held there. At the eyed-stage, a portion of eggs (*N* = 1,050) from each wild female spawned at WNFH (7 from Twisp weir and 45 from WNFH angling [not shown in Table 5.1]), were transferred back to DCPUD facilities for rearing and release as age-1 smolts.

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

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											
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
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
2017	0	0	0	0	0	175	15	0	160	0	160
Mean	46	2	0	41	2	303	19	11	265	9	307
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
2017	10	0	0	10	0	18	0	18	0	0	10
Mean	20	0	0	20	0	16	0	11	6	0	22

Age at Maturity

Most summer steelhead collected for 2017 Wells Hatchery broodstock were fish that had spent two winters in salt water before returning to Wells Dam (2-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). No hatchery origin fish from the Twisp River weir were spawned in 2017, and most natural origin fish spawned were 2-salt fish.

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	--	--	--
2017	0.05	0.95	173	--	--	--
Mean	0.52	0.48	287	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
2017	--	--	--	0.30	0.70	10
Mean	0.41	0.59	22	0.43	0.57	19

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 2017 brood was more skewed towards female fish than average for both the Wells Hatchery and Twisp River broodstocks. Of the female fish spawned, fecundity of the 2017 brood was lower than overall mean values for the Twisp River broodstock, but higher than the mean value for the Wells Hatchery broodstock. Gonadal mass (estimated weight of eggs (g) prior to fertilization) and overall fecundity was recorded for females spawned at the Wells and Methow hatchery facilities, and for Twisp program females spawned at the Winthrop National Fish Hatchery. Data for the last three broods was combined because sample sizes for wild fish were low within each year. The gonad mass-fork length relationships for hatchery and wild females produced similar linear regression relationships with less variance than fecundity-fork length regressions (Figure 5.1).

Table 5.3. Sex ratio (Male/Female) and mean fecundity by return year and origin of summer steelhead spawned for the Wells Hatchery and Twisp River 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
2017	58	96	6,767	0.60:1	--	--	--	--	0.60:1	6,767
Mean	129	148	5,858	0.87:1	24	34	5,715	0.71:1	0.84:1	5,830

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
					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
2017	--	--	--	--	3	7	5,097	0.43:1	0.43:1	5,097
Mean	4	5	6,615	0.80:1	8	11	5,242	0.73:1	0.75:1	5,356

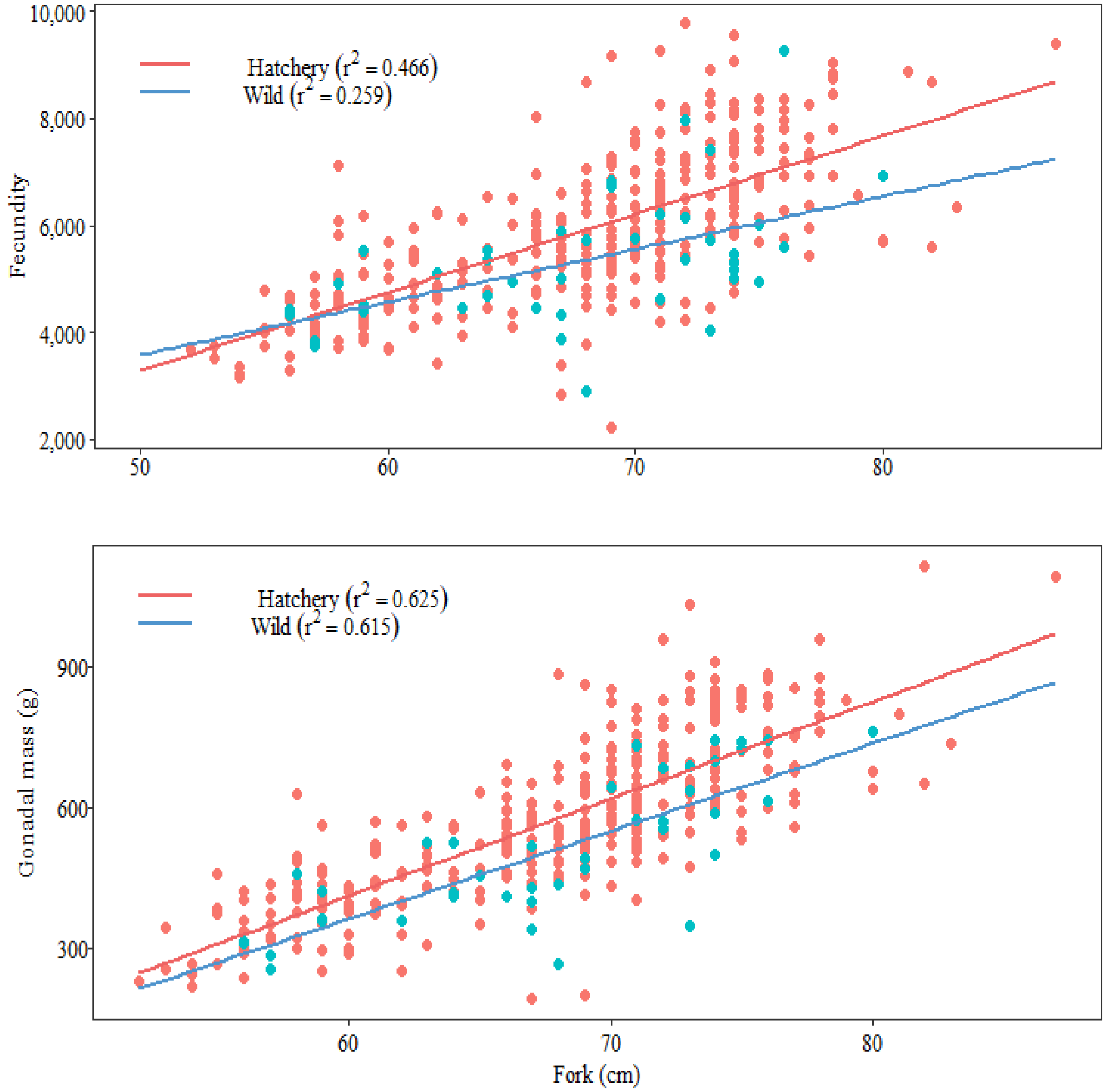

Figure 5.1. Total fecundity vs. fork length (top panel) and egg mass vs. fork length (bottom panel) relationships for the 2015-2017 broods of hatchery and wild steelhead spawned at the Wells, Methow, and Winthrop National Fish Hatchery (Twisp females) facilities.

5.2: Within-hatchery Monitoring

Juvenile Marking and Tagging

Juvenile releases from the 2017 brood were slightly above the overall release goal of 408,000 fish for PUD programs (Tonseth 2016). Safety-net releases into the Methow and Columbia Rivers achieved 73% and 131% of their respective release goals by location, and were 109% of the goal when locations were combined. Releases into the Twisp River were also slightly higher (113%) than the program goal of 48,000 smolts and an additional 24,093 fish were released from WNFH into the Twisp River (M. Humling U.S. Fish and Wildlife Service, personal communication), to improve future return demographics. The release of 24,093 additional fish by WNFH was not a component of the DCPUD mitigation program. Steelhead releases into the Okanogan River basin achieved 102% of the release goal of 100,000 fish combining Omak Creek, and other other Okanogan Basin locations. 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

Table 5.4. Continued.

Brood	Release location										Total
	Methow R.	Twisp R.	Chewuch R.	Columbia R.	Similk. R.	Omak Cr.	Okan. R.	Salmon Cr.	Aeneas Cr.	Antoine Cr.	
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
2017	72,768	54,297	0	210,328	23,580	33,545	0	33,260	5,000	6,135	438,913

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

Table 5.5. Continued.

Brood year	Mark	CWT code(s)	Release location	Mark rate	*N*
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
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
2017	Ad+CWT	637141	Okanogan Basin	0.9734	67,975
2017	PBWT	--	Omak Creek	0.9882	33,545
2017	CWTO	637108	Twisp River	0.9348	54,297

Juvenile Size and Condition at Release

Size-at-release fish-per-pound (FPP) and coefficient of variation (CV; fork length) targets for DCPUD program fish are described in Hillman et al. (2017). The 2017 brood Wells and Twisp program fish were close to the target values of 6 FPP (Table 5.6), but fork length CV was higher than the target value (< 10) for both programs.

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. SN = safety-net program.

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

Table 5.6. Continued.

Brood	Stock	Fork length (mm)			Weight (g)				K
		Mean	SD	CV	Mean	SD	CV	FPP	
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
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
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
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
2016	Wells SN	185.8	18.5	9.9	60.8	17.7	29.1	7.5	0.95
2016	Twisp WxW	155.3	23.4	15.0	46.0	20.2	44.0	9.9	1.23
2017	Wells SN	181.4	19.3	11	68.4	20.9	31	6.6	1.15
2017	Twisp WxW	170.9	25.9	15	68.3	28.6	42	6.6	1.37
Target		191.0	17.2	<10.0	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 2017 brood adults for all programs was above target values for both the Wells and Twisp programs (Table 5.7). Survival from initial fertilization through early rearing was below target values for the Wells Hatchery program and affected all post-fertilization survival categories. Survival for the Twisp River program was very near or above target levels for all survival categories (Table 5.7).

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

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
				Wells Hatchery program					
1999	99.3	99.8	77.0	98.0	97.1	96.6	92.8	- -	70.0
2000	98.0	99.2	85.2	97.4	98.1	98.7	95.3	- -	79.1
2001	98.0	99.0	83.9	98.6	97.0	96.9	95.0	- -	78.6
2002	98.0	99.5	82.2	96.2	99.0	98.7	97.8	- -	77.3
2003	99.0	99.3	83.5	99.9	93.6	77.6	73.5	- -	61.3
2004	98.6	98.4	86.2	94.0	99.4	95.5	94.0	- -	76.1
2005	96.4	99.5	87.4	95.9	96.9	92.2	85.7	- -	71.8
2006	95.2	93.3	86.6	99.5	92.7	89.8	80.4	- -	69.3

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									
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
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
2017	91.0	94.0	78.8	97.2	91.8	91.3	71.4	--	54.7
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
2017	100.0	100.0	94.9	97.7	96.3	95.8	93.8	--	87.0
Target	90	85	92	98	97	93	90	95	81

5.3 Natural Origin Juvenile Productivity

Smolt trapping was conducted in 2018 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 cohort 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 4 December 2018 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 one occasion for a total of 26 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 436 wild summer steelhead emigrants (smolt and transitional) between 1 March and 30 June in the Methow River trap, with peak capture on 26 April (*N* = 68). We PIT tagged 421 wild steelhead emigrants and released 418 tagged fish after three fish shed their tags prior to release. A single mortality of the 436 wild emigrant steelhead captured was observed in 2018 (0.23%). We also captured 1,375 hatchery steelhead juveniles at the Methow River trap, with two mortalities of these fish recorded (0.15%).

We captured four wild fry and 32 wild summer steelhead parr during trapping in 2018 at the Methow trap site. Steelhead parr greater than 65 mm and in good physical condition were PIT tagged (*N* = 28), and 27 were released after subtracting a single shed tag. No mortality of fry or parr captured at the Methow trap occurred in 2018.

Six mark/recapture trials were conducted with migratory steelhead in 2018 at the Methow trap, but all contained less than 100 fish, and no adequate flow/efficiency model developed from these releases. 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 19,001 (± 4,620, 95% CI) summer steelhead emigrated from the Methow River basin. However, an additional 62 migrants were estimated from redds located downstream of the trap in 2014 through 2017, which resulted in a total estimated migration of 19,063 (± 4,627, 95% CI) summer steelhead from the Methow River basin in 2018. We estimated the entire 2014 brood migration to be 14,602 (± 4,043, 95% CI) fish, including 765 migrants that were expected from redds (*N* = 46) located downstream of the Methow trap in 2014. The mean number of emigrants (smolts) produced per redd in the Methow Basin for the 2003-2014 broods was 20 (Table 5.8).

Twisp Trap

Trapping at the Twisp River trap site (rkm 2) occurred between 9 March and 3 December 2018 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 26 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 305 wild summer steelhead emigrants at the Twisp trap between 9 March and 30 June. Peak capture occurred on 27 April ($N = 88$). We PIT tagged 273 wild steelhead emigrants and 271 were released after subtracting one mortality and one shed tag (Attachment A). Non-migrant summer steelhead captured at the Twisp trap included 10 wild fry and 251 wild parr. We PIT tagged 234 steelhead parr with a fork length greater than 65 mm and released 227 tagged parr after subtracting four mortalities and three shed tags. Overall mortality of fry ($N = 0$) and parr ($N = 4$) represented 1.5% of the total fry and parr captured ($N = 261$). Wild steelhead parr and fry had mean fork lengths of 103.6 mm and 31.9 mm respectively. In addition to the wild fish captured, an additional 8,230 juvenile hatchery summer steelhead were captured at the Twisp River trap and five mortalities were recorded (0.06%).

Numerous mark/recapture trials were conducted with wild summer steelhead at the Twisp site in 2018, but most of them contained less than 40 fish. A flow efficiency relationship from previous years' release groups was used to estimate steelhead emigration at the Twisp site in 2018 ($P < 0.01$, $r^2 = 0.53$). The flow model regression ($y = -0.00029807x + 0.410559405$) was used to estimate that 6,024 (± 1,932, 95% CI) wild summer steelhead migrated past the Twisp River trap between 9 March and 30 June 2018. An additional 584 migrants were estimated from redds located downstream of the trap in 2014 through 2017, which provides a total estimated migration of 6,608 (± 2,024, 95% CI) summer steelhead from the Twisp River in 2018. Most 2018 migrants were age-2 fish (81.2%) from the 2016 brood (Attachment A). Combining numbers from the last four years, the entire 2014 brood migration was estimated to be 5,302 (± 1,727, 95% CI) fish, which includes 626 expected migrants produced from redds ($N = 17$) that were identified downstream of the Twisp trap in 2014. The mean number of emigrants (smolts) produced per redd in the Twisp Basin for the 2003-2014 broods was 36 (Table 5.9).

Table 5.8. Estimated emigrant-per-redd and egg-to-emigrant survival of Methow Basin steelhead. Methow Basin estimates are for redds deposited upstream and downstream of the trap site. Emigrant-per-redd values were not calculated for incomplete brood years.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants					Egg to emigrant (%)	Emigrants per redd
				Age-1	Age-2	Age-3	Age-4	Total		
Methow	2003	2,019	12,824,688	1,602	4,895	2,471	109	9,076	0.07	4
Methow	2004	997	4,580,218	1,989	9,592	1,319	365	13,265	0.29	13
Methow	2005	1,784	11,075,072	2,144	13,413	913	1,136	17,606	0.16	10
Methow	2006	808	5,161,504	644	6,503	3,932	328	11,406	0.22	14
Methow	2007	740	3,779,180	3,255	25,588	4,774	122	33,739	0.89	46
Methow	2008	867	5,136,975	1,430	13,229	1,884	131	16,674	0.32	19
Methow	2009	1,030	6,283,000	3,425	13,133	1,858	660	19,076	0.30	19
Methow	2010	1,720	10,022,440	1,214	7,243	8,641	116	17,214	0.17	10
Methow	2011	854	5,339,208	303	10,162	1,761	275	12,501	0.23	15
Methow	2012	591	3,402,387	402	21,827	3,396	101	25,726	0.76	44
Methow	2013	810	4,834,890	1,649	15,155	2,474	0	19,278	0.40	24
Methow	2014	878	4,630,572	1,008	11,569	1,863	162	14,602	0.32	17
Methow	2015	991	5,776,539	3,495	18,609	3,583	--	25,687	--	--
Methow	2016	638	3,295,270	2,196	14,552	--	--	16,748	--	--
Methow	2017	533	3,309,930	766	--	--	--	766	--	--
Mean 2003-2014		1,092	6,422,511	1,589	12,692	2,941	292	17,514	0.34	20

Table 5.9. 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	117	5,302	0.70	37
Twisp	2015	161	938,469	461	5,818	901	--	7,180	--	--
Twisp	2016	166	857,390	422	5,363	--	--	5,785	--	--
Twisp	2017	140	869,400	227	--	--	--	227	--	--
Mean 2003-2014		282	1,684,039	120	4,391	1,409	119	6,029	0.64	36

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 5.10). However, sample sizes for some release years and trap sites were likely too low to produce accurate estimates.

Table 5.10. 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
Total	4,011	21	21	42	1.04
		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
Total	3,313	11	11	22	0.66

In-stream PIT Tagging

Natural origin juvenile steelhead were primarily PIT tagged in the Twisp subbasin in 2018 (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 5.11).

Table 5.11. 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 to Rocky Reach Dam 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	2018	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	163	25	1	191	0.15 (0.01)
2016	2,210	--	--	--	--	--	--	65	27	92	0.23 (0.04)
2017	3,320	--	--	--	--	--	--	--	113	113	0.14 (0.02)
2018	1,927	--	--	--	--	--	--	--	--	--	--
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	3	13	0.12 (0.03)
2017	192	--	--	--	--	--	--	5	8	13	0.12 (0.04)
2018	60	--	--	--	--	--	--	--	--	--	--
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	13	29	0.23 (0.10)

Table 5.11. Continued.

Tag year	SHR tagged	Recovered at Rocky Reach juvenile bypass									CJS survival (SE)
		2011	2012	2013	2014	2015	2016	2017	2018	Total	
						Chewuch River					
2017	0	--	--	--	--	--	--	--	--	--	--
2018	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 14 March and 28 May 2018 in the Twisp River and between 5 March and 24 April 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 752 steelhead were estimated to have spawned in the Methow River Basin in 2018 (Table 5.12), with most spawners found in the Lower Methow subbasin (N = 311). The 2018 escapement estimates were derived from redd counts and from PIT tag detections at arrays located throughout the Methow Basin (Attachment D) and represent a combined total of hatchery-origin and natural-origin spawners. Escapement estimates in all river sections in 2018 were lower than the overall mean values (Table 5.12).

Table 5.12. Estimated steelhead escapement (hatchery and wild fish combined) by sample year for the four major subbasins in the Methow 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

Table 5.12. Continued.

Sample year	Steelhead escapement				Total
	Upper Methow	Lower Methow	Twisp	Chewuch	
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
2018	109	311	136	196	752
Mean	583	526	488	271	1,868

Redd Distribution

Because most of the spawning escapement of steelhead in 2018 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 Libby Creek were important spawning areas (Table 5.13). In the Twisp River, all redds in 2018 were found in the mainstem (Table 5.14).

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 in some years, 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 three of 24 redds (13%) in 2018 (Table 5.15). Based on these, and previous years' observations, no significant differences in spawn timing or location between hatchery and wild females were found when fish from all broods (2009-2018) were considered (Goodman et al. 2019).

Table 5.13. 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 using 1.79 fish per redd. Ns = not surveyed.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Methow River (MRW PIT array – Red Barn)	MRW8	13	131	30
Methow River (Red Barn – Halderman Hole)	MRW7	25		
Methow River (Halderman Hole – Braids)	MRW6	4		
Methow River (Braids – Carlton Bridge)	MRW5	Ns		
Methow River (Carlton Bridge – WDFW Access)	MRW4	0		
Methow River (WDFW Access – Upper Burma Br.)	MRW3	Ns		
Methow River (Upper Burma Br. – Lower Burma Br.)	MRW2	2		
Methow River (Lower Burma Bridge – Pateros)	MRW1	Ns		
Chewuch River (CRW PIT array to – Confluence)	CRW1	Ns	--	--
Methow Hatchery outfall	MH1	11	--	--
Winthrop NFH Outfall	WN1	43	--	--
1890’s channel	18N	0	--	--
Beaver Creek (above PIT antenna)	Beaver	4	7 (0-20)	0 (0-0)
Beaver Creek (below PIT antenna)	BV1	Ns	--	--
Libby Creek (above PIT antenna)	Libby	37	17 (4-38)	49 (22-83)
Gold Creek (above PIT array)	Gold	35	25 (8-48)	37 (16-66)
Total		174	--	--

Table 5.14. Twisp River mainstem and tributary census redd counts by section number and survey year. Ns = not surveyed.

Stream reach	Code	Length (km)	2012	2013	2014	2015	2016	2017	2018
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	2	0	0	0
Poplar Flats C.G. - Mystery Bridge	T8	3.2	0	1	1	2	1	0	0
Mystery Bridge - War Creek Bridge	T7	6.9	5	8	4	9	2	6	0
War Creek Bridge - Buttermilk Bridge	T6	7.4	43	21	36	30	3	13	1
Buttermilk Bridge - Little Bridge Creek	T5	5.9	26	18	25	10	4	7	7
Little Bridge Creek - Twisp weir	T4	3.8	5	7	3	10	1	6	6
Twisp weir - Upper Poorman Bridge	T3	3.5	20	46	30	44	7	38	3
Up. Poorman Br. - Lower Poorman Br.	T2	5.0	12	23	23	18	1	21	4
Lower Poorman Bridge - Confluence	T1	2.9	11	7	12	11	2	10	3
Twisp River mainstem total		46.4	122	131	134	136	21	101	24
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	3	0	0	0	1	0	0
Little Br. Cr. (2nd Culvert - 1st Culvert)	LBC2	2.4	0	1	0	0	0	0	0
Little Br. Cr. (1st Culvert - Confluence)	LBC1	2.4	7	4	1	13	0	0	0
MSRF pond outfalls[1]	MSRF1	0.1	0	3	6	12	11	4	0
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	Ns
W. Fork Buttermilk Creek	BMW1	3.1	Ns	Ns	1	0	Ns	0	Ns
Buttermilk Cr. (Fork - Cattle Guard)	BM2	2.1	1	0	0	0	0	0	0
Buttermilk Cr. (Cattle Guard - Conf.)	BM1	2.0	0	0	2	0	0	0	0
South Creek (Falls - Confluence)	SO1	0.6	Ns	Ns	0	0	Ns	0	0
Twisp River tributary total		14.7	11	8	10	25	12	4	0

[1] Methow Salmon Recovery Foundation pond outfall.

Table 5.15. Mean spawning location (river kilometer [rkm]) and date of hatchery and wild female steelhead in the Twisp River by spawn year.

Spawn year	Hatchery females			Wild females		
	Location (rkm)	Date	*N*	Location (rkm)	Date	*N*
2009	20.8	5/3/2009	46	23.2	5/4/2009	17
2010	19.2	4/22/2010	39	19.8	4/21/2010	25
2011	18.4	4/26/2011	28	19.0	4/25/2011	21
2012	18.9	5/2/2012	9	21.3	4/25/2012	18
2013	16.4	5/3/2013	5	21.0	4/19/2013	7
2014	18.3	5/6/2014	8	22.2	5/1/2014	20
2015	16.7	4/26/2015	11	21.8	5/1/2015	11
2016	13.9	4/13/2016	2	18.9	4/14/2016	3
2017	9.4	5/2/2017	1	22.1	4/19/2017	3
2018	12.7	4/24/2018	2	18.6	4/23/2018	1

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 (see Table 5.15). No significant differences in spawn timing were observed between hatchery and wild female steelhead from 2009 to 2018 (Goodman et al. 2019).

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 (in years when fisheries are opened) 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
2017	H	57	6	5	73	60	5	58	9	3	73	209	4
2017	W	64	11	4	75	19	5	65	4	6	74	48	4
Mean	H	61	83	3	75	33	5	60	54	3	72	99	4
Mean	W	63	24	4	76	12	4	62	27	4	73	32	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 2006-2017 run years overall, wild fish arrived at Wells Dam an average of 5 days earlier than hatchery fish (Table 5.17). Similarly, arrival time for the 2017 run year was earlier for natural origin fish (23 September) than for hatchery origin steelhead (29 September) to Wells Dam (Table 5.17), but arrival time at Wells Dam and most Methow Basin tributaries was similar, regardless of salt-age at return (Figure 5.2).

Table 5.17. Arrival date at Wells Dam of 10%, 50%, and 90% of the hatchery (H) and natural origin (W) steelhead return based on adult steelhead PIT tagged and released at Priest Rapids Dam during the 2006-2017 run years.

Run year	Origin	Steelhead arrival time				
		10%	50%	90%	*N*	Mean date
2006	H	8/23/2006	9/15/2006	10/8/2006	408	9/16/2006
2006	W	8/5/2006	9/14/2006	10/2/2006	33	9/9/2006
2007	H	8/22/2007	9/21/2007	10/18/2007	404	9/21/2007
2007	W	8/15/2007	9/11/2007	10/20/2007	131	9/17/2007
2008	H	8/13/2008	9/18/2008	10/19/2008	517	9/15/2008
2008	W	8/8/2008	9/11/2008	10/10/2008	115	9/8/2008
2009	H	8/24/2009	9/12/2009	10/8/2009	1,348	9/14/2009
2009	W	8/15/2009	9/10/2009	10/9/2009	245	9/11/2009
2010	H	8/4/2010	9/8/2010	10/10/2010	589	9/7/2010
2010	W	7/30/2010	8/22/2010	10/7/2010	205	8/28/2010
2011	H	8/22/2011	9/19/2011	10/13/2011	904	9/18/2011
2011	W	8/15/2011	9/4/2011	10/17/2011	250	9/12/2011
2012	H	8/18/2012	9/17/2012	10/12/2012	439	9/16/2012
2012	W	8/10/2012	9/3/2012	10/12/2012	162	9/9/2012
2013	H	8/14/2013	9/14/2013	10/16/2013	379	9/15/2013
2013	W	8/13/2013	9/6/2013	10/16/2013	329	9/18/2013
2014	H	8/21/2014	9/22/2014	10/13/2014	689	9/20/2014
2014	W	8/10/2014	9/19/2014	10/18/2014	479	9/16/2014
2015	H	8/18/2015	9/13/2015	10/13/2015	1,129	9/15/2015
2015	W	8/8/2015	8/31/2015	10/7/2015	438	9/4/2015
2016	H	8/18/2016	9/26/2016	10/25/2016	515	9/26/2016
2016	W	8/4/2016	9/17/2016	10/10/2016	181	9/12/2016
2017	H	9/4/2017	9/29/2017	10/20/2017	563	9/29/2017
2017	W	8/22/2017	9/27/2017	10/13/2017	235	9/23/2017
Mean	H	20-Aug	18-Sep	15-Oct	657	18-Sep
Mean	W	11-Aug	10-Sep	12-Oct	234	13-Sep

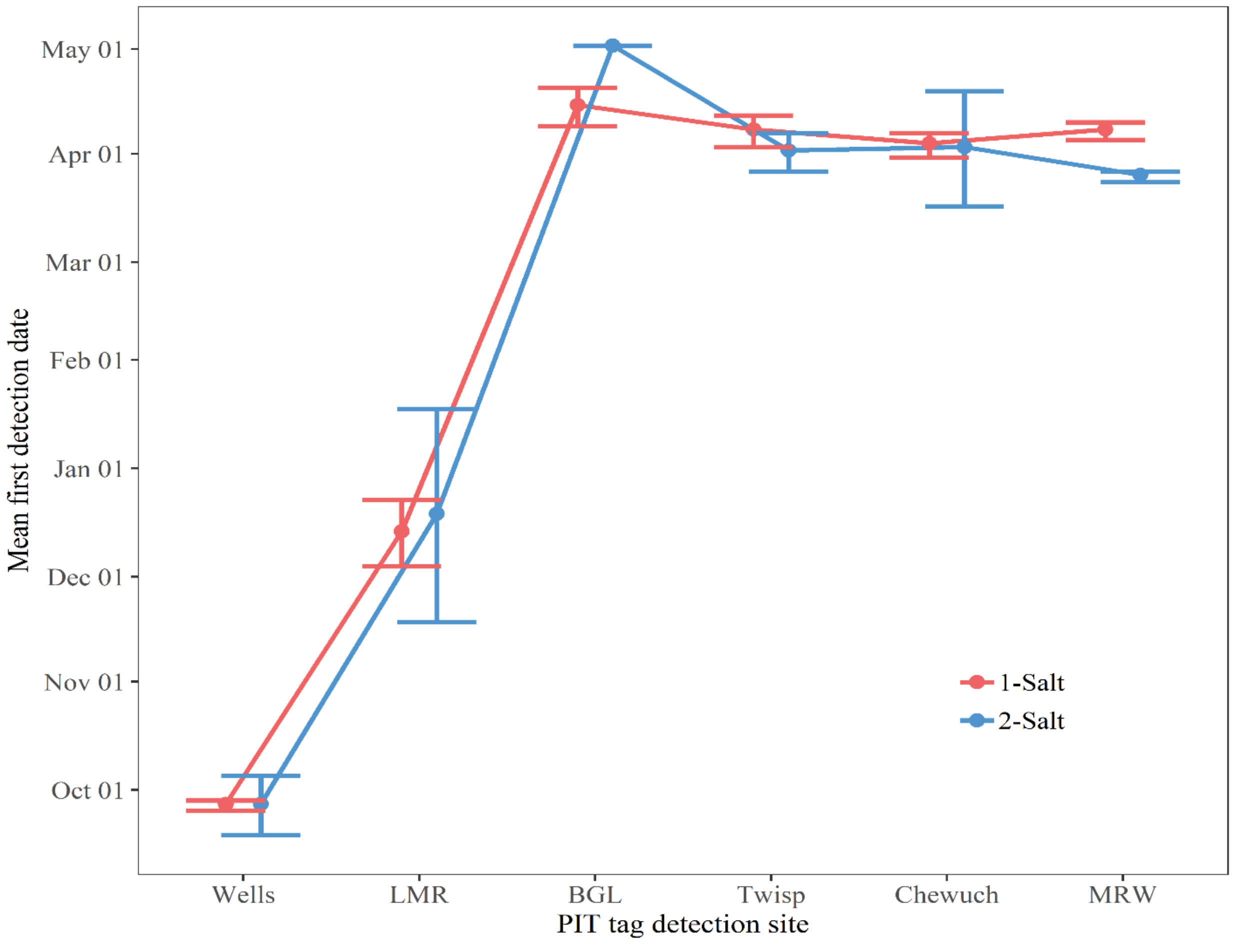

Figure 5.2. Mean (+/- 95% CI) migration timing based on salt-age of hatchery and wild steelhead PIT tagged at Priest Rapids Dam in 2017. Detection locations include the Lower Methow River (LMR), and the Beaver, Gold, and Libby Creek (BGL) antenna arrays. The Upper Methow category (MRW) includes the Wolf 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 2018 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 7% of the hatchery steelhead and 3% of the wild steelhead upstream of Wells Dam on average (Table 5.18).

Table 5.18. 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	11,733	2,083	275	55	839	313	1,304	48	9,315	1,667
2012	11,163	1,736	267	62	1,123	341	731	25	9,042	1,308
2013	9,146	1,279	229	21	694	365	1,229	56	6,994	837
2014	5,585	2,359	205	0	415	486	471	56	4,494	1,817
2015	5,660	2,491	193	1	433	505	567	110	4,467	1,875
2016	7,924	2,256	212	0	1,008	538	622	78	6,082	1,640
2017	4,226	1,084	146	0	577	204	60	45	3,443	835
2018	3,355	995	110	1	723	178	84	26	2,438	790
Mean	9,315	1,415	264	45	480	186	590	35	7,981	1,150

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 17 years (Table 5.19). 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 23% of the estimated hatchery escapement and 3% of the wild escapement within the Methow and Okanogan tributaries between 2002 and 2018 (Table 5.19). Estimates of pHOS for the 2018 brood in both the Methow and Okanogan rivers were slightly below mean values for those rivers. An increased focus on removing excess hatchery origin fish during tributary broodstock collections somewhat offset the lack of tributary fisheries in reducing pHOS.

Table 5.19. 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 5.18.

Brood	Tributary escapement		Local broodstock		Tributary fisheries		Net escapement		pHOS
	H	W	H	W	H	W	H	W	
					Methow Basin				
2002	10,350	624	--	--	--	--	9,321	562	0.943
2003	4,775	556	--	--	254	13	4,072	489	0.893
2004	5,084	734	--	--	336	10	4,276	652	0.868
2005	4,907	560	--	--	679	9	3,808	496	0.885
2006	3,677	476	--	--	683	8	2,697	422	0.865
2007	3,592	410	--	--	--	--	3,006	369	0.891
2008	3,344	819	14	--	470	9	2,576	729	0.779
2009	4,391	748	8	8	636	11	3,375	656	0.837
2010	11,736	1,284	322	12	4,002	48	6,679	1,102	0.858
2011	5,407	1,181	141	33	2,913	53	2,117	985	0.682
2012	5,248	927	135	46	1,302	20	3,430	774	0.816
2013	4,059	593	117	34	904	14	2,735	490	0.848
2014	2,608	1,216	79	92	791	43	1,555	973	0.615
2015	2,593	1,328	289	71	601	32	1,532	1,103	0.581
2016	3,530	1,162	320	94	736	25	2,227	938	0.704
2017	1,987	591	387	82	--	--	1,440	459	0.758
2018	1,415	560	306	131	--	--	998	386	0.721
Mean	4,630	810	193	60	1,101	23	3,820	782	0.830
					Okanogan Basin[1]				
2002	5,781	183	--	--	--	--	4,685	157	0.968
2003	2,667	163	1	4	120	2	2,294	142	0.942
2004	2,840	216	11	5	385	1	2,202	189	0.921
2005	2,741	165	15	3	528	3	1,981	142	0.933
2006	2,054	140	10	3	492	5	1,399	119	0.922
2007	2,007	120	4	7	--	--	1,676	102	0.946
2008	1,868	241	5	3	288	7	1,419	208	0.872
2009	2,453	220	5	11	446	5	1,804	184	0.907
2010	6,556	377	4	13	3,110	16	3,103	314	0.908

Table 5.19. Continued.

Brood	Tributary escapement		Local broodstock		Tributary fisheries		Net escapement		pHOS
	H	W	H	W	H	W	H	W	
					Okanogan Basin[1]				
2011	3,021	347	--	16	899	15	1,910	285	0.870
2012	2,932	273	10	5	400	5	2,270	236	0.906
2013	2,268	174	8	4	534	3	1,554	151	0.911
2014	1,457	358	42	16	223	8	1,073	300	0.782
2015	1,449	391	42	16	255	11	1,036	327	0.760
2016	1,972	342	42	16	152	3	1,601	290	0.847
2017	1,110	174	2	10	--	--	998	148	0.871
2018	791	165	39	4	--	--	676	145	0.823
Mean	2,586	238	16	9	602	6	1,864	202	0.888

[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 2014 and 2015 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 2014 brood, stray rates for Wells Hatchery steelhead releases averaged 50% (Table 5.20). However, the 2014 brood estimates may not be statistically defensible since only a singe PIT tagged fish from the Methow and Twisp release groups was detected as an adult in the Wells Dam fish ladders. The low return rate is likely a result of poor emigration conditions in the Columbia River in 2015, exacerbated by poor rearing conditions in the marine environment resulting from warmer-than-normal sea-surface temperatures.

Table 5.20. 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 in the Lower Methow / Wells pool are not considered strays for the Methow or Twisp release groups. Detections of 2015 brood releases are considered incomplete because they include only 1-salt returns. 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	Wells Pool	Foster Creek / tribs below Wells	Okanogan Basin	Total	% stray
2014	Columbia	0	0	0	0	4	0	0	4	0.0
2014	Methow	0	0	0	0	0	0	0	0	N/A
2014	Twisp	1	0	0	0	0	0	0	1	100.0
2015	Columbia	0	0	0	0	12[a]	1	1	14	14.3
2015	Methow	0	0	0	0	0	0	0	0	N/A
2015	Twisp	0	0	0	0	0	0	0	0	N/A

[a] Includes two returns to Wells tailrace.

Smolt to Adult Survival and HRR

The smolt-to-adult return of hatchery 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 (2014 brood) was 2.5 for Wells Hatchery releases, and 1.2 for Twisp River conservation program releases (Table 5.21). These values were below the HRR target of 26.5 for Wells Hatchery (including Twisp River) releases. In fact, these values are approximately one tenth of the historical mean and are the lowest on record. Survival of the 2014 brood steelhead was likely affected by poor Columbia River emigration conditions in 2015, and a warmer than normal Pacific Ocean sea-surface temperature anomoly (i.e., “the Blob”) that persisted into 2016.

Table 5.21. 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
2014	113	229,798	286	0.124	803	2.5
Mean	246	497,648	6,846	1.333	135	27.0
			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
2014	23	51,983	27	0.052	1,925	1.2
Mean	24	48,853	346	0.721	565	13.9

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 (2012 brood) was 0.326 (Table 5.22), which is slightly above the mean NRR of the 1998-2012 broods (0.245).

Table 5.22. 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
1998	1,971	69	2,341	745	0.318
1999	1,337	136	1,636	194	0.119
2000	1,618	242	2,085	1,011	0.485
2001	3,038	336	3,758	651	0.173
2002	9,321	562	10,974	395	0.036
2003	4,072	489	5,064	450	0.089
2004	4,276	652	5,472	1,047	0.191
2005	3,808	496	4,779	1,171	0.245
2006	2,697	422	3,462	1,545	0.446
2007	3,006	369	3,748	1,523	0.406
2008	2,576	729	3,670	842	0.229
2009	3,375	656	4,475	1,200	0.268
2010	6,679	1,102	8,637	1,976	0.229
2011	2,117	985	3,443	970	0.282
2012	3,430	774	4,204	1,371	0.326
Median	3,038	496	3,758	1,011	0.245

Proportionate Natural Influence

The Biological Opinion associated with Methow River hatchery steelhead programs (National Marine Fisheries Service [NMFS] Consultation Number WCR-2017-6986) includes guidelines for assessing the genetic risk of hatchery programs to natural populations by calculating the proportionate natural influence (PNI) of the Methow Basin steelhead population based on four population components. These components are; 1) the conservation programs including the

Twisp River and WNFH relases; 2) the safety-net program which includes Methow River releases from Wells Hatchery; 3) The annual spawning population of the upper Methow River and tributaries (also including Beaver, Gold, and Libby creeks); and 4) the annual spawning population of the main-stem Methow River downstream of the Methow and Winthrop hatcheries.

The PNI is calculated from these four components using a model described in Busack (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. In the NMFS Biological Opinion, a five-year running average PNI of $\geq$ 0.67 is targeted by 2022.

To calculate PNI using the four-population criteria, we estimated the natural spawning escapement of hatchery-origin and natural-origin fish into the Methow Basin overall by expanding PIT tag detections at the lower Methow in-stream PIT tag array (LMR) by the estimated efficiency of the PIT tag antenna, and the PIT tag rate of hatchery and wild fish tagged at Priest Rapids Dam within each return year. We assumed that all adipose fin-clipped fish lacking a CWT were fish from the Wells safet-net program, and that those with a CWT were from the WNFH conservation program. Steelhead with a CWT but without an adipose fin-clip were considered to be from the Twisp conservation program. Some returning fish from previous marking strategies (e.g., yellow elastomer) were included as conservation program fish if their parental origin was $\geq$ 0.5 natural-origin fish. Similarly, known conservation program fish from other basisn (e.g., Omak Creek) were grouped with other conservation program returns in the Methow Basin. All other hatchery-origin fish were considered safety-net program fish for modeling purposes.

After estimating the basin total escapement, we subtracted escapement estimates for the upper Methow River and tributaries, estimated as above, from the LMR-generated basin estimate to achieve separate escapement estimates for conservation (upper Methow and tributaries) and management (lower Methow main-stem) areas. From the management area estimate, we subtracted all known fish removed from annual broodstock collection or adult management activities including sport fisheries, broodstock collections, or excess hatchery fish management at the Methow and Winthrop hatcheries. From the conservation area estimate, we subtracted all known fish removed at the Twisp River weir for broodstock or to reduce escapement of hatchery-origin fish.

The proportion of natural-origin fish in the returning conservation program adults (pNOB) in each spawn year was estimated as an average of the pNOB for each returning age class and program (i.e., Twisp 1- and 2-salt, WNFH 1- and 2-salt). The genetic parentage of safety-net program adults was assumed to be 75% safety-net program fish and 25% conservation program fish. Based on these calculations, PNI has been below 0.67 for the last five spawn years but increasing slightly during that time (Table 5.23). The PNI value should continue to increase as pNOB HOR-c increases, reflecting changes to the broodstock collection protocols focusing on achieving a high pNOB for conservation programs.

Table 5.23. The proportionate natural influence (PNI) and proportion of hatchery origin fish on spawning grounds (pHOS) calculated by spawn year in the Methow River conservation and management areas based on expanded PIT tag observations. The PNI was estimated using the model described by Busack (2015) using the proportion of hatchery origin returns in each area that derive from conservation program returns (HOR-c), safety-net program returns (HOR-sn) and natural-origin returns (NOR). The net proportion of natural origin fish within the HOR-c returns (pNOB HOR-c) was calculated as a mean value from contributing adult broods. The genetic contribution of the returning HOR-sn component (not shown) was estimated as being 75% from safety-net adults, and 25% from conservation program adults.

Spawn year	Conservation areas				Management area				Overall PNI	pNOB HOS-c
	NOR	HOR-c	HOR-sn	pHOS	NOR	HOR-c	HOR-sn	pHOS		
2014	0.61	0.13	0.26	0.39	0.29	0.34	0.36	0.71	0.50	0.53
2015	0.54	0.14	0.32	0.46	0.17	0.11	0.71	0.83	0.46	0.56
2016	0.64	0.14	0.22	0.36	0.35	0.15	0.50	0.65	0.53	0.56
2017	0.39	0.18	0.44	0.61	0.25	0.19	0.56	0.75	0.43	0.71
2018	0.62	0.14	0.24	0.38	0.49	0.46	0.06	0.51	0.59	0.83

References

Busack, C. 2015. Extending the Ford model to three or more populations. August 31, 2015. Sustainable Fisheries Division, West Coast Region, National Marine Fisheries Service. 5p.

Goodman, B., T. Seamons, A. Murdoch, and C. Snow. 2019. Monitoring the reproductive success of naturally spawning hatchery- and natural-origin steelhead in the Twisp River. 2018 annual report for BPA Project # 2010-033-00.

Hillman, T., T. Kahler, G. Mackey, J. Murauskas, A. Murdoch, K. Murdoch, T. Pearsons, and M. Tonseth. 2013. Monitoring and evaluation plan for PUD hatchery programs: 2013 update. Report to the HCP and PRCC Hatchery Committees, Wenatchee and Ephrata, WA.

Hillman, T., T. Kahler, G. Mackey, A. Murdoch, K. Murdoch, T. Pearsons, M. Tonseth, and C. Willard. 2017. Monitoring and evaluation plan for PUD hatchery programs: 2017 update. Report to the HCP and PRCC Hatchery Committees, Wenatchee and Ephrata, WA.

HSRG. 2008. Preview of key findings for Lower Columbia River steelhead hatchery programs. Memo to the Hatchery Scientific Review Group Steering Committee from the Hatchery Scientific Review Group dated March 2008.

HSRG. 2009. Columbia River Hatchery Reform System-Wide Report. Prepared by the Hatchery Scientific Review Group.

MRT (Methow Research Team). 2017. Implementation of comprehensive monitoring and evaluation of Wells Hatchery Complex programs in 2018. Proposal submitted to the Wells HCP Hatchery Committee in September, 2017.

Malvestuto, S. P., W. D. Davies, and W. L. Shelton. 1978. An evaluation of the roving creel survey with non-uniform probability sampling. Transactions of the American Fisheries Society 107 (2): 255–262.

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.

Rocky Reach HCP. 2002. Anadromous fish agreement and habitat conservation plan. Rocky Reach hydroelectric project; FERC license No. 2145.

Snow, C. 2015. Survival of age-0 hatchery summer-run Chinook Salmon is enhanced by early release. North American Journal of Aquaculture 78:45-51.

Snow, C, C. Frady, A. Repp, and A. Murdoch. 2012. Monitoring and evaluation of Wells and Methow hatchery programs in 2011. Report to Douglas County Public Utility District. Washington Department of Fish and Wildlife, Olympia, WA.

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

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

Tonseth, M. 2018. Final Upper Columbia River 2018 BY salmon and 2019 BY steelhead hatchery program management plan and associated protocols for broodstock collection, rearing/release, and management of adult returns. Memorandum dated 24 April, 2018 to NMFS and the HCP HC and PRCC HSC Committees.

WDFW. 2016. 2015-2016 Upper Columbia River steelhead fishery report. Memorandum dated September 2016 to NOAA Fisheries, Portland Oregon.

Wells HCP. 2002. Anadromous fish agreement and habitat conservation plan, the Wells Hydroelectric Project, FERC License No. 2149.

Wells HCP HC. 2007. Conceptual approach to monitoring and evaluation for hatchery programs funded by Douglas County Public Utility District. Report prepared for Douglas PUD Habitat Conservation Plan Hatchery Committee.

Attachment A. 2018 Twisp and Methow River Smolt Estimates.

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

22 May, 2019

To: Charlie Snow

From: David Grundy

Subject: 2018 Twisp and Methow River Smolt Estimates.

Smolt trapping in the Methow River basin was conducted to estimate the number of emigrating spring Chinook Salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) from the Twisp and Methow Rivers. This information should assist in estimating the freshwater productivity and survival of target stocks and provide the productivity indicator information necessary to evaluate Objective 2 of the M&E Plan adopted by the Wells HCP Hatchery Committee (Hillman et al. 2017):

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

Methods

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

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

Biological Sampling

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

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

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

Fisheries Commission. Non-salmonids were counted by species or by family if they were too small to identify to species (e.g., *Catostomidae*).

Age, trap location, and DNA analysis was used to determine race (spring or summer) of captured juvenile Chinook Salmon. All Chinook Salmon captured in the Twisp River trap were considered spring Chinook, regardless of size, because summer Chinook have not been documented spawning upstream of the trap. All yearling (i.e., age-1) Chinook captured at the Methow River trap during the spring migration period were considered spring Chinook because 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 and two days after the day being estimated. 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 utilized 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 = $\widehat{N}_i = \frac{(C_i+1)}{\hat{e}_i}$

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 =

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

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 = $var\left[\widehat{N}_i\right] = \widehat{N}_i^2 \frac{E_p(1-E_p)/\sum M}{E_p^2}$ 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 past the Twisp and Methow smolt traps during the spring 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 through expanded interrogations of PIT tag observations.

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 2018 began at the Methow River site on 1 March and at the Twisp River site on 9 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 one occasion for a total of 25 days between 1 March and 4 December. Trapping at the Twisp site was interrupted for a total of 26 days between 9 March and 3 December. River discharge was near or slightly above typical seasonal values until about 24 April, when flow increased sharply. Operational limits at both trapping sites were exceeded on 5 May, and trapping activities ceased at both trapping locations at that time (Figures 1 and 2). On 10 May, the Methow River reached the highest level it has been since 1983, and stayed above average until the end of May. Traps were redeployed at the end of May, and below average discharge was then experienced for the remainder of the year. There were no rain-induced freshet events in the fall, as there has occasionally been in previous years. Trap operation ultimately ended in early December because of ice accumulation.

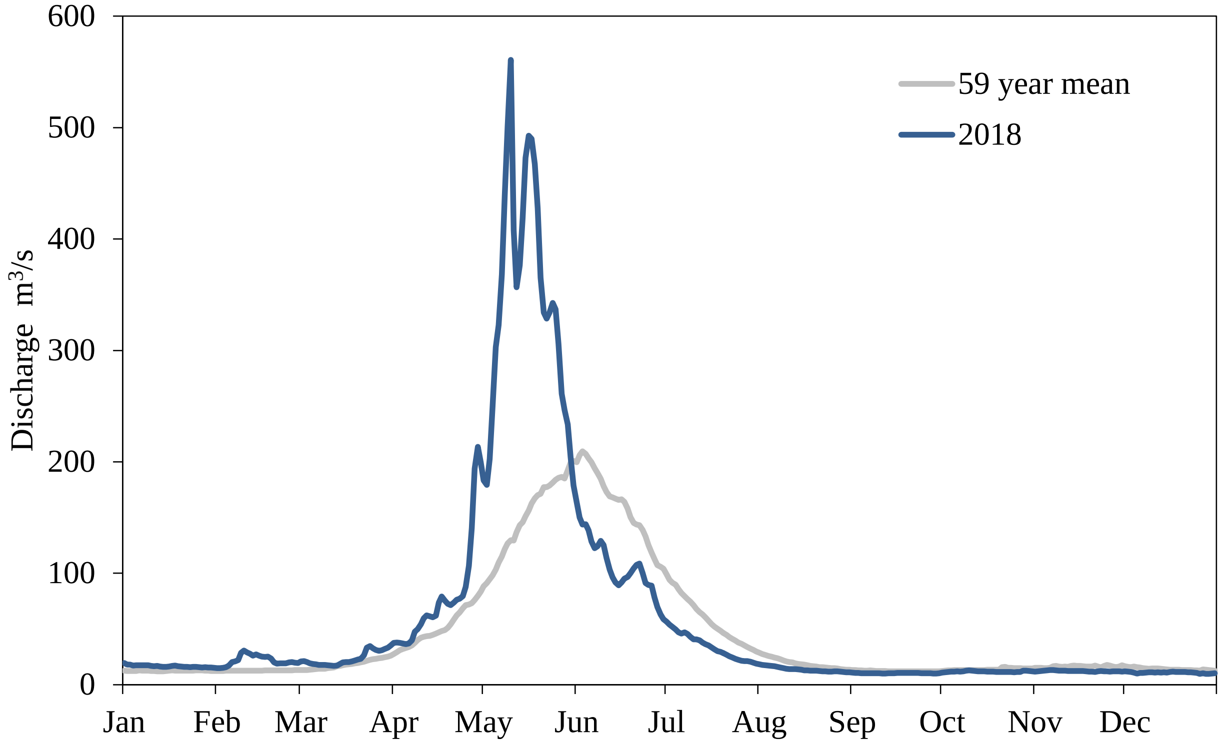

Figure 1. Methow River 2018 daily discharge and 59-year mean as measured at the USGS gauging station No. 12449950 (Methow River near Pateros, Washington).

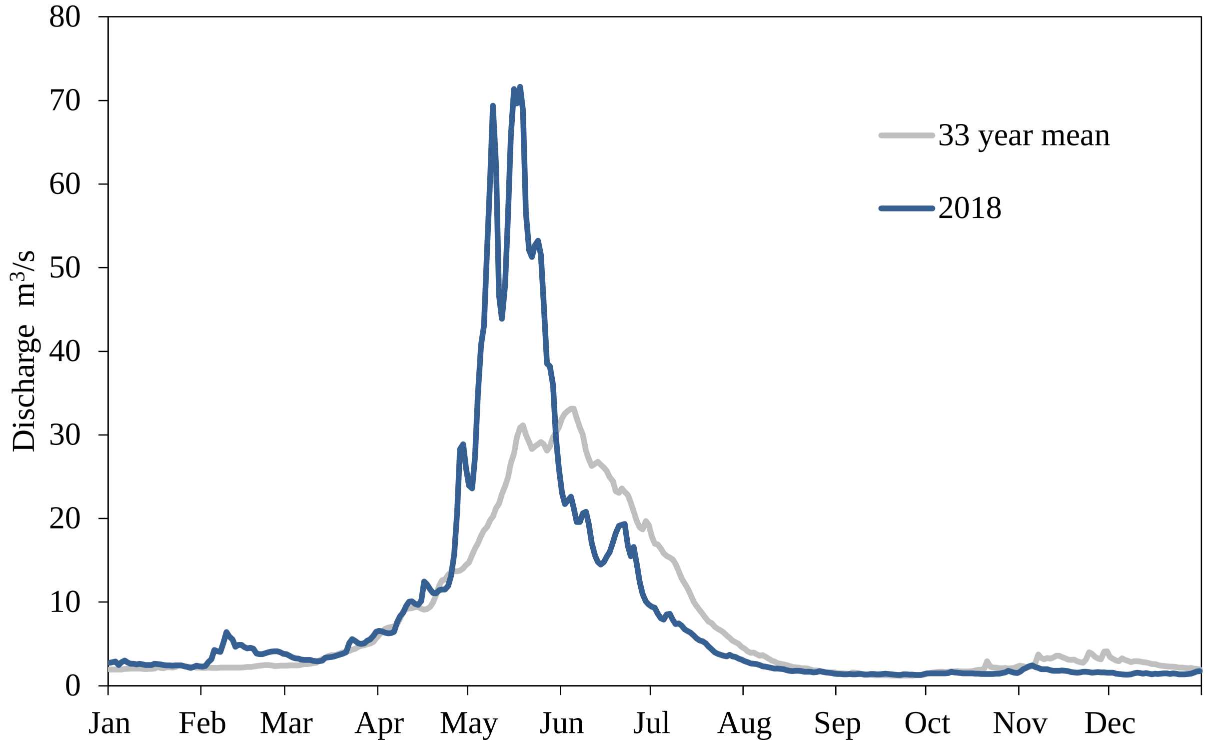

Figure 2. Twisp River 2018 daily discharge and 33-year mean as measured at the USGS gauging station No. 12448998 (Twisp River near Twisp, Washington).

Daily Captures and Biological Sampling

<u>2016 Brood Chinook Salmon</u>

A total of 265 wild yearling Chinook salmon emigrants were captured at the Methow site between 1 March and 30 June, with the peak capture (*N* = 31) occurring on 17 April (Figure 3). We inserted PIT tags into 255 of the 265 wild smolts captured, and all fish (tagged and un-tagged) were released with no mortalities experienced (Appendix A). Instead of PIT tagging hatchery fish, we utilized 597 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 one out of the 17,426 fish captured (<0.01%). Hatchery smolts had a significantly greater mean fork length (132.4 mm) than wild Chinook smolts (105.3 mm) captured at the Methow trap (Mann-Whitney U-test: $P < 0.001$; Table 1).

The Twisp River trap captured 492 wild yearling spring Chinook Salmon smolts between 9 March and 30 June. Peak capture occurred on 8 April (*N* = 49; Figure 4). We inserted PIT tags into 480 of the wild smolts captured, and subsequently released 475 after subtracting four mortalities and one shed tag (Appendix A). Overall mortality of wild yearling Chinook at the Twisp site totaled four of the 492 fish captured (0.81%). We utilized caudal fin-clips on 227 hatchery spring Chinook and used 477 hatchery spring Chinook with existing PIT tags for mark/recapture trials. There was one mortality out of the 3,401 hatchery Chinook salmon smolts captured at the Twisp trap (0.03%).

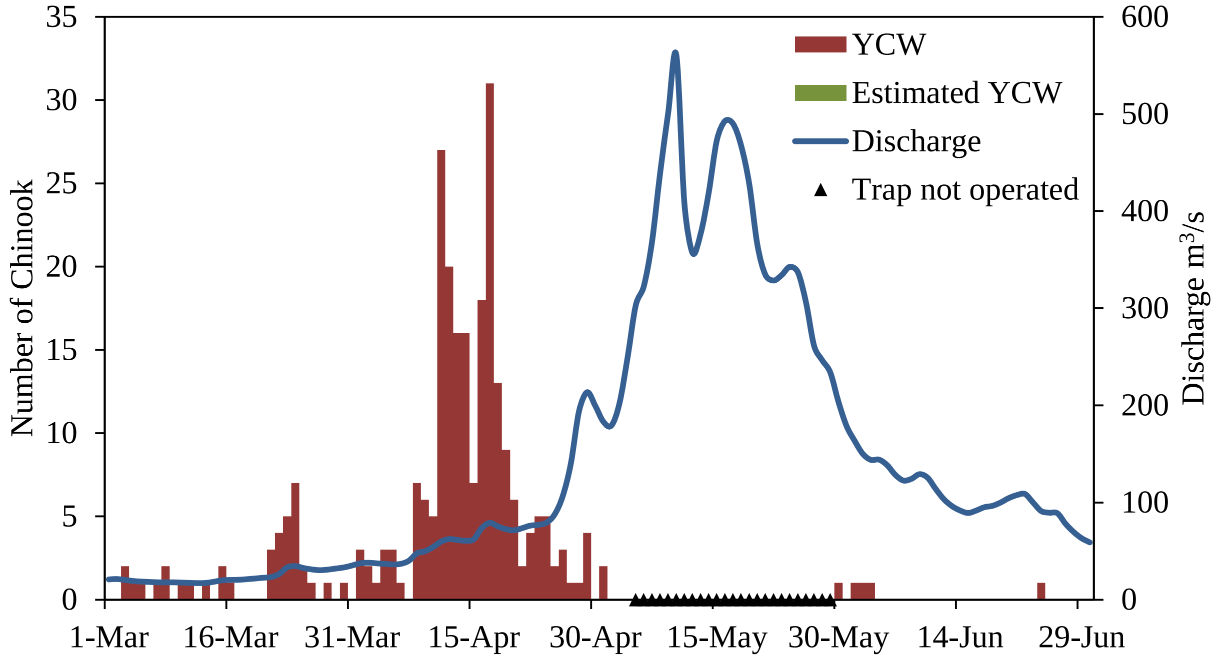

Figure 3. Daily capture of wild Chinook salmon smolts (YCW) at the Methow River smolt trap in 2018.

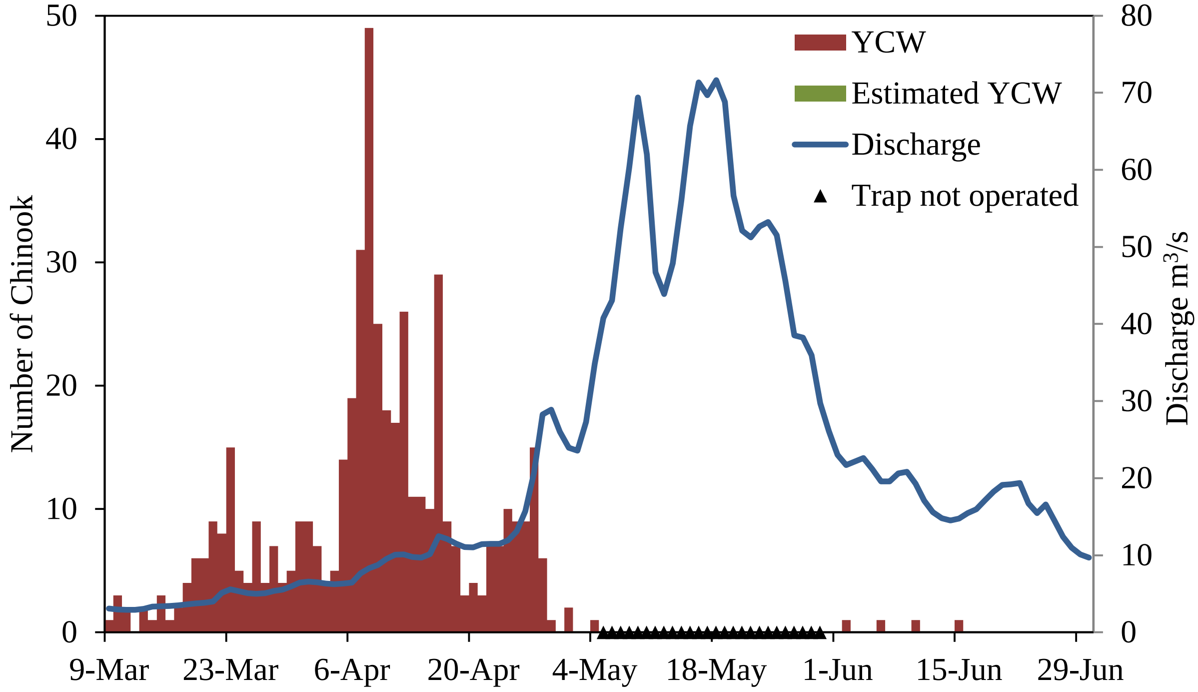

Figure 4. Daily capture of wild spring Chinook salmon smolts (YCW) at the Twisp River smolt trap in 2018.

2017 Brood Chinook Salmon

Subyearling Chinook Salmon fry (*N* = 3,135) and parr (*N* = 849) captured at the Methow trap between 1 March and 30 September had mean fork lengths of 40.7 mm and 63.6 mm, respectively (Table 1). Mortality during this period totaled 38 fry (1.2%) and 20 parr (2.4%). An additional 19 emigrant Chinook parr were captured during the fall trapping period between 1 October and 4 December. The mean fork length of Chinook parr during this period was 103.3 mm (Table 1), and peak captures occurred on 30 October, 8 November, and 9 November (*N* = 2/day). We inserted PIT tags into all 19 parr captured and no mortalities occurred prior to release (Appendix A). Tissue samples were also collected from all 19 of the fall-captured parr, and genetic analysis indicated that 18 (94.7%) of the sampled parr were spring Chinook, and one (5.3%) was a summer Chinook (Appendix B). These results are similar to results from sampling of fall parr in previous years (Table 2).

The Twisp trap captured 249 subyearling spring Chinook Salmon between 9 March and 3 December, and peak captures occurred on 3 November (*N* = 22; Figure 5). Two of the parr had existing PIT tags at time of capture, and we inserted PIT tags into 168 of the un-tagged fish. All captured Chinook (tagged and un-tagged) were subsequently released without mortalities (Appendix A). Fall migrant parr had a mean fork length of 93.3 mm (Table 1).

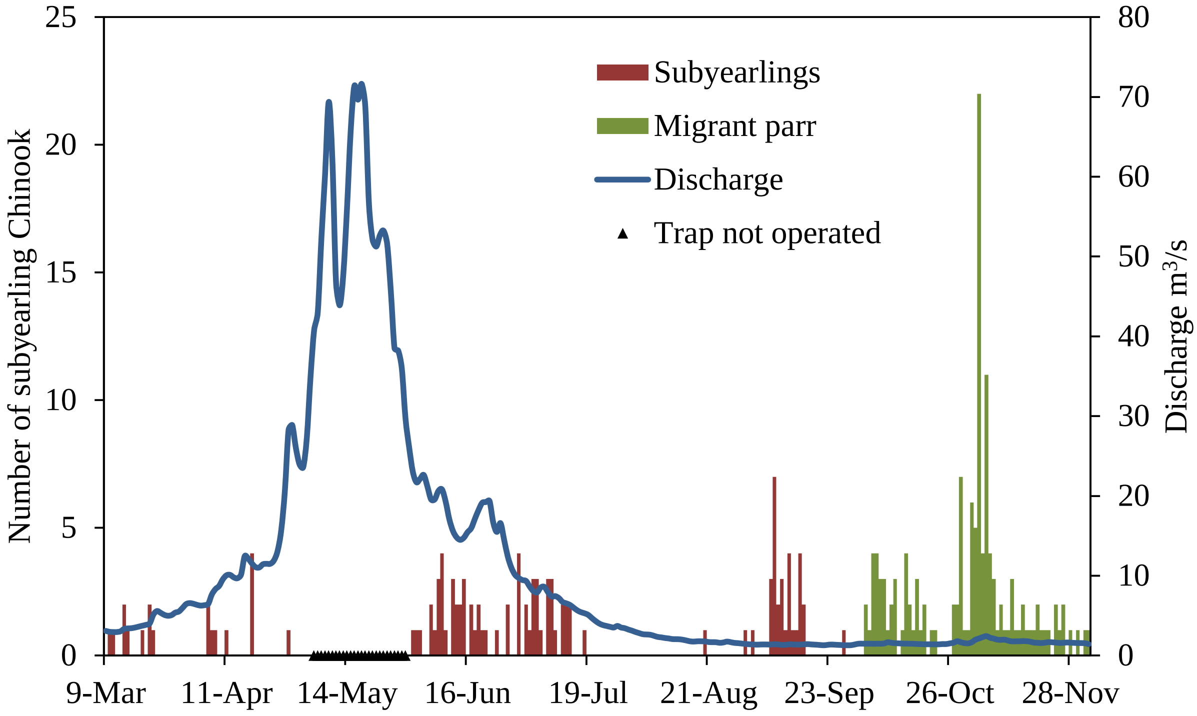

Figure 5. Daily capture of subyearling wild spring Chinook Salmon (Mar-Sep) and migrant parr (Oct-Dec) at the Twisp River smolt trap in 2018.

Table 1. Summary of length and weight sampling of Chinook Salmon captured at Methow Basin smolt traps in 2018.

Brood	Origin/stage	Fork length (mm)			Weight (g)			Mean
		Mean	*N*	SD	Mean	*N*	SD	K-factor
		Methow River trap						
2017	Wild fry	40.7	1,177	3.8	--	--	--	--
2017	Wild parr (Mar-Sep)	63.6	579	12.7	3.3	575	2.5	1.1
2017	Wild parr (Oct-Dec)	103.3	19	10.0	12.2	19	3.7	1.1
2016	Wild smolt	105.3	265	9.7	12.8	264	3.6	1.1
2016	Hatchery smolt	132.4	805	9.5	26.9	552	6.9	1.1
		Twisp River trap						
2017	Wild fry	41.6	44	5.4	--	--	--	--
2017	Wild parr (Mar-Sep)	74.0	69	19.1	5.7	69	4.4	1.1
2017	Wild parr (Oct-Dec)	93.3	136	7.1	9.1	136	2.1	1.1
2016	Wild smolt	95.5	492	6.6	9.4	492	1.9	1.1
2016	Hatchery smolt	128.3	765	10.7	25.5	537	6.9	1.1

Table 2. 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
2018	N/A	N/A	94.7
Mean	Yearling = 97.8, parr = 9.7	11.5	93.6

Summer Steelhead

The Methow River trap captured 436 wild summer steelhead emigrants (smolt and transitional) between 1 March and 30 June, with peak capture on 26 April (*N* = 68; Figure 6). We inserted PIT tags into 421 wild steelhead emigrants and 418 were released with tags after three fish shed their tags (Appendix A). There was one mortality out of the 436 wild emigrant steelhead captured at the Methow trap (0.23%). Most wild summer steelhead migrants were age-2 fish (76.3%), which had a mean fork length of 176.4 mm (Table 3). A total of 1,375 hatchery steelhead juveniles were captured at the Methow River trap, with two mortalities experienced (0.15%).

The Methow River trap captured four wild summer steelhead fry and 32 wild parr between 1 March and 4 December. Steelhead parr greater than 65 mm and in good physical condition were PIT tagged (*N* = 28), and 27 were released with tags after subtracting a single shed tag (Appendix A). There was no mortality experienced by any steelhead fry or parr captured at the Methow trap. Wild steelhead parr and fry had mean fork lengths of 100.0 mm and 26.3 mm respectively.

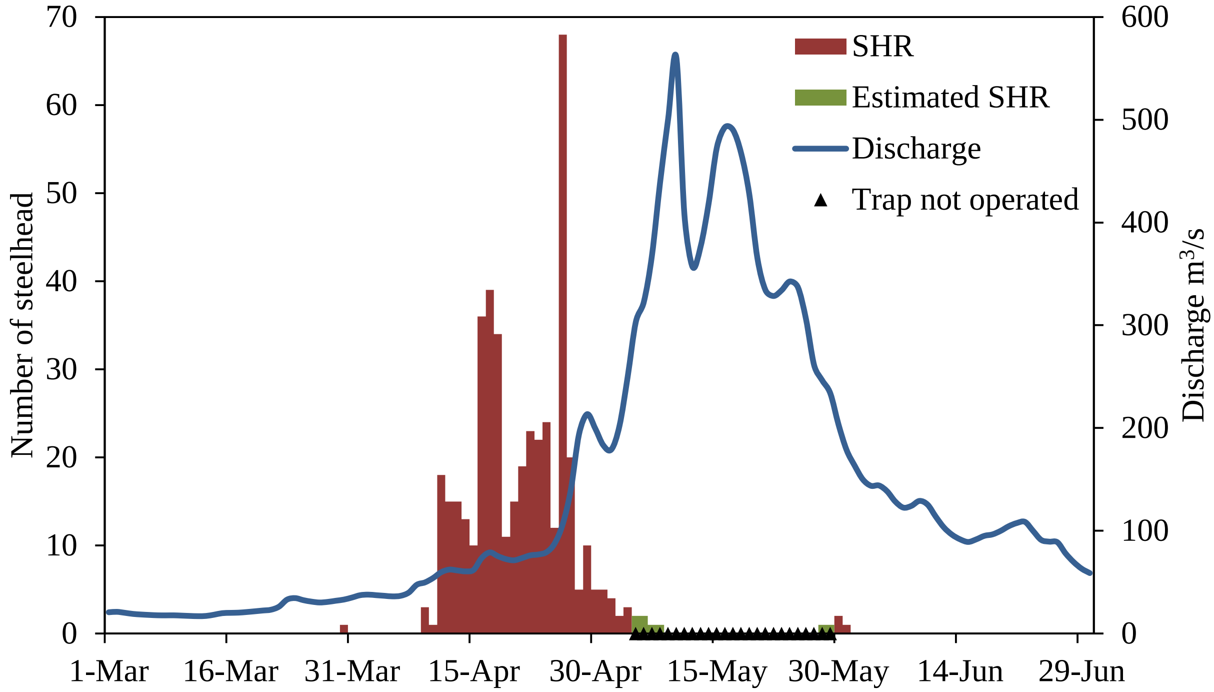

Figure 6. Daily capture of wild steelhead smolt and transitional migrants at the Methow River smolt trap in 2018.

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 2018.

Age	*N* (%)	Fork (mm)			Weight (g)			Mean
		Mean	*N*	SD	Mean	*N*	SD	K-factor
				Methow River trap				
1	15 (4.0)	148.1	15	12.4	31.9	15	8.3	1.0
2	284 (76.3)	176.4	284	18.1	53.6	284	16.6	1.0
3	70 (18.8)	182.7	70	18.7	59.2	70	19.6	0.9
4	3 (0.8)	180.3	3	6.7	53.3	3	3.6	0.9
				Twisp River trap				
1	8 (3.4)	148.1	8	18.5	34.4	8	10.7	1.0
2	192 (82.1)	160.3	192	14.2	39.8	192	10.3	1.0
3	30 (12.8)	173.5	30	18.2	49.8	30	15.0	0.9
4	4 (1.7)	200.3	4	30.8	72.7	4	32.4	0.9

A total of 305 wild summer steelhead emigrants (smolt and transitional) were captured at the Twisp trap between 9 March and 30 June, and the peak capture occurred on 27 April (*N* = 88; Figure 7). Wild emigrants (all ages combined) had a mean fork length of 164.1 mm, and were primarily age-2 fish (82.1%; Table 3). We inserted PIT tags into 273 wild steelhead emigrants and 271 were released after subtracting one mortality and one shed tag (Appendix A). Overall, there were three mortalities experienced by smolt or transitional steelhead at the Twisp site (0.98%). A total of 8,230 hatchery summer steelhead juveniles were captured at the Twisp River trap, and five mortalities were observed (0.06%). Instead of PIT tagging hatchery fish, we utilized 983 hatchery steelhead that had existing PIT tags to facilitate trap efficiency mark/recapture trials.

Non-migrant summer steelhead captured at the Twisp trap included 10 wild fry and 251 wild parr captured between 9 March and 3 December (Figure 8). We inserted PIT tags into 234 steelhead parr greater than 65 mm, and 227 were released after subtracting four mortalities and three shed tags (Appendix A). Overall mortality of fry (*N* = 0) and parr (*N* = 4) represented 1.5% of the total fry and parr captured (*N* = 261). Wild steelhead parr and fry had mean fork lengths of 103.6 mm and 31.9 mm respectively.

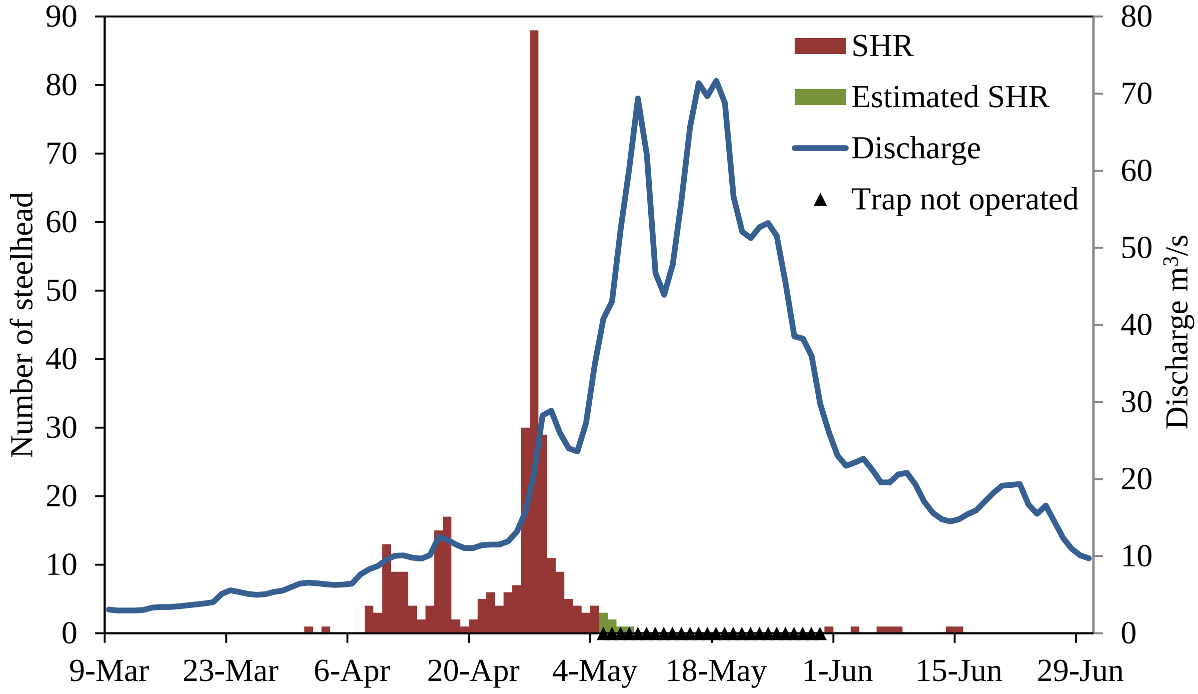

Figure 7. Daily capture of wild steelhead (SHR) smolt and transitional migrants at the Twisp River smolt trap in 2018.

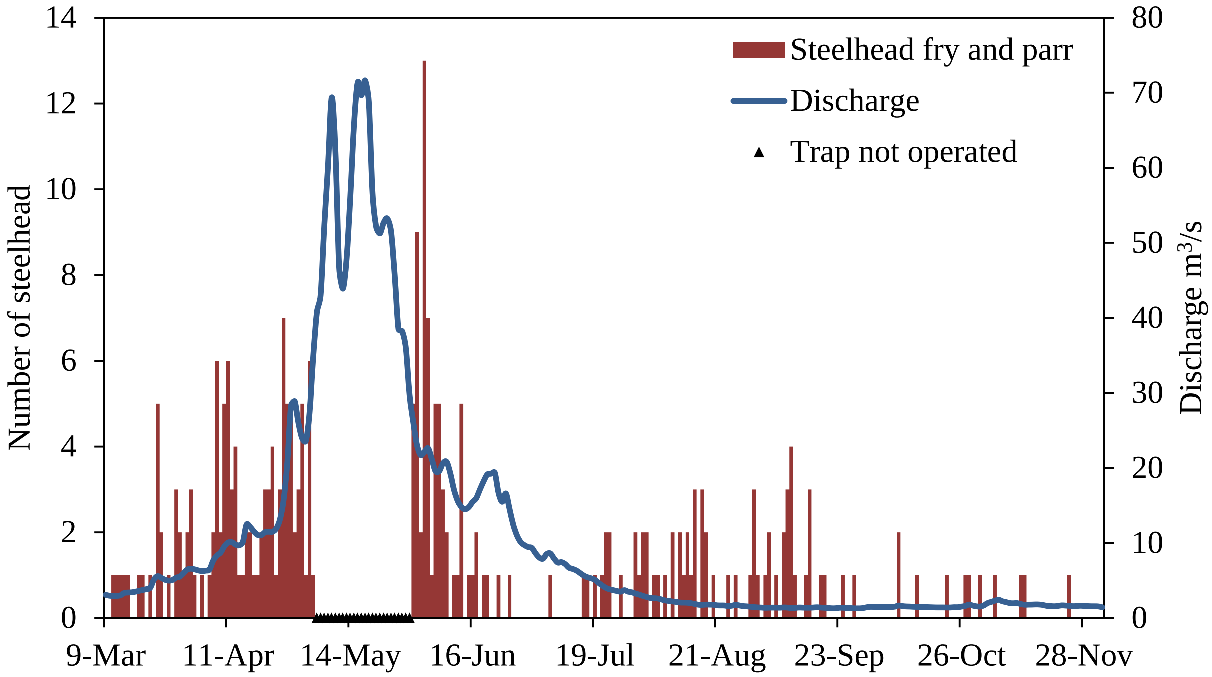

Figure 8. Daily capture of wild steelhead fry and parr at the Twisp River smolt trap in 2018.

Incidental Species

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 of incidental species is shown in Table 4.

Table 4. Biological sampling conducted on selected incidental species captured at Methow River basin smolt traps in 2018.

Species	Captured	Fork length (mm)			Weight (g)		
		Mean	*N*	SD	Mean	*N*	SD
Methow River trap							
Hatchery Coho (*O. kisutch*)	2,922	131.5	64	8.0	24.9	47	5.5
Longnose Dace (*Rhinichthys cataractae*)	932	32.0	466	19.0	5.1	65	4.8
Pacific Lamprey (*Lampetra tridentata*)	437	145.0	171	29.1	5.2	166	1.7
Wild Coho fry (*O. kisutch*)	211	38.4	122	4.7	--	--	--
Sucker (*Catostomus spp.*)	173	72.0	111	51.9	23.6	54	21.2
Sculpin (*Cottus spp.*)	68	40.3	61	10.5	2.9	6	1.1
Redside Shiner (*Richardsonius balteatus*)	60	36.4	58	22.7	12.6	6	2.6
Wild Coho parr (*O. kisutch*)	50	74.9	50	16.5	5.8	48	3.7
Sockeye fry (*O. nerka*)	48	28.0	42	2.3	--	--	--
Mountain Whitefish (*Prosopium williamsoni*)	39	36.0	30	5.6	--	--	--
Wild Coho smolt (*O. kisutch*)	13	118.4	13	12.1	19.9	13	10.8
Bull Trout (*Salvelinus confluentus*)	1	--	--	--	--	--	--
Cutthroat Trout (*O. clarki*)	1	258.0	1	--	163.7	1	--
Rainbow Trout (*O. mykiss*)	1	276.0	1	--	184.2	1	--
Fathead Minnow (*Pimephales promelas*)	1	57.0	1	--	2.9	1	--
Twisp River trap							
Longnose Dace (*Rhinichthys cataractae*)	2,088	94.3	1,341	20.5	12.5	1,276	5.9
Mountain Whitefish (*Prosopium williamsoni*)	75	59.5	72	69.1	14.1	19	46.0
Sculpin (*Cottus spp.*)	53	56.6	50	29.4	9.5	23	8.1
Bull Trout (*Salvelinus confluentus*)	27	187.9	26	40.2	64.8	26	37.6
Sucker (*Catostomus spp.*)	20	76.1	18	29.2	9.5	15	11.1
Wild Coho fry (*O. kisutch*)	15	38.7	15	3.2	--	--	--
Wild Coho parr (*O. kisutch*)	8	102.3	8	13.1	13.0	8	5.1
Cutthroat Trout (*O. clarki*)	8	190.4	8	32.8	76.1	8	42.4
Pacific Lamprey (*Lampetra tridentata*)	4	45.5	4	13.7	1.4	1	--
Rainbow Trout (*O. mykiss*)	3	286.5	2	26.2	282.6	2	108.3
Brook Trout (*Salvelinus fontinalis*)	1	154.0	1	--	30.3	1	--

Population Estimates

2016 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 2018. For the upper trapping position, two mark/recapture trials were conducted using hatchery Chinook. These groups were combined with releases conducted during the previous four years, which resulted in a significant relationship ($P < 0.01$, $r^2 = 0.66$; Table 5) and the regression ($y = -2.28E-05x + 0.254115208$) was used for the upper position in 2018. Using both these flow models, the estimated number of yearling spring Chinook Salmon emigrants was 12,732 (± 2,298, 95% CI). Combining the yearling emigrants with the estimate of parr that emigrated past the trap in the fall of 2017 (13,227 ± 60,884, 95% CI), an estimated 25,959 (± 60,927, 95% CI) 2016 brood wild spring Chinook migrated from the Methow River basin between 1 October 2017 and 30 June 2018. The majority of the emigrants moved as sub-yearlings, with 42.9% moving during the month of November 2017 (Figure 9).

Four mark/recapture trials were conducted with Chinook at the Twisp trap in the spring of 2018, one with wild spring Chinook, one with hatchery spring Chinook, and two containing both wild and hatchery spring Chinook. Combining these groups with historical trials, a significant relationship existed between river discharge and trap efficiency ($P < 0.01$, $r^2 = 0.67$; Table 6). The flow model regression ($y = -0.000351573x + 0.514895270$) was used to estimate that 3,554 (± 486, 95% CI) smolts emigrated past the Twisp River trap between 9 March and 30 June 2018. There were no spring Chinook redds identified below the Twisp trap in 2016, so no expansion for this area was necessary. Snow et al. (2018) estimated that 21,056 (± 5,923, 95% CI) 2016 brood spring Chinook Salmon parr emigrated from the Twisp River in the fall of 2017. In addition to the smolt trap estimates, mark/detection trials performed at the Twisp PIT tag array (Table 7) were used to estimate that 1,327 (± 272, 95% CI) spring Chinook emigrated between 4 December 2017 and 8 March 2018 when the smolt trap was not operating. Adding all emigrant totals, the complete emigration estimate for the 2016 spring Chinook brood was 25,937 (± 5,949, 95% CI) fish. Emigration peaked during November 2017, when 49.2% of the 2016 brood migrated as sub-yearlings from the Twisp River (Figure 10).

Spring Chinook abundance estimates were also calculated for the Twisp River by expanding PIT interrogations at the TWR PIT array. We found the 2016 brood Chinook captured between 1

September 2017 and 30 June 2018 to have an existing PIT tag rate of 2.26 percent. The PIT tag rate in conjunction with the flow/efficiency regression created for the TWR PIT antennas ($y = -0.00113056x + 1.244939734$; Table 7) was used to estimate that 29,659 (± 6,220, 95% CI) 2016 brood spring Chinook migrated past the TWR interrogation site between 1 September 2017 and 30 June 2018. There were no spring Chinook redds identified below the Twisp array in 2016, 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 more sub-yearling and yearling migrants than the screw trap. For consistency, all production tables include the population estimates created from the screw trap estimation method.

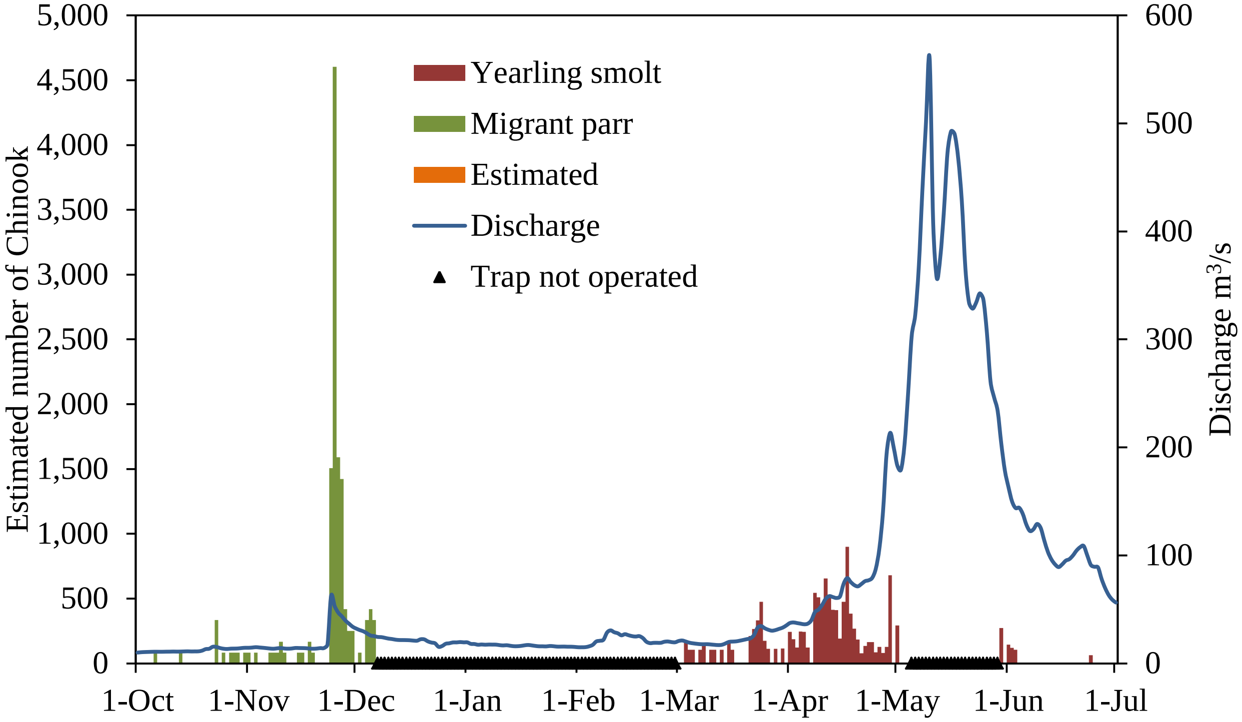

Figure 9. Estimated daily emigration of 2016 brood spring Chinook Salmon from the Methow River by life stage.

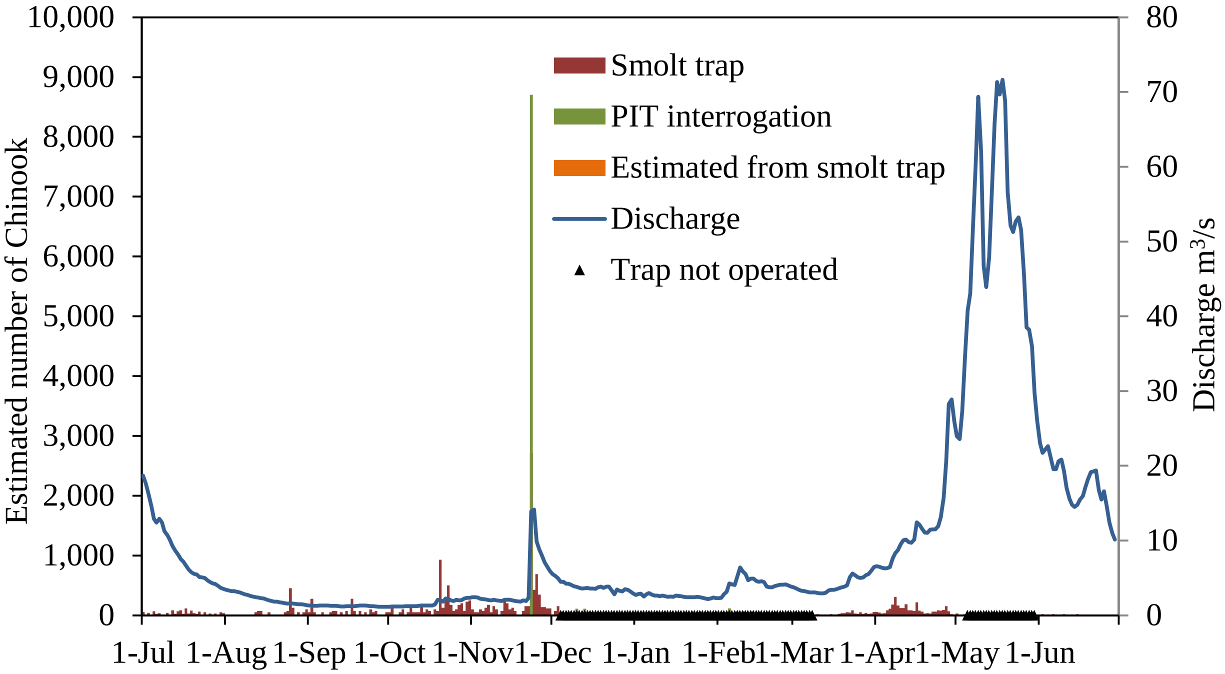

Figure 10. Estimated daily emigration of 2016 brood spring Chinook from the Twisp River by estimation method.

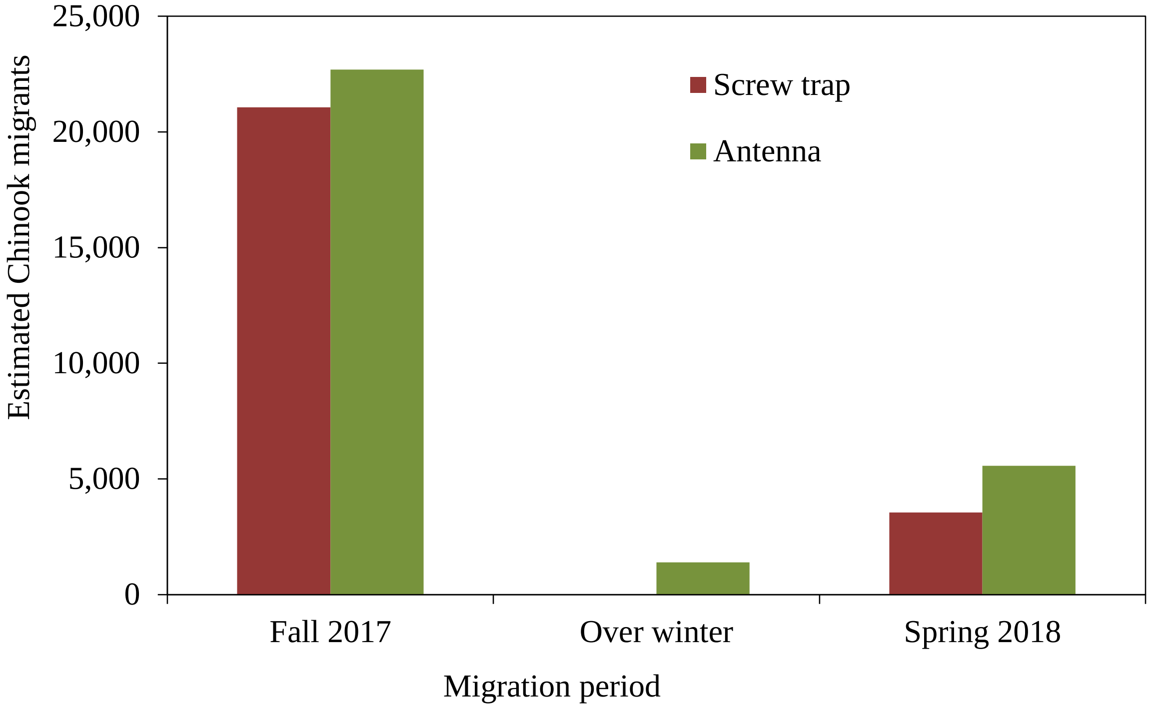

Figure 11. Estimated 2016 brood spring Chinook migration from the Twisp River by migration time and estimation method.

Table 5. Mark/recapture efficiency trials used to estimate emigration of 2016 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
YCH	23-Apr-18	Upper	309	16	5.18	77.3
YCH	26-Apr-18	Upper	288	6	2.08	118.6
	Flow model		3,775	102	2.70	

Table 6. Mark/recapture efficiency trials used to estimate emigration of 2016 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	29-Apr-08	Low	117	23	19.7	5.9
YCW	12-Apr-14	Low	142	17	12.0	7.9
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
YCW	08-Apr-18	Low	110	15	13.6	8.5
YCH, YCW	17-Apr-18	Low	147	18	12.2	11.8
YCH, YCW	20-Apr-18	Low	220	30	13.6	11.3
YCH	24-Apr-18	Low	227	33	14.5	12.5
	Flow model		2,939	468	15.9	

2017 Brood Spring Chinook Salmon

Sufficient numbers of fish could not be obtained at the Methow trap site to develop a flow regression model in the fall of 2018. There were no recaptures of the 19 Chinook that were trapped and released above the Methow trap in the fall, so a pooled efficiency from 2017 Twisp trap releases was used to estimate fish passage during this time period (Table 8). Of the 586 Chinook released above the Twisp trap in 2017, seven of them were recaptured at the Methow trap providing a pooled efficiency of approximately 1.19%. Using this pooled efficiency, an estimated 1,507 (± 6,967, 95% CI) subyearling spring Chinook migrated past the trap in the fall of 2018.

Sufficient numbers of fish could not be obtained at the Twisp trap site to develop a flow regression model for the low position in the fall of 2018. 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 6,179 (± 1,522, 95% CI) 2017 brood spring Chinook Salmon parr emigrated past the Twisp trap between 1 July and 3 December 2018. The trap operated for the entire fall period, so adding estimated migrants using the Twisp PIT tag array was not needed in the fall of 2018. In addition, there were no Chinook redds observed below the Twisp trap site in 2017, so no expansion to account for migrants originating from downstream of the trap was necessary.

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

Species	Date	Released	Detected 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
YCW	11-Apr-18	59	15	5	33.3	10.19
	Flow model	1,023	336	177	52.7	

Table 8. Mark/recapture efficiency trials used to estimate emigration of 2017 brood subyearling spring Chinook Salmon (SBC) at the Methow River smolt trap in 2018.

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 2017 brood subyearling Chinook Salmon (SBC) at the Twisp River smolt trap.

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

Summer Steelhead

Six mark/recapture trials were conducted with migratory steelhead in 2018 at the Methow trap, but all contained less than 100 fish, and no flow/efficiency model existed from these releases. 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 19,001 (± 4,620, 95% CI) summer steelhead emigrated past the Methow River trap in 2018. An additional 62 migrants were estimated from redds located downstream of the trap in 2014 through 2017, which provided a total estimated migration of 19,063 (± 4,627, 95% CI) summer steelhead from the Methow River basin in 2018. Most 2018 migrants were age-2 fish (76.3%) from the 2016 brood (Table 10). The entire 2014 brood migration was estimated to be 14,602 (± 4,043, 95% CI) fish, including 765 migrants that were expected from the 46 redds located downstream of the Methow trap in 2014 (Table 14).

Numerous mark/recapture trials were conducted with wild summer steelhead at the Twisp site in 2018, but most of them contained less than 40 fish. A flow efficiency relationship from previous years' release groups was used to estimate steelhead emigration at the Twisp site in 2018 ($P < 0.01$, $r^2 = 0.53$; Table 11). The flow model regression ($y = -0.00029807x + 0.410559405$) was used to estimate that 6,024 (± 1,932, 95% CI) wild summer steelhead migrated past the Twisp River trap between 9 March and 30 June 2018. An additional 584 migrants were estimated from redds located downstream of the trap in 2014 through 2017, which provides a total estimated migration of 6,608 (± 2,024, 95% CI) summer steelhead from the Twisp River in 2018. Most 2018 migrants were age-2 fish (81.2%) from the 2016 brood (Table 10). Combining numbers from the last four years, the entire 2014 brood migration was estimated to be 5,302 (± 1,727, 95% CI) fish, which includes 626 expected migrants produced from 17 redds downstream of the Twisp trap in 2014 (Table 14).

Table 10. Estimated number of steelhead emigrants from the Methow River basin in 2018 by age and brood.

Age	Brood	Percent of emigrants	Number
		Methow River trap	
1	2017	4.0	766
2	2016	76.3	14,552
3	2015	18.8	3,583
4	2014	0.9	162
Total		100.0	19,063
		Twisp River trap	
1	2017	3.4	227
2	2016	81.2	5,363
3	2015	13.6	901
4	2014	1.8	117
Total		100.0	6,608

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	

2017 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 2018, but no significant relationship was found between flow and efficiency, so a pooled efficiency of approximately 1.68 percent was used to estimate Chinook emigration during that period (Table 12). Three mark/recapture trails were conducted with subyearling Chinook for the upper trapping position in 2018. Combining these groups with historical trials, a significant relationship existed between river discharge and trap efficiency ($P < 0.01$, $r^2 = 0.78$; Table 12). The flow model regression ($y = -0.000021507091x + 0.2114340$), was used in addition to the pooled efficiency to estimate that 352,899 (± 481,655, 95% CI) wild summer Chinook migrated past the Methow trap in 2018. There were 120 summer Chinook redds located downstream of the Methow trap in 2017, so an estimated 74,294 (± 220,998 95% CI) fish migrated from redds located below the trap, resulting in a total estimate of 427,193 (± 529,935, 95% CI) wild 2017 brood summer Chinook migrants from the Methow River in 2018.

Table 12. Mark/recapture efficiency trials used to estimate emigration of 2017 brood summer Chinook Salmon (SBC) at the Methow River smolt trap in 2018.

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
SBC	06-Mar-18	Low	116	2	1.72	18.0
SBC	09-Mar-18	Low	131	5	3.82	17.7
SBC	12-Mar-18	Low	164	1	0.61	17.0
SBC	15-Mar-18	Low	159	4	2.52	20.2
SBC	18-Mar-18	Low	183	4	2.19	21.4
SBC	22-Mar-18	Low	119	1	0.84	29.4
SBC	26-Mar-18	Low	78	0	0.00	30.7
SBC	30-Mar-18	Low	62	0	0.00	34.0
	Pooled		1,012	17	1.68	
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	28-Jun-07	Upper	833	21	2.52	71.6
SBC	31-May-16	Upper	400	6	1.50	114.0
SBC	13-Jun-16	Upper	320	7	2.19	87.4
SBC	17-Jun-16	Upper	435	7	1.61	66.3
SBC	10-Apr-17	Upper	352	7	1.99	62.8
SBC	03-Jun-18	Upper	139	1	0.72	142.9
SBC	17-Jun-18	Upper	130	2	1.54	95.0
SBC	29-Jun-18	Upper	129	3	2.33	60.4
	Flow model		5,811	84	1.45	

2016 Brood Coho Salmon

A total of six wild juvenile Coho migrants were captured at the Twisp site and fourteen were captured at the Methow site between 1 July 2017 and 30 June 2018. Utilizing the same mark/recapture efficiency trial data used for spring Chinook at each site (see Tables 5-9), an estimated 242 (± 177, 95% CI) and 857 (± 624, 95% CI) wild 2016 brood Coho emigrated past the Twisp and Methow River traps, respectively.

Juvenile Survival

2016 Brood Spring Chinook Salmon

Yearling emigrants accounted for 13.7% of all 2016 brood spring Chinook salmon migrating from the Twisp River, and 49.0% of the overall emigrants from the Methow River basin (Table 13). The 2016 brood had more emigrants per redd than average in both the Twisp River and Methow River.

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	6.0	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	3,554	25,937	12.4	564
Twisp	2017	22	81,867	6,179	--	6,179	--	--
Twisp	Mean 2003-2016	83	316,828	8,104	5,484	14,121	5.0	196

Table 13. Continued.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants			Egg to emigrant (%)	Emigrants per redd
				Age-0	Age-1	Total		
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	12,732	25,959	1.8	72
Methow	2017	210	823,356	1,507	--	1,507	--	--
Methow	Mean 2002-2016	738	2,801,980	10,627	24,533	33,743	1.2	48

Summer Steelhead

Since juvenile steelhead may emigrate as age-4 fish, completed emigration estimates have only been calculated for broods prior to 2015 (Table 14). The 2014 brood produced an estimated 17 and 37 emigrants from each redd in the Methow and Twisp River basins, respectively.

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	117	5,302	0.70	37
Twisp	2015	161	938,469	461	5,818	901	--	7,180	--	--
Twisp	2016	166	857,390	422	5,363	--	--	5,785	--	--
Twisp	2017	140	869,400	227	--	--	--	227	--	--
Twisp mean 2003-2014		282	1,684,039	120	4,391	1,409	119	6,029	0.64	36

Table 14. 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	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	162	14,602	0.32	17
Methow	2015	991	5,776,539	3,495	18,609	3,583	--	25,687	--	--
Methow	2016	638	3,295,270	2,196	14,552	--	--	16,748	--	--
Methow	2017	533	3,309,930	766	--	--	--	766	--	--
Methow mean 2003-2014		1,092	6,422,511	1,589	12,692	2,941	292	17,514	0.34	20

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

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	0	1	0.23
2014	2016	400	0	0	--	0	0.00
2015	2017	799	1	--	--	1	0.13
2003-2013 brood mean							0.49
Pooled 2003-2013 broods		7,719	7	39	10	56	0.73
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	0	1	0.23
2014	2016	478	0	3	--	3	0.63
2015	2017	484	0	--	--	0	0.00
2003-2013 brood mean							0.60
Pooled 2003-2013 broods		5,220	5	21	2	28	0.54

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. Total row excludes 2017 brood data because adult returns are incomplete.

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	0	1	0.63
2017	236	0	--	0	0.00
Total	4,011	21	21	42	1.05
		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	2	1.06
2017	368	2	--	2	0.54
Total	3,313	11	12	23	0.69

Discussion

River conditions at both the Methow and Twisp sites were generally favorable for trapping activities until May of the 2018 season. The Methow trap was not operated for 25 days between 5 May and 29 May because of high river discharge. The Twisp trap was pulled from the river for 26 days between 5 May and 30 May 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.

Abnormally high river turbitity was observed at both the Methow and Twisp trapping sites in 2016 and 2017 due to the additional sediment input from recent wildfire scars. Daytime captures were enumerated at the Twisp trap which operates during all hours of the day. Captures of wild spring Chinook during the daytime accounted for over half of the total captures in April 2016, and around 20 percent of total captures in April 2017. Daytime observations were conducted again this season at the Twisp trap site, and suggest that approximately 10 percent of wild spring Chinook were captured during daylight hours during April 2018. The Methow trap did not operate during daylight hours due to permit obliations. Turbidity levels were always higher at the Methow trap site than they were at the Twisp trap site, but 2018 observations suggest that daytime emigration past the Methow trap site may have been lower in 2018 compared to 2016 and 2017.

The TWR PIT array plays in integral role in assessing juvenile migration during periods when the Twisp trap is inoperable. In some years, the TWR PIT array has sustained significant damage from ice during the winter, which makes it difficult to account for juvenile migration during the winter months. The antennas have historically been constructed from PVC (Polyvinyl chloride), which has proven to be fairly brittle. In December 2017, all six PIT antennas present at the site were replaced with antennas constructed from HDPE (High-density polyethylene), which were able to withstand much more ice accumulation without breaking. The TWR PIT array operated very well during the 2017-2018 over-winter period when the Twisp trap was pulled from the river, so the associated migration estimate should be considered fairly accurate.

Emigration estimates for the 2015 and 2016 brood summer steelhead have been updated from what was previously reported. The 2015 Twisp estimates were increased to incorporate additional redds that were located below the trap. The 2016 values for both the Methow and Twisp estimates were changed to reflect an adjustment in the redd counts and corresponding egg deposition. The modification in redd counts changed the proportion of redds that were found above and below the traps, and thus the total production estimates.

Production estimates and associated variance estimates for the 2018 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 2018 to determine the proportion of subyearling fish that were spring Chinook salmon. Spring Chinook Salmon accounted for 94.7% 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.

References

Hillman, T., T. Kahler, G. Mackey, A. Murdoch, K. Murdoch, T. Pearsons, M. Tonseth, and C. Willard. 2017. Monitoring and evaluation plan for PUD hatchery programs: 2017 update. Report to the HCP and PRCC Hatchery Committees, Wenatchee and Ephrata, WA.

Murdoch, A. R., T.L. Miller, B.L. Truscott, C. Snow, C. Frady, K. Ryding, J.E. Arterburn, and D. Hathaway. 2012. Upper Columbia spring Chinook salmon and steelhead juvenile and adult abundance, productivity, and spatial structure monitoring. BPA Project Number 2010-034-00. Bonneville Power Administration, Portland, OR.

Snow, C., C. Frady, D. Grundy, B. Goodman, and A. Haukenes. 2018. Monitoring and evaluation of the Wells Hatchery and Methow Hatchery programs: 2017 annual report. Report to Douglas PUD, Grant PUD, Chelan PUD, and the Wells and Rocky Reach HCP Hatchery Committees, and the Priest Rapids Hatchery Subcommittees, East Wenatchee, WA.

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
2018	Twisp	475	1	168	271	0	227
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
2018	Methow	255	0	19	418	3	27

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

2018 Methow Chinook salmon juvenile assignments

Maureen P. Small and Alicia Terepocki
Conservation Biology Unit, Molecular Genetics Lab, WDFW
Report, January 2019

Summary

In fall 2018, 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 26% of the spring type appeared to originate in the Twisp population.

Methods

We genotyped 19 juvenile Chinook salmon (WDFW collection code 18GH, 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.

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 one juvenile assigned to the summer collection (plotted within the cluster formed by the Methow summer Chinook). Nine 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 for their highest assignment likelihood of assignment in Table 2.

In summary, one smolt assigned with high likelihood to the Methow summer Chinook salmon collection and 18 smolts assigned to Methow or Twisp spring Chinook salmon collections.

Acknowledgments

Juvenile samples were gathered by Charles Snow and David Grundy (WDFW). Funding was provided by Douglas Co. PUD and Washington State General Funds. Todd Kassler (WDFW-MGL) administered the contract.

References

Belkhir, K., P. Borsa, L. Chikhi, N. Raufaste and F. Bonhomme. 2004. GENETIX, logiciel sous WindowsTM pour la génétique des populations. Laboratoire Génome, Populations, Interactions CNRS UMR 5000, Université de Montpellier II, Montpellier (France). Available at http://www.univ-montp2.fr/~genetix/ genetix/genetix.htm

Piry S., Alapetite A, Cornuet, J.-M., Paetkau D, Baudouin, L., and A. Estoup. 2004. GeneClass2: a software for genetic assignment and first generation migrants detection. Journal of Heredity. 95(6): 536–539.

Pritchard, J. K., Stephens, M. and P. Donnelly. 2000. Inference of population structure using multilocus genotype data. Genetics. 155:945-959.

Rannala B. and J. L. Mountain. 1997. Detecting immigration by using multilocus genotypes. Proceedings of the National Academy of Sciences. 94:9197-9201.

Small, M. P., K. Warheit, C. Dean, and A. Murdoch. 2007. Genetic monitoring of Methow spring Chinook salmon. WDFW unpublished report.

Small, M.P. and J. Von Bargen. 2009. 2009 Methow Chinook salmon juvenile assignments. Draft WDFW Molecular Genetics Lab report.

Small, M. P. and C. Dean. 2010. 2010 Methow Chinook salmon juvenile assignments.

Small, M. P. S. Bell and C. Dean. 2011. 2011 Methow Chinook salmon juvenile assignments, WDFW Molecular Genetics Lab report.

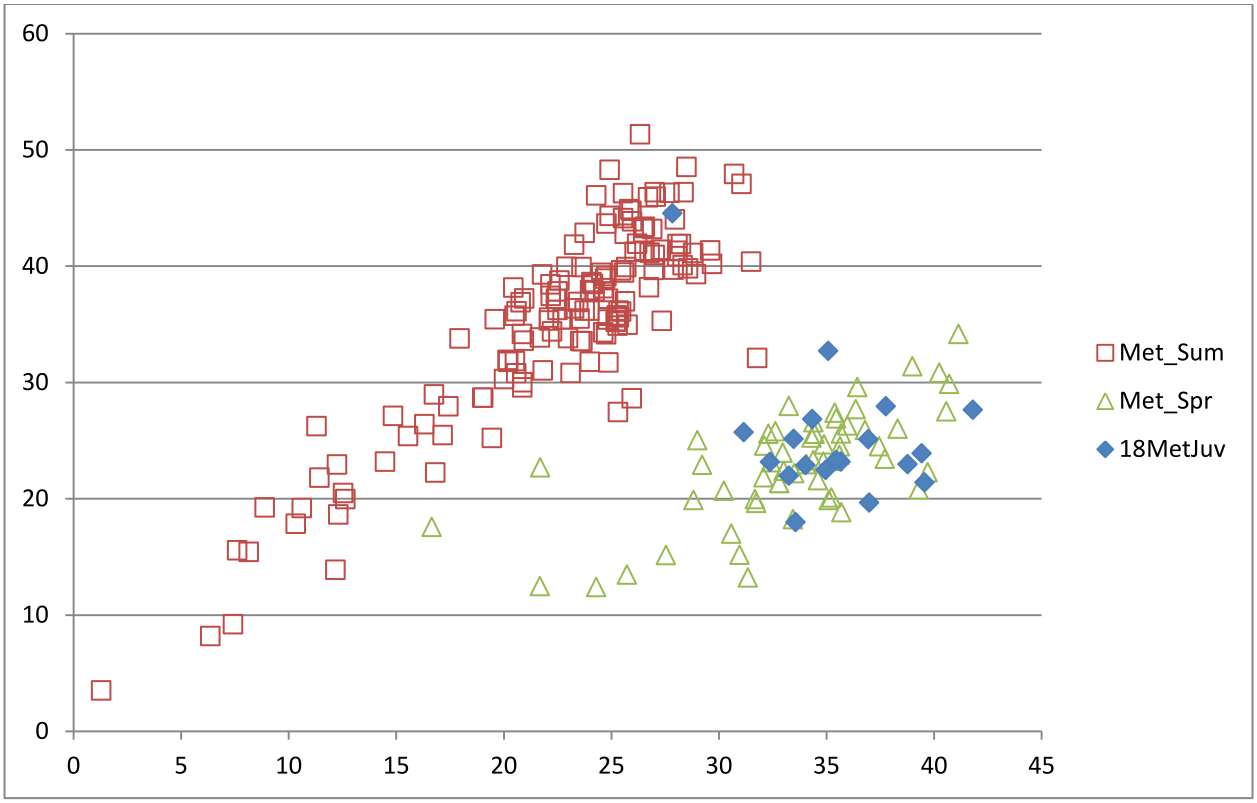

Figure 1. Graph of negative log likelihood assignment scores from GENECLASS. Methow juveniles (blue diamonds) are abbreviated Juv.

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

Code	Name	N
18GH	Methow juveniles - 2018	19
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	assingment	Rel like	MethowSum '-log(L)	MetSpring '-log(L)	TwispSpr '-log(L)	N loci
18GH001	MetSpring	83.35	35.66	23.19	23.89	13
18GH002	MetSpring	84.73	39.43	23.90	24.64	13
18GH003	MetSpring	100.00	34.02	22.89	32.17	13
18GH004	MetSpring	85.28	39.56	21.39	22.16	13
18GH005	MetSpring	98.84	33.57	17.98	19.91	11
18GH006	MethowSum	100.00	27.84	44.54	44.58	13
18GH007	TwispSpr	99.99	36.94	25.10	21.23	13
18GH008	TwispSpr	58.14	35.45	23.32	23.18	13
18GH009	MetSpring	58.76	34.33	26.85	27.00	13
18GH010	MetSpring	100.00	33.25	21.97	27.47	13
18GH011	MetSpring	85.26	37.76	27.94	28.70	13
18GH012	MetSpring	100.00	36.98	19.65	24.94	13
18GH013	MetSpring	100.00	38.77	22.96	32.27	13
18GH014	TwispSpr	61.57	41.81	27.65	27.45	13
18GH015	TwispSpr	94.97	32.37	23.17	21.89	13
18GH016	MetSpring	99.93	34.96	22.46	25.60	13
18GH017	MetSpring	99.86	31.15	25.72	28.58	13
18GH018	MetSpring	61.33	33.47	25.14	25.34	13

Attachment B. In-stream PIT tagging of juvenile spring Chinook and steelhead in the Methow River basin in 2018.

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

To: Charlie Snow

From: Danielle Grundy and Ben Goodman

Subject: 2018 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 2018, 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 2018.

Methods

We used a combination of angling and electrofishing to collect spring Chinook Salmon and *O. mykiss* parr in 2018. 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 39), Little Bridge Creek (mouth to rkm 10), and Buttermilk Creek (rkm 1–4). Angling effort occurred from 2 July to 24 August 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 are defined as the Twisp River mainstem from Upper Poorman Creek Bridge (rkm 8) to the top of T7 (rkm 36). These reaches were fished completely (i.e., a single angling pass was conducted along the entire length of each reach) up to Buttermilk Bridge (rkm 21). Angling effort was reduced beyond Buttermilk Bridge to the top of T7, because of safety and limited access due to the Crescent Mountain fire. The lower reaches from the Twisp River mouth to Upper Poorman Creek Bridge were also fished completely. In tributaries (i.e. Little Bridge Creek and Buttermilk Creek) angling effort was reduced. To reduce spatial bias in the sampling within these areas, 15 sites were randomly selected, and 13 were subjected to 3 hrs of angling effort. The remaining two sites were inaccessible due to the Crescent Mountain fire. Electrofishing in the Twisp River basin was conducted from 17 September to 17 October, 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; 27% (N = 11) of the sites were downstream of the weir, 53% (N = 21) were upstream of the weir, and 20% (N = 8) 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. Two types of electrofishing sampling methods were used at sampling sites: single-pass and recapture sampling. For both 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. A recapture pass was conducted at 10 randomly selected single-pass sites within 24 hours after the initial sample in order to evaluate mark-recapture as an estimate of single pass 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. Sampled fish were allowed to fully recover in a bucket of river water prior to being released in a calm part of the river near the sampling location. 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. At all sampling locations a hand-held GPS device was used for geo-reference. 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 2018, we captured a total of 1,992 wild *O. mykiss* parr, 308 residual hatchery-origin steelhead parr, and 187 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 and electrofishing effort in 2018 was similar to previous years; however, angling catch of *O. mykiss* as well as electrofishing catch of Chinook were less than previous years (Table 2). Wild steelhead fork length in the Twisp River basin was greater for those captured by angling (mean = 152 mm) than by electrofishing (mean = 92 mm) in 2018 (Figure 1; $P < 0.001$; Kolmogorov-Smirnov test).

Recapture passes were conducted at 10 sites in 2018 and fish were recaptured at all 10 of these sites (including only PIT-tagged fish that were originally tagged during the first pass) for a total of 77 recaptures. The average number of recaptures per site was 5 fish (20%) in tributaries and 9 fish (21%) in the Twisp mainstem. For all species combined, recapture percentage varied from 3% in site 27600 to 33% in site 44900 (Table 3). Across sites, recapture rate was greatest for spring Chinook Salmon (24%), followed by *O. mykiss* (21%), and Bull Trout (0%; Table 3). Of the 1,439 unique PIT-tagged fish captured during electrofishing, only three (all *O. mykiss*) were captured at multiple GRTS sites and all were recaptured within 6 days following tagging, and within 200 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 2018. 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	0.0	0	0	0.0	0	0
T9	0.0	0	0	0.0	0	0
T8	6.0	0	1	0.0	0	0
T7	25.8	0	41	3.8	32	131
T6	27.0	0	16	7.6	99	111
T5	34.7	0	27	5.9	21	196
T4	25.4	0	78	2.4	4	119
T3	21.0	0	90	4.7	15	210
T2	25.0	0	85	4.0	12	161
T1	19.5	0	106	2.2	4	123
LBC4	3.0	0	10	0.2	0	22
LBC3	9.0	0	58	1.0	0	56
LBC2	6.0	0	31	0.2	0	21
LBC1	12.0	0	93	0.8	0	54
BM2	3.0	0	40	0.0	0	0
BM1	5.5	0	47	0.0	0	0
Total	222.9	0	723	32.8	187	1,204

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
2018	222.9	0	723	32.8	187	1,204

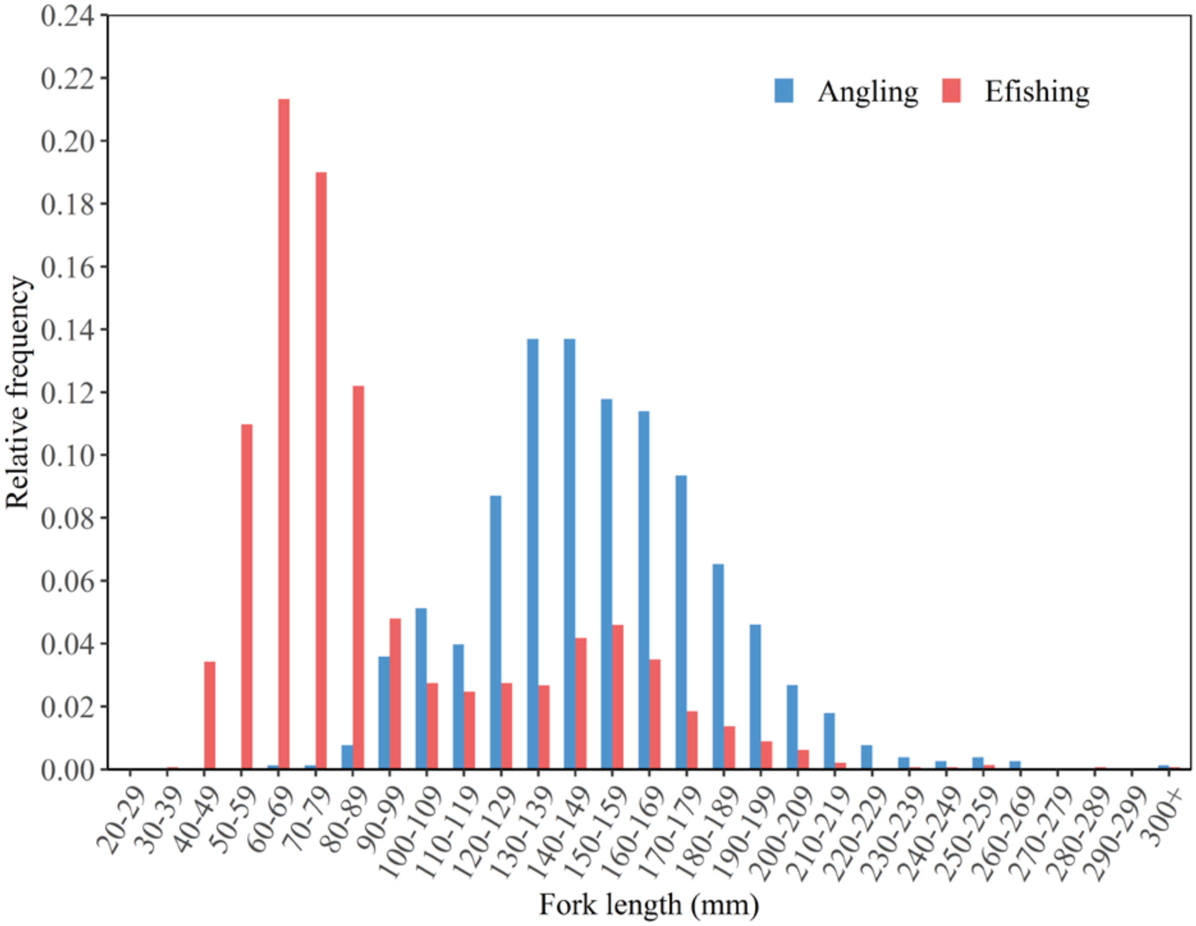

Figure 1. Relative frequency distribution of *O. mykiss* parr fork length by capture method in the Twisp River basin.

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 2018.

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															
3300							3	0	*0*	38	8	*21*	41	8	*20*
6400							7	2	*29*	31	5	*16*	38	7	*18*
16700							4	0	*0*	38	11	*29*	42	11	*26*
27600							3	1	*33*	30	0	*0*	33	1	*3*
28400							14	5	*36*	36	7	*19*	50	12	*24*
34600	1	0	*0*				28	6	*21*	12	3	*25*	41	9	*22*
42000	1	0	*0*				1	0	*0*	19	5	*26*	21	5	*24*
44900							3	1	*33*	42	14	*33*	45	15	*33*
Twisp tributaries															
4100	1	0	*0*							22	3	*14*	23	3	*13*
7500										23	6	*26*	23	6	*26*
Total	3	0	*0*				63	15	*24*	291	62	*21*	357	77	*22*

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 2018.

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

From: Charles Frady

To: Charlie Snow

Date: 28 May 2019

Subject: Results of 2018 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 2018). 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 2018 brood. PIT tags were also used to estimate proportions of fish escaping to the Methow and Okanogan basins. Fish were assigned to either basin based on their last PIT detection. Detections at Chief Joseph Hatchery were included in the Okanogan estimate. 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 subsequent to sampling and recovery.

Digital video records of fish passage at Wells Dam between 3 June and 7 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 into the Methow River and from the Riverside Acclimation Pond into the Okangoan River are tagged with a CWT but are not externally marked (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 denote 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 2018 MH broodstock (WDFW, unpublished data). Female carcasses with intact abdominal cavities, a large number of eggs, and no external signs of spawning (i.e., eroded caudal fin) were categorized as pre-spawn mortalities. Estimated egg deposition was calculated using mean fecundities from MH broodstock (i.e., MetComp stock for Methow and Chewuch subbasins, Twisp stock for Twisp subbasin) and adjusted for mean egg-retention rates.

Natural Replacement Rate

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

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

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 2018, 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 rate 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 2018 spring Chinook salmon migration to Wells Dam was monitored beginning 7 May on both the East and West Ladders, respectively, and continued into the summer Chinook migration monitoring period on both ladders. 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 281 fish were double counted and 148 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 4,962 fish. The run was composed primarily of hatchery fish (85.2%), 52.9% of which were adipose fin-clipped. After correcting for sex determination errors and accounting for fish retained for Methow Basin broodstock (N = 511), fish destined for the Okanogan Basin or Chief Joseph Hatchery (N = 2,347), and fish removed as surplus from the Methow and Winthrop hatcheries (N = 1,010), the remaining estimated escapement in the Methow River was 1,094 fish.

Table 1. Mean migration date of hatchery (H) and wild (W) spring Chinook to Wells Dam of the overall return for the 2006-2018 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
2018	H	26-May	30-May	3-June	8-June	14-June	3-June	1,199
2018	W	24-May	29-May	3-June	7-June	13-June	3-June	211

Redd Distribution, Spawn Timing, and Spawner Demographics

Spawning ground surveys were performed on foot between 30 July and 26 September. A total of 250 spring Chinook redds were constructed in the Methow basin in 2018 (Tables 2-4); the majority of redds were found in the Methow River subbasin (54.0%; *N* = 135; Table 2). The greatest number of redds within that subbasin were found in the 9 km reach downstream of Weeman Bridge (*N* = 54). On average, Methow Hatchery females spawned slightly earlier than wild females in the Methow subbasin but slightly later than wild females in the Chewuch and Twisp subbasins (Tables 5-7). On average, wild females spawned between three and 18 km further upstream than Methow Hatchery females, depending on subbasin (Tables 5-7).

Based on expanded redd counts, there were an estimated 500 spawners in the Methow River basin in 2018, of which 265 (53.0%) 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 69.0%, 50.0%, and 46.9% of the estimated spawning escapement in the Twisp, Methow, and Chewuch subbasins, respectively (see Tables 2-4).

A total of 108 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 had generally similar mean lengths within age groups for both MetComp and Twisp stocks though wild Twisp 4-year old males were slightly larger on average than their hatchery counterparts (Table 8).

Egg retention was estimated for 84 of the 96 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 966,908 eggs were deposited in the Methow River basin in 2018 (Table 9).

Table 2. 2018 spring Chinook salmon redd distribution, estimated spawning escapement, and carcass recoveries in the Methow River subbasin.

Reach	Redds		Estimated spawning escapement	Carcasses				
	Count	Subbasin Prop. (%)		Recoveries			Expanded count	
				H	W	Total	H	W
Methow River mainstem								
M17	1	0.7	2	1	1	2	1	1
M16	1	0.7	2	0	1	1	0	2
M15	2	1.5	4	2	1	3	3	1
M14	4	3.0	8	1	1	2	4	4
M13	1	0.7	2	1	0	1	2	0
M12	5	3.7	10	3	2	5	6	4
M11	6	4.4	12	2	2	4	6	6
M10	18	13.3	36	1	6	7	5	29
M9	54	40.0	108	14	11	25	63	47
M8	1	0.7	2	2	1	3		
M7	10	7.4	20	7	3	10	14	6
M6	5	3.7	10	6	1	7	9	1
M5,4	0	0.0	0	0	0	0	0	0
Total	108	80.0	216	40	30	70	113	103
Lost River								
L2	4	3.0	8	0	1	1	0	8
L1	4	2.9	8	0	0	0	0[a]	8[a]
Total	8	5.9	16	0	1	1	0	16
Early Winters Creek								
EW5,4	0	0.0	0	0	0	0	0	0
EW3	4	3.0	8	1	0	1	8	0
EW2,1	0	0.0	0	0	0	0	0	0
Total	4	3.0	8	1	0	1	8	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	3	2.2	6	0	0	0	6[b]	0[b]
Lsusp1	0	0.0	0	0	0	0	0	0
Susp1	4	3.0	8	0	1	1	0	8
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	8	5.9	16	1	1	2	8	8
Total	15	11.1	30	1	2	3	14	16
Grand total	135	100.0	270	42	33	75	135	135

[a] Expanded count based on H and W proportions from L2.

[b] Expanded count based on H and W proportions from previous years' data.

Table 3. 2018 spring Chinook salmon redd distribution, estimated spawning escapement, and carcass recoveries in the Chewuch River subbasin.

Reach	Redds		Estimated spawning escapement	Carcasses				
	Count	Subbasin Prop. (%)		Recoveries			Expanded count	
				H	W	Total	H	W
Chewuch River mainstem								
C13	0	0.0	0	0	0	0	0	0
C12	1	1.5	2	0	0	0	1[a]	1[a]
C11	0	0.0	0	0	0	0	0	0
C10	3	4.6	6	1	1	2	3	3
C9	0	0.0	0	0	0	0	0	0
C8	5	7.7	10	4	3	7	6	4
C7	12	18.5	24	4	8	12	8	16
C6	19	29.2	38	10	15	25	15	23
C5	10	15.4	20	6	2	8	15	5
C4	8	12.3	16	4	1	5	13	3
C3	0	0.0	0	0	0	0	0	0
C2	7	10.8	14	4	3	7	8	6
C1	0	0.0	0	0	0	0	0	0
Total	65	100.0	130	33	33	66	69	61

[a] Expanded count based on H and W proportions from C10.

Table 4. 2018 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[a]	ns	ns	ns	ns	ns	ns	ns	ns
T9[a]	ns	ns	ns	ns	ns	ns	ns	ns
T8	1	2.0	2	0	0	0	0	2[b]
T7	2	4.0	4	0	2	2	0	4
T6	22	44.0	44	1	3	4	11	33
T5	19	38.0	38	6	8	14	15	23
T4	0	0.0	0	0	1	1		
T3	6	12.0	12	0	0	0	5	7
T2	0	0.0	0	0	0	0	0	0
T1	0	0.0	0	0	0	0	0	0
Total	50	100.0	100	7	14	21	31	69

[a] Prevented from surveying above Poplar Flats due to Crescent Fire.

[b] Expanded count based on H and W proportions from T7.

[c] Expanded count based on H and W proportions from T5/4.

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 2018.

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
2018	H	104	8	13	253	5
2018	W	110	8	22	250	6
Mean	H	104	10	37	251	6
Mean	W	112	12	29	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 2018.

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
2018	H	90	3	5	252	4
2018	W	108	14	15	253	7
Mean	H	94	10	101	251	7
Mean	W	106	11	33	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 2018. 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	- -	- -	- -	- -	- -
2018	H	88	3	2	257	4
2018	W	91	4	8	254	4
Mean	H	87	5	14	250	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 2018. 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 (2015 BY)	Age-4 (2014 BY)	Age-5 (2013 BY)	Age-3 (2015 BY)	Age-4 (2014 BY)	Age-5 (2013 BY)
MetComp	H	- -	60 (*8*; 4)	- -	- -	61 (*20*; 3)	- -
Methow / Chewuch	W	46 (*3*; 1)	59 (*23*; 5)	70 (*1*; - -)	- -	60 (*37*; 3)	- -
Twisp	H	- -	55 (*2*; 1)	- -	- -	55 (*1*; - -)	- -
Twisp	W	- -	59 (*6*; 8)	- -	- -	57 (*7*; 3)	- -

Table 9. Estimated egg deposition for spring Chinook salmon in the Methow Basin in 2018. 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		
						2016	2017	2018
Chewuch	42	3,784	0.40	65	25.5	351,373	253,038	244,976
Methow	34	3,787	0.60	140	54.9	866,006	488,451	526,999
Twisp	8	3,901	0.06	50	19.6	209,262	81,867	194,933
Total	84			255		1,426,641	823,356	966,908

Natural Replacement Rates

Natural replacement rates (NRR) for the latest complete brood (2012) were less than 1.0 in all subbasins (Chewuch = 0.37; Methow = 0.31; Twisp = 0.27; Appendices A-C). NRR values from each subbasin have been less than one for at least five years. HRR values from the 2012 brood were between four and 49 times greater than corresponding NRR values within subbasins (Appendices A-C). There were no hatchery releases in the Chewuch subbasin from 2012 brood parents.

Stray Rates by Brood Year

There were no hatchery releases in the Chewuch subbasin from 2012 parent broodstock. 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 = 31.5%) was greater than the 5% target. Based on total expanded CWT recoveries, an estimated 0.6% of the 2012 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 = 2.9%) was less than the 5% target. Based on total expanded CWT recoveries, an estimated 15.0% of the 2012 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 = 18.2%) was greater than the 5% target.

Stray Rates within the Methow Basin

A total of 71 coded wire tags (CWTs) were successfully decoded from the adult spring Chinook salmon collected during spawning ground surveys in the Methow River basin in 2018. These fish were expanded by tag-specific retention rates and stream-specific sample rates to account for 216 fish (Appendix G). As a percent of the spawning escapement, most within-basin strays were recovered in the Methow subbasin (Table 10-12; 2.3%, Chewuch releases). These values are based on stream-scale CWT expansions and only approximate total reach-scale escapement. Thus, the hatchery stock escapement 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 all subbasins at rates greater than long term averages (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 or Chiwawa rivers (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
2018	69	61	130	29.5	1.5	0.0	3.1	- -	16.1

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
2018	135	135	270	2.3	9.2	0.0	15.8	- -	19.2

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

Run year	Estimated spawning			Hatchery stock (% of spawning escapement)					
	H	W	Total	Chewuch	Methow	Twisp	Winthrop	MetComp	Out-of basin
2000	235	21	256	0.0	0.0	72.6	2.2	- -	0.0
2001	384	506	890	1.5	0.8	19.6	0.8	0.0	0.0
2002	60	181	241	0.0	0.0	9.1	12.1	3.1	0.0
2003	18	25	43	0.0	0.0	30.2	0.0	0.0	0.0
2004	98	243	341	0.0	0.0	19.7	1.2	1.3	4.4
2005	34	87	121	2.6	0.0	15.8	0.0	0.0	0.0
2006	100	65	165	0.0	2.5	40.0	2.8	- -	0.0
2007	65	40	105	0.0	0.0	55.2	0.0	- -	0.0
2008	126	40	166	2.7	0.0	60.1	0.0	- -	4.0
2009	97	32	129	0.0	0.0	55.6	3.4	- -	3.4
2010	96	156	252	1.4	0.0	30.1	2.8	- -	1.4
2011	85	159	244	2.5	0.0	17.4	0.0	- -	32.4
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
2018	31	69	100	0.0	0.0	19.2	0.0	- -	5.1

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.

References

Meekin, T. K. 1967. Report on the 1966 Wells Dam Chinook tagging study. Washington Department of Fisheries. Olympia, Washington.

Tonseth, M. 2018. Final Upper Columbia River 2018 BY salmon and 2019 BY steelhead hatchery program management plan and associated protocols for broodstock collection, rearing/release, and management of adult returns. Memo dated 24 April, 2018 to NMFS, HCP HC's, and PRCC HSC.

Appendix A. Natural Replacement Rates (NRR) in the Chewuch subbasin for brood years 1992 to 2012 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
1992	421.75	0	25	14	41.25	0.10	1.50
1993	184.34	2	69	21	95.53	0.52	1.00
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	4.90
2011	868.50	10	144	29	194.49	0.22	8.59
2012	337.48	0	103	18	125.75	0.37	- -

Appendix B. Natural Replacement Rates (NRR) in the Methow subbasin for brood years 1992 to 2012 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
1992	924.26	0	44	43	92.38	0.10	- -
1993	759.56	5	79	32	119.66	0.16	1.93
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	8.86
2011	1,823.00	8	153	25	197.87	0.11	11.40
2012	743.60	14	180	29	232.49	0.31	15.29

Appendix C. Natural Replacement Rates (NRR) in the Twisp subbasin for brood years 1992 to 2012 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	5.19
2011	243.18	9	106	10	132.55	0.55	2.57
2012	198.77	3	48	0	52.74	0.27	1.21

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 % 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/ harv.	No harv.
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	62	0	2	318	321	0	0	0	0	0	2	705	45.5%	45.6%
2002	93	3	59	174	299	0	0	0	1	3	1	632	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	91	6	0	120	112	0	0	0	0	1	3	333	33.6%	34.0%
2011	378	2	0	108	122	0	0	1	4	1	11	627	19.8%	20.3%
2012	No releases this brood year													

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/harv.	No harv.
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	8	3	762	1.7%	1.7%
2010	1,080	34	0	655	81	0	0	0	0	5	68	1,923	4.2%	4.4%
2011	2,941	0	0	409	39	3	0	0	2	7	88	3,489	1.1%	1.2%
2012	2,112	0	0	173	14	3	0	0	0	17	9	2,328	0.6%	0.6%

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/harv.	No harv.
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	71	0	156	70	0	0	0	0	1	3	302	23.2%	23.4%
2011	0	8	0	45	6	0	0	0	0	0	0	59	10.2%	10.2%
2012	5	10	0	19	6	0	0	0	0	0	0	40	15.0%	15.0%

Appendix G. Expanded coded wire tag (CWT) recoveries in 2018 by recovery location. Recoveries were expanded by tag-specific mark rates and stream sample rates.

Stream	BY	CWT	Release location	Stray status	Estimated escapement
Chewuch River	2014	636761	Chewuch	Homed	26
Chewuch River	2014	200117	Okanogan (Riverside)	Out-of-Basin	21
Chewuch River	2014	636757	Chewuch	Homed	12
Chewuch River	2014	636687	Methow	Within-Basin	2
Chewuch River	2014	055239	Methow	Winthrop	2
Chewuch River	2014	055719	Methow	Winthrop	2
Early Winters Creek	2015	636932	Nason	Out-of-Basin	8
Methow River	2013	055718	Methow	Winthrop	3
Methow River	2014	200117	Okanogan (Riverside)	Out-of-Basin	26
Methow River	2014	055239	Methow	Winthrop	22
Methow River	2014	200122	Columbia (CJH)	Out-of-Basin	17
Methow River	2014	636687	Methow	Homed	9
Methow River	2014	636759	Methow	Homed	9
Methow River	2014	055719	Methow	Winthrop	10
Methow River	2014	636761	Chewuch	Within-Basin	6
Methow River	2014	636826	Chiwawa	Out-of-Basin	3
Methow River	2014	636773	Methow	Homed	3
Methow River	2015	636984	Methow (Goat Wall)	Homed	3
Twisp River	2014	636688	Twisp	Homed	19
Twisp River	2014	200117	Okanogan (Riverside)	Out-of-Basin	5
WNFH outfall	2014	055239	Methow	Winthrop	8

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	2018
Trout Creek - Rattlesnake Creek	M17	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	1
Rattlesnake Creek - Ballard C.G.	M16	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	1
Ballard C.G. - Lost River	M15	0	0	0	6	4	1	0	8	3	1	4	5	1	2	1	2
Lost River - Gate Creek	M14	4	9	7	17	12	17	11	32	23	20	31	27	6	16	4	4
Gate Creek - Early Winters Creek	M13	0	14	0	5	3	13	1	34	9	13	15	25	2	5	4	1
Early Winters Creek - Mazama Bridge	M12	6	9	10	20	13	9	10	14	15	6	10	12	13	5	1	5
Mazama Bridge - Suspension Bridge	M11	7	10	12	24	15	17	14	50	22	21	17	24	10	17	9	6
Suspension Bridge - Weeman Bridge	M10	34	51	45	36	19	31	44	63	26	24	21	62	84	25	18	18
Weeman Bridge - Along Highway 20	M9	105	104	136	173	84	94	138	332	156	161	97	200	294	75	35	54
Along Highway 20 - Wolf Creek	M8	2	3	5	9	2	4	11	8	0	7	0	5	14	2	3	1
Wolf Creek - Foghorn Dam	M7	20	16	19	59	10	13	11	67	37	48	26	66	68	16	13	10
Foghorn Dam - Winthrop Bridge	M6	19	17	18	46	12	20	12	71	54	74	26	67	19	15	4	5
Winthrop Bridge – MVID diversion	M5	5	0	7	0	Ns	2	3	9	3	2	0	1	10	1	1	0
MVID diversion – Twisp Bridge	M4	Ns	0	0	0	Ns	1	Ns	1[a]	0	1	0	1	3	0	Ns	0
Twisp Bridge – Upper Burma Bridge	M3,2	Ns	Ns	Ns	Ns	Ns	Ns	Ns	4[a]	Ns	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	4
Lost River Bridge - Confluence	L1	0	5	1	2	0	2	4	5	4	3	4	3	1	1	0	4
Klipchuck C,G. - Early Winters Bridge	EW5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Early Winters Bridge - Highway 20	EW4	0	0	0	0	0	0	3	4	0	0	1	0	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	4
Diversion dam - Highway 20 Bridge	EW2	1	0	0	1	0	0	0	1	0	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	0
Various reaches of Gold Creek + Foggy	GDN4-	Ns	Ns	0	0	1	0	0	5	1	Ns	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	4
Little Suspension Creek (Entire length)	Lsusp1	Ns	Ns	Ns	Ns	Ns	Ns	Ns	0	5	2	0	7	0	0	0	0
Methow Hatchery Outfall (Entire length)	MH1	13	9	8	75	7	10	14	50	38	55	33	79	19	2	2	3
Winthrop NFH Outfall(Entire length)	WN1	11	8	5	21	3	25	17	55	44	33	10	81	39	29	14	8
Hancock Cr. (Kumm Rd. to Wolf Cr.	HA2	Ns	Ns	Ns	Ns	Ns	Ns	Ns	19	2	9	1	12	0	0	0	0
Hancock Cr. (Wolf Cr. Rd. to	HA1	Ns	Ns	Ns	Ns	Ns	Ns	Ns	1	0	1	1	3	4	1	0	0
Wolf Creek (Rd 5505 access -	W3,2	0	Ns	Ns	Ns	Ns	Ns	5	30	0	4	1	14	0	0	0	0
Wolf Creek (footbridge - Confluence)	W1	2	0	0	0	0	0	0	3	0	3	0	2	3	0	0	0
Upper Methow River subbasin total		252	287	294	569	199	278	323	935	472	520	336	763	654	231	124	135

[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	2018
Chewuch Falls - 30 Mile Bridge	C13	Ns	Ns	0	Ns	0	2	2	2	8	4	3	5	2	0	1	0
30 Mile Bridge - Road Side Camp	C12	0	0	3	1	5	4	10	32	35	12	20	24	12	5	0	1
Road Side Camp - Andrews Creek	C11	0	0	1	1	1	3	4	9	8	8	3	6	1	1	0	0
Andrews Creek - Lake Creek	C10	0	0	7	9	0	7	4	10	14	7	13	18	6	3	2	3
Lake Creek - Buck Creek	C9	2	0	0	0	0	1	0	0	0	1	1	2	0	0	1	0
Buck Creek - Camp 4 C.G.	C8	14	10	5	10	7	7	7	8	18	14	6	14	10	6	6	5
Camp 4 C.G. - Chewuch Campground	C7	25	2	16	32	9	16	11	24	17	22	14	17	17	9	5	12
Chewuch C.G. - Falls Creek C.G.	C6	16	19	33	54	23	21	30	37	25	42	29	51	33	14	15	19
Falls Creek C.G. - Eightmile Creek	C5	18	27	32	22	8	12	14	15	23	18	17	23	21	9	11	10
Eightmile Creek - Boulder Creek	C4	49	20	44	63	9	19	26	82	45	66	34	44	36	12	12	8
Boulder Creek - Chewuch Bridge	C3	3	0	10	5	0	0	0	5	0	0	0	0	0	2	0	0
Chewuch Bridge - WDFW Land	C2	51	29	55	51	13	21	29	52	27	41	30	31	61	22	8	7
WDFW Land - Confluence	C1	26	10	11	25	4	7	6	9	5	1	1	4	7	1	3	0
Eightmile Creek Bridge - Confluence	EM1	0	Ns	0	Ns	Ns	0	0	0	0	0	0	Ns	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	Ns
Chewuch River subbasin total		204	117	217	273	79	120	143	286	225	236	171	239	206	84	64	65

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	2018
Road’s End C.G. - South Creek Bridge	T10	0	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	0
Poplar Flats C.G. - Mystery Bridge	T8	0	1	0	3	0	0	0	11	3	6	3	5	5	0	2	1
Mystery Bridge - War Creek Bridge	T7	1	24	5	19	7	18	5	21	7	19	20	25	17	15	2	2
War Creek Bridge - Buttermilk Bridge	T6	8	62	24	39	14	24	11	54	40	74	46	66	56	14	11	22
Buttermilk Bridge - Little Bridge Cr.	T5	7	26	10	15	9	26	3	35	8	24	7	27	30	14	6	19
Little Bridge Creek - Twisp Weir	T4	1	9	3	3	0	7	3	9	0	6	2	3	4	0	0	0
Twisp Weir - Upper Poorman Bridge	T3	1	5	8	2	0	2	1	9	1	4	4	7	5	3	1	6
Up. Poorman Br. - Lower Poorman Br.	T2	0	8	4	2	0	2	1	5	3	3	0	3	2	0	0	0
Lower Poorman Bridge - Confluence	T1	0	4	1	4	0	0	0	0	0	3	2	1	0	0	0	0
Twisp River subbasin total		18	139	55	87	30	79	24	145	63	139	85	138	119	46	22	50

Appendix K. HOR and NOR spawner composition in the Chewuch subbasin by release group (Methow Hatchery (MH), 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															HOR Total	NOR spawners			NOR Total	Combined MH PNOB
	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	32	0	409	0	8	0	0	0	0	0	0	13	0	3	0	465	4	2	19	25	0.589
2004	18	252	4	4	0	0	0	0	0	0	11	0	0	0	0	289	0	46	0	46	0.039
2005	2	217	21	4	14	0	0	2	0	0	10	0	15	4	0	289	2	205	12	219	0.377
2006	0	194	36	0	25	0	0	9	0	5	33	6	41	27	2	378	0	87	48	135	0.057
2007	13	11	55	18	0	0	0	0	0	20	0	9	18	59	0	203	4	13	57	74	0.004
2008	2	74	2	2	10	0	0	0	0	15	24	7	0	10	20	166	4	51	31	86	0.006
2009	127	124	5	75	8	0	13	0	0	88	38	9	13	0	0	500	18	249	4	271	0.023
2010	2	209	0	2	34	0	0	2	0	0	79	0	0	13	0	341	7	141	7	155	0.035
2011	67	219	21	24	7	0	0	0	0	10	38	11	35	67	0	499	19	144	207	370	0.151
2012	2	162	29	2	10	0	2	7	0	0	9	0	0	20	0	243	3	66	25	94	0.231
2013	5	157	22	9	9	0	5	5	0	7	5	0	0	2	0	226	2	74	13	89	0.393
2014	12	126	0	15	68	0	0	7	0	5	34	0	0	0	0	267	10	151	5	166	0.500
2015	0	95	1	0	14	4	0	0	1	0	14	0	21	2	0	152	0	115	19	134	0.333
2016	0	0	15	0	5	0	0	5	0	3	23	0	0	10	0	61	0	81	20	101	0.403
2017	5	45	0	0	2	0	2	0	0	0	9	5	0	13	0	81	7	41	12	61	0.574
2018	0	41	0	0	2	0	0	0	0	0	4	0	0	22	0	69	2	55	4	61	1.000

Appendix L. HOR and NOR spawner composition in the Methow subbasin by release group (Methow Hatchery (MH), 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															HOR Total	NOR spawners			NOR Total	Combined MH PNOB
	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	0	0	5	36	324	2	25	2	2	6	190	0	5	0	597	4	2	2	8	0.597
2004	35	0	0	37	338	7	0	40	0	35	126	4	0	0	0	622	3	196	0	199	0.083
2005	13	251	0	13	118	10	10	3	0	14	73	6	0	10	5	526	0	182	39	221	0.374
2006	0	273	4	0	302	12	3	55	0	7	258	11	0	12	5	942	0	93	35	128	0.013
2007	37	22	41	22	6	12	32	18	5	109	110	55	0	76	0	545	12	55	85	152	0.163
2008	36	38	4	25	68	0	0	2	0	45	177	0	0	17	0	412	10	138	24	172	0.015
2009	89	108	3	367	127	1	33	9	3	404	237	36	13	50	0	1,480	25	207	29	261	0.033
2010	24	160	3	25	584	0	1	13	0	12	498	0	0	8	3	1,331	7	281	2	290	0.039
2011	181	285	10	171	170	24	57	6	3	111	234	53	8	78	0	1,391	13	232	187	432	0.172
2012	8	190	9	35	258	7	3	57	0	4	49	4	0	10	7	641	0	72	31	103	0.249
2013	26	107	6	63	195	4	39	15	4	22	8	8	4	4	0	505	13	84	16	113	0.436
2014	14	83	6	110	622	2	6	20	0	45	209	2	0	12	0	1,131	7	226	17	250	0.495
2015	0	124	0	6	362	31	2	0	0	8	192	16	6	2	0	749	14	118	22	154	0.336
2016	0	0	7	0	106	13	0	0	0	13	132	13	0	3	0	287	3	144	12	159	0.472
2017	0	21	0	5	57	5	0	0	0	5	63	0	0	26	0	182	5	70	19	94	0.538
2018	0	6	0	3	22	0	0	0	0	0	43	3	9	49	0	135	8	127	0	135	0.982

Appendix M. HOR and NOR spawner composition in the Twisp subbasin by release group (Methow Hatchery (MH), 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															HOR Total	NOR spawners			NOR Total	Combined MH PNOB
	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	0	0	0	0	0	6	12	0	0	0	0	0	0	0	18	8	4	13	25	0.374
2004	0	4	0	0	0	0	4	71	0	0	4	0	4	11	0	98	24	219	0	243	0.138
2005	0	5	0	0	0	0	0	29	0	0	0	0	0	0	0	34	0	72	15	87	0.545
2006	0	0	0	0	5	0	0	93	0	0	2	0	0	0	0	100	0	45	20	65	0.000
2007	0	0	0	0	0	0	20	37	8	0	0	0	0	0	0	65	7	0	33	40	0.513
2008	2	2	0	0	0	0	8	105	2	0	0	0	2	5	0	126	4	36	0	40	0.626
2009	0	0	0	0	0	0	60	16	11	5	0	0	5	0	0	97	8	16	8	32	0.181
2010	0	4	0	0	9	0	0	79	4	0	0	0	0	0	0	96	4	148	4	156	0.027
2011	4	0	0	0	0	0	20	8	0	0	0	0	49	4	0	85	6	96	57	159	0.186
2012	0	5	0	0	2	0	4	120	0	0	2	0	0	2	0	135	5	51	8	64	0.220
2013	0	4	0	0	7	0	40	58	4	0	0	0	4	0	0	117	17	20	2	39	0.550
2014	0	5	0	3	7	0	10	128	2	0	2	0	0	0	0	157	9	81	2	92	0.630
2015	0	2	0	0	10	0	0	36	3	0	3	0	0	0	0	54	2	89	19	110	0.678
2016	0	0	0	0	2	0	4	15	4	4	0	0	0	0	0	29	9	42	9	60	0.574
2017	0	0	0	0	0	0	3	16	0	3	3	0	0	0	0	25	10	12	0	22	0.556
2018	0	0	0	0	0	0	0	25	0	0	0	0	0	6	0	31	0	69	0	69	1.000

Appendix N. Spring Chinook run escapement and hatchery activities 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.

Brood year	Wells Dam Spring Chinook Salmon Ladder Count	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 + WNFH and MH hatchery surplus		Redd-based spawning escapement					
										M		O/CJH		M		Chewuch		Methow		Twisp	
		H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W	H	W
2006	4,376	--	--	--	--	4,055	310	163	10	3,782	300	110	0	607	0	378	135	942	128	100	65
2007	2,793	--	--	--	--	1,929	202	113	23	1,638	179	178	0	429	0	203	74	545	152	65	40
2008	3,134	116	18	43	6	2,503	423	28	50	2,346	373	129	0	628	6	166	86	412	172	126	40
2009	8,174	50	9	149	28	4,051	753	19	115	3,656	638	376	0	606	5	500	271	1,480	261	97	32
2010	8,257	160	8	102	8	7,415	1,151	18	155	6,338	996	1,059	0	2,450	11	341	155	1,331	290	96	156
2011	8,122	257	24	663	71	7,256	965	11	111	7,139	854	106	0	2,238	5	499	370	1,391	432	85	159
2012	6,011	191	25	371	56	4,624	663	2	53	4,619	610	3	0	2,208	8	243	94	641	103	135	64
2013	10,113	329	23	112	79	4,898	603	2	46	4,752	557	144	0	3,179	1	226	89	505	113	117	39
2014	17,921	67	4	291	31	9,508	1,038	0	94	9,488	944	20	0	5,745	35	267	166	1,131	250	157	92
2015	21,491	5	1	83	100	9,202	790	3	96	9,199	694	0	0	6,635	0	152	134	749	154	54	110
2016	12,622	2	0	42	54	4,553	658	1	68	4,180	590	372	0	3,569	17	61	101	287	159	29	60
2017	7,409	49	1	42	60	4,393	549	19	67	2,953	482	1,421	0	1,797	8	81	61	182	94	25	22
2018	8,476	200	82	65	83	4,356	604	1	124	2,003	480	2,352	0	1,413	0	69	61	135	135	31	69

Attachment D. Summary of summer steelhead spawning ground surveys and escapement estimates conducted in the Methow River basin in 2018.

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

From: Charles Frady

To: Charlie Snow

Date: 28 May 2019

Subject: Results of 2018 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 2019) 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 fish (Tonseth 2018). 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 2018, trapping was conducted at Wells Dam East Ladder during the typical migration period (August through October) but trapping on Wells Dam West Ladder was interrupted from 18 August through 27 September due to lack of hatchery staff to operate the West Ladder trap and adult facility. Trapping at the Wells Hatchery Adult Facility Volunteer trap occurred opportunistically to augment trapping efforts at the Wells Dam West ladder.

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 2018 as numbers of returning adults were not sufficient to allow a fishery administered by WDFW. 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. 2019). 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, except those retained for broodstock. These objectives targeted a spawning population upstream of the Twisp River weir comprised of equal numbers of NOR and HOR fish. All excess HOR steelhead are lethally removed from the spawning population, but no HOR fish were removed in 2018. All steelhead released upstream of the weir received uniquely colored anchor tags that represented their origin and sex (pink = NOR male, green = HOR male, red = HOR female, blue = 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 2018, 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. 2019). 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 2018 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.

Recently, PIT tag antenna arrays have 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 2014 and 2015 brood fish and the release location of tagged fish was recorded during release monitoring.

None of the 2014 or 2015 brood releases from the Wenatchee Basin were given unique external marks to distinguish them from Wells Hatchery, Methow Hatchery, or WNFH releases. Only fish released from Ringold Hatchery were identified as strays. The number of stray HOR steelhead reported should be considered a minimum value. Unmarked HOR fish (identified through scale analysis) were apportioned to local or stray populations based on proportions of externally-marked fish in the weekly collections. Since stray HOR fish are largely no longer distinguishable from local HOR fish, all comparisons of HOR and NOR fish include all hatchery-origin fish.

Results

Run Composition

Stock assessment and collection of the 2018 brood Wells Hatchery steelhead broodstock occurred at Wells Dam between 30 July and 31 October 2017 though trapping on Wells Dam West Ladder was interrupted for most of August and September. During that time, a total of 3,498 steelhead were counted passing through the Wells Dam Fish Ladders. Of those fish, 315 (9.0%) were sampled for hatchery marks or were scale sampled to determine origin. Of the sampled fish, 110 HOR steelhead and one NOR steelhead (mistakenly) 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 2018 brood was 3,339 fish (Table 1). Analysis of scale samples and observations of hatchery marks indicate that NOR fish comprised 25.9% of the steelhead run to Wells Dam post adjustments (Table 1). Based on biological sampling during 2018 run evaluation at Wells Dam, the age distribution of HOR steelhead was skewed towards 1-salt fish (92.8%); NOR steelhead were also skewed towards 2-salt fish (90.8%). Identification of hatchery marks, and coded-wire-tags from fish retained for broodstock indicated that only 4.6% of total escapement was composed of out-of-basin stray hatchery fish, mainly from Ringold Hatchery. The abundance and relative proportion of NOR steelhead in the 2018 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 84 HOR and 26 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 (Table 1; English et al. 2001, 2003). An estimated 143 and 382 wild fish were available for natural spawning in the Okanogan and Methow River basins, respectively (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 1,002 HOR and 382 NOR steelhead were available for natural spawning in the Methow River basin (Table 1), resulting in a basin pHOS estimate of 0.72 prior to spawning.

Table 1. Escapement and disposition of the 2018 brood summer steelhead passing 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 2017 through 14 June 2018.

Area	Description (Variable)	Number
Wells Dam	Wells Dam fish count (DCPUD raw data)	4,350
	Wells Dam HOR total (based on trapping)	3,355
	Wells Dam NOR total (based on trapping)	995
	Broodstock retained from ladders (HOR)	110
	Estimated double counted fish (HOR)	490
	Estimated fallback fish (HOR)	233
	Adjusted Wells Dam HOR total	2,523
	Broodstock retained from ladders (NOR)	1
	Estimated double counted fish (NOR)	75
	Estimated fallback fish (NOR)	103
	Adjusted Wells Dam NOR total	816
Above Wells Dam	Local HOR fish	2,369
	Stray HOR fish	154
	Hatchery fish removed in WDFW fishery	0
	HOR fish removed in CCT fisheries	84
	Above Wells HOR run estimate	2,439
	NOR fish	816
	NOR fish removed in WDFW fishery	0
	NOR fish removed in CCT fisheries	26
	Above Wells NOR run estimate	790
Okanogan Basin	HOR run escapement estimate	791
	HOR fish removed in WDFW fishery	0
	HOR fish collected for broodstock	39
	HOR pre-spawn mortality estimate (10%)	76
	HOR spawn escapement estimate	679
	NOR run escapement estimate	165
	NOR fish removed in WDFW fishery	0
	NOR fish collected for broodstock	4
	NOR pre-spawn mortality estimate (10%)	16
	NOR spawn escapement estimate	145
Methow Basin	HOR run escapement estimate	1,415
	HOR fish removed in WDFW fishery	0
	HOR fish collected for broodstock	79
	HOR fish removed as excess	227
	HOR pre-spawn mortality estimate (10%)	111
	HOR spawn escapement estimate	998
	NOR run escapement estimate	560
	NOR fish removed in WDFW fishery	0
	NOR fish collected for broodstock	131
	NOR pre-spawn mortality estimate (10%)	43
	NOR spawn escapement estimate	386

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

PIT-tagged steelhead were detected between 14 March and 28 May as they ascended the Twisp River to spawn. Based on recaptures of PIT-tagged fish at the Twisp weir above the Twisp River array, detection efficiency for adult steelhead was 100%. Based on scale analysis, 59.8% (*N* = 67) of the steelhead sampled at the Twisp River weir were NOR (Table 2). Eleven NOR steelhead were retained for broodstock. No HOR steelhead were removed as surplus at the weir but three HOR steelhead were retained for Methow Safety-Net (MSN) broodstock.

Redd surveys in the Twisp River basin were conducted from 19 March to 1 June and a total of 24 redds were documented (Table 3). In 2018, survey conditions were poor due to high flow and tubidity (Goodman et al. 2019). Thus, while a small number of observations were made of anchor-tagged HOR and NOR steelhead on redds, sample sizes were too low to make comparisons of spawn timing and spawner distributions of HOR and NOR fish.

Redd surveys in the Mainstem Methow River from the MRW array upstream of Winthrop downstream to Pateros were conducted from 5 March to 24 April. A total of 44 redds were found in the Methow Mainstem and 54 redds were found in the two hatchery outfalls combined (Table 4) Recent fires throughout the Methow Basin have compromised the effectiveness of spring steelhead surveys. Based on PIT-based escapement estimates (Truscott et al. 2019), an estimated 422 steelhead redds were created in the Methow River basin in 2018 (Table 5). Using mean fecundities by salt age and origin, an estimated 1,964,832 were deposited in the Methow Basin (Table 6). Historic redd counts for each of the subbasins are listed in Appendices B1-B4.

Table 2. Summary of adult steelhead sampled at the Twisp weir in 2018, 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	32	3	0	37	31
	M	None	3	27	0	0	30	25
	Total NOR		5	59	3	0	67	56
HOR	F	CWTO	0	14	1	0	15	15
	Total F		0	14	1	0	15	15
	M	Ad-only	0	0	0	0	0	0
		CWTO	3	26	1	0	30	27
	Total M		3	26	1	0	30	27
	Total HOR		3	40	2	0	45	42
Grand total			8	99	5	0	112	98

Table 3. Twisp River mainstem and tributary census redd counts by section number and survey year. Ns = not surveyed. Data from Goodman et al. 2019.

Stream reach	Code	Length (km)	2011	2012	2013	2014	2015	2016	2017	2018
				Twisp River mainstem						
Road's End C.G. - South Creek Bridge	T10	4.6	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
South Creek Bridge - Poplar Flats C.G.	T9	3.2	0	0	0	0	2	0	0	0
Poplar Flats C.G. - Mystery Bridge	T8	3.2	0	0	1	1	2	1	0	0
Mystery Bridge - War Creek Bridge	T7	6.9	8	5	8	4	9	2	6	0
War Creek Bridge - Buttermilk Bridge	T6	7.4	43	43	21	36	30	3	13	1
Buttermilk Bridge - Little Bridge Creek	T5	5.9	33	26	18	25	10	4	7	7
Little Bridge Creek - Twisp weir	T4	3.8	13	5	7	3	10	1	6	6
Twisp weir - Upper Poorman Bridge	T3	3.5	46	20	46	30	44	7	38	3
Up. Poorman Br. - Lower Poorman Br.	T2	5.0	30	12	23	23	18	1	21	4
Lower Poorman Bridge - Confluence	T1	2.9	4	11	7	12	11	2	10	3
Twisp River mainstem total		46.4	177	122	131	134	136	21	101	24
				Twisp River tributaries						
Little Br. Cr. (Road's End - Vetch Cr.)	LBC4	1.3	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Little Br. Cr. (Vetch Cr. - 2nd Culvert)	LBC3	3.0	0	3	0	0	0	1	0	0
Little Br. Cr. (2nd Culvert - 1st Culvert)	LBC2	2.4	0	0	1	0	0	0	0	0
Little Br. Cr. (1st Culvert - Confluence)	LBC1	2.4	0	7	4	1	13	0	0	0
MSRF pond outfalls[1]	MSRF1	0.1	3	0	3	6	12	11	4	0
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	Ns
W. Fork Buttermilk Creek	BMW1	3.1	Ns	Ns	Ns	1	0	0	0	Ns
Buttermilk Cr. (Fork - Cattle Guard)	BM2	2.1	0	1	0	0	0	0	0	0
Buttermilk Cr. (Cattle Guard - Conf.)	BM1	2.0	0	0	0	2	0	0	0	0
South Creek (Falls - Confluence)	SO1	0.6	Ns	Ns	Ns	0	0	0	0	0
Twisp River tributary total		14.7	3	11	8	10	25	12	4	0

[1] Methow Salmon Recovery Foundation pond outfall.

Table 4. Lower Methow River redd counts and estimated escapement by reach(es). Redd totals in Methow River mainstem reaches (MRW8-1) are direct counts only; escapement derived from PIT-based escapement estimates (Truscott et al. 2019) and reflect removal of fish for broodstock and adult management. Escapement in Beaver, Gold, and Libby Creeks are from PIT-based escapement and redd totals, back-calculated using 1.79 fish per redd. Ns = not surveyed. * Poor survey conditions and limited surveys. Redd total in WN1 provided by USFWS.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Methow River (MRW PIT array – Red Barn)	MRW8	13	131	30
Methow River (Red Barn – Halderman Hole)	MRW7	25		
Methow River (Halderman Hole – Braids)	MRW6	4		
Methow River (Braids – Carlton Bridge)	MRW5	Ns		
Methow River (Carlton Bridge – WDFW Access)	MRW4	0*		
Methow River (WDFW Access – Upper Burma Br.)	MRW3	Ns		
Methow River (Upper Burma Br. – Lower Burma Br.)	MRW2	2*		
Methow River (Lower Burma Bridge – Pateros)	MRW1	Ns		
Chewuch River (CRW PIT array to – Confluence)	CRW1	Ns	--	--
Methow Hatchery outfall	MH1	11	--	--
Winthrop NFH Outfall	WN1	43	--	--
1890’s channel	18N	0	--	--
Beaver Creek (above PIT antenna)	Beaver	4	7 (0-20)	0 (0-0)
Beaver Creek (below PIT antenna)	BV1	Ns	--	--
Libby Creek (above PIT antenna)	Libby	37	17 (4-38)	49 (22-83)
Gold Creek (above PIT array)	Gold	35	25 (8-48)	37 (16-66)
Total		174	--	--

Table 5. Estimated escapement of HOR and NOR fish based on redd counts and PIT tag array data (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. 2019) using 1.79 fish per redd. Twisp totals reflect removal of HOR and NOR fish at the Twisp weir.

Location	Estimated redds	Spawners		
		HOR	NOR	Total
Upper Methow River	61	45 (20-79)	68 (34-115)	109 (54-194)
Chewuch River	109	48 (20-85)	148 (92-212)	196 (112-297)
Twisp River	78[a]	59 (30-93)	77 (42-117)	136 (72-210)
Lower Methow River	174	--	--	--
Total	422	--	--	--

[a] Not from Table 2 redd counts, but includes two redds found below the TWR array.

Table 6. Estimated 2018 steelhead redd totals from PIT-based expansions and estimated egg deposition in the Methow Basin. Fecundities are from Wells MEOK HOR females and WNFH NOR females and proportions are estimated from PIT-based escapement and run-at-large composition (mean; %): HOR 1-salt (4,769; 41.6), HOR 2-salt (6,158; 3.2), NOR 1-salt (4,341; 50.1), NOR 2-salt (5,884; 5.1). Twisp redd total is from Table 5.

Area	Redds	% of redds	Estimated egg deposition						
			2012	2013	2014	2015	2016	2017	2018
U. Met.	61	14.5	1,548,633	1,647,444	1,086,444	1,562,172	477,834	627,210	284,016
Chew.	109	25.8	184,224	1,211,707	1,075,896	1,189,116	822,080	689,310	507,504
Twisp	78	18.5	759,924	835,660	759,456	938,469	1,078,980	869,400	363,168
L. Met.	174	41.2	909,606	1,140,079	1,708,776	2,086,782	1,125,222	1,124,010	810,144
Total	422	100.0	3,402,387	4,834,890	4,630,572	5,776,539	3,504,116	3,309,930	1,964,832

Natural Replacement Rate (NRR)

A total of 317 steelhead were trapped and sampled at Wells Dam, of which 78 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 = 920) 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 651 NOR steelhead returning to the Methow Basin prior to broodstock collection, fallback estimation, and Columbia River fishery-related mortality (Table 7). The NRR of the Methow Basin steelhead population above replacement levels (i.e., > 1.0) in only one (1996) of the 17 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 2018. Brood years 1991 to 2006 based on Wells Hatchery broodstock. Brood years 2007 to 2018 based on run-at-large sampling at Wells Dam.

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	
2018	920	78	0.0848	27	526	89	9	0	651
2017	1,026	83	0.0809	0	161	484	71	10	726
2016	2,086	87	0.0417	20	847	473	138	0	1,478
2015	2,381	127	0.0533	31	402	1,006	232	15	1,686
2014	2,174	147	0.0676	24	782	672	61	0	1,539
2013	1,180	78	0.0661	40	296	364	135	0	835
2012	1,584	88	0.0556	0	389	703	30	0	1,122
2011	1,988	130	0.0654	13	628	730	77	0	1,448
2010	2,070	113	0.0546	57	747	618	43	0	1,465
2009	1,217	119	0.0978	38	461	325	38	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	91	0.1190	6	159	332	45	0	542
2005	861	69	0.0801	10	276	324	0	0	610
2004	1,161	118	0.1016	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 steelhead calculated from broodstock sampling at Wells Hatchery. 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	237	1999	2000	2001	2002	2003	319	1.3460
1997	1,501	2000	2001	2002	2003	2004	715	0.4763
1998	2,041	2001	2002	2003	2004	2005	745	0.3650
1999	1,473	2002	2003	2004	2005	2006	194	0.1317
2000	1,860	2003	2004	2005	2006	2007	1,011	0.5435
2001	3,374	2004	2005	2006	2007	2008	651	0.1929
2002	9,884	2005	2006	2007	2008	2009	395	0.0400
2003	4,561	2006	2007	2008	2009	2010	450	0.0987
2004	4,928	2007	2008	2009	2010	2011	1,047	0.2125
2005	4,304	2008	2009	2010	2011	2012	1,171	0.2721
2006	3,119	2009	2010	2011	2012	2013	1,545	0.4954
2007	3,375	2010	2011	2012	2013	2014	1,523	0.4513
2008	3,306	2011	2012	2013	2014	2015	842	0.2547
2009	4,031	2012	2013	2014	2015	2016	1,200	0.2977
2010	7,781	2013	2014	2015	2016	2017	1,976	0.2540
2011	3,103	2014	2015	2016	2017	2018	970	0.3126
2012	4,205	2015	2016	2017	2018	2019	1,371	0.3260

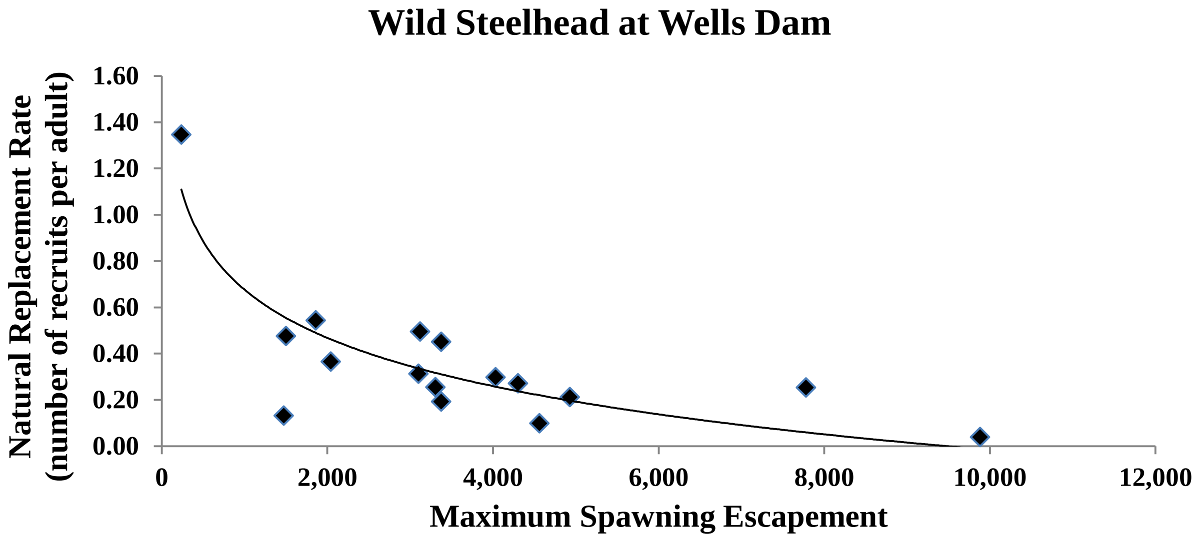

Figure 1. Methow Basin steelhead run escapement (HOR + NOR; x-axis) verses natural replacement rate of Methow Basin adult returns to Wells Dam (NRR; y-axis) for parent brood years 1996-2012.

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. Stray rates were not estimated for 2014 brood due to very low adult returns likely resulting from poor out-migrating conditions in 2015 (Table 9). Partial returns from the Columbia release group show 1-salt fish straying into Foster Creek and the Okanogan Basin; this outcome is essentially unavoidable as the mainstem Columbia has little to no available known spawning habitat (Table 9).

Table 9. Detection of adult HOR summer steelhead released from Wells Hatchery into Methow Basin tributaries. Detections of 2015 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
2014	Columbia	0	0	0	0	0	4	0	0	4	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
2015	Columbia	0	0	0	0	0	12[a]	1	1	14	14.3
2015	Methow	0	0	0	0	0	0	0	0	0	N/A
2015	Twisp	0	0	0	0	0	0	0	0	0	N/A

[a] Includes two returns to Wells tailrace.

References

English, K. K., C. Sliwinski, B. L. Nass, and J. R. Stevenson. 2001. Assessment of adult steelhead migration through Mid-Columbia River using radio-telemetry techniques, 1999-2000. Report prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, Washington.

English, K. K., C. Sliwinski, B. L. Nass, and J. R. Stevenson. 2003. Assessment of adult steelhead migration through Mid-Columbia River using radio-telemetry techniques, 2001-2002. Report prepared for Public Utility District No. 1 of Douglas County, East Wenatchee, Washington.

Goodman, B., C. Snow, A. Murdoch, and T. Seamons. 2019. Monitoring the reproductive success of naturally spawning hatchery and natural-origin steelhead in the Twisp River, 1/1/2018 - 12/31/2018. Annual Report to the Bonneville Power Administration, Project 2010-033-00, Portland, Oregon.

OBMEP. 2019. 2018 Okanogan Subbasin Steelhead Spawning Abundance and Distribution. Colville Confederated Tribes Fish and Wildlife Department, Nespelem, WA. Report submitted to the Bonneville Power Administration, Project No. 2003-022-00.

Tonseth, M. 2018. Final upper Columbia River 2018 BY salmon and 2019 BY steelhead hatchery program management plan and associated protocols for broodstock collection, rearing/release, and management of adult returns. Memo dated April 24, 2018 from Mike Tonseth, WDFW, to NMFS, HCP-HC and PRCC-HSC.

Truscott, B. L., T. De Boer, T. J. Desgroseillier, and J. M. Cram. 2019. Upper Columbia Spring Chinook Salmon and Steelhead Juvenile and Adult Abundance, Productivity, and Spatial Structure Monitoring. Washington Department of Fish and Wildlife, BPA Project # 2010-034-00.

Appendix A. 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	11,733	2,083	275	55	206	40	633	273	1,131	19	173	29	5,407	1,181	3,021	347	2,913	53	899	15	141	33	0	16	2,117	985	1,910	285
2012	11,163	1,736	267	62	495	90	628	251	551	6	180	19	5,248	927	2,932	273	1,302	20	400	5	135	46	10	5	3,430	774	2,270	236
2013	9,146	1,279	229	21	317	77	377	288	941	12	288	44	4,059	593	2,268	174	904	14	534	3	117	34	8	4	2,735	490	1,554	151
2014	5,585	2,359	205	0	120	85	295	401	389	11	82	45	2,608	1,216	1,457	358	791	43	223	8	90	92	42	16	1,555	973	1,073	300
2015	5,660	2,491	193	1	118	109	315	396	392	12	175	98	2,593	1,328	1,449	391	601	32	255	11	289	71	42	16	1,532	1,103	1,036	327
2016	7,924	2,256	212	0	733	169	275	369	517	9	105	69	3,530	1,162	1,972	342	736	25	152	3	320	94	42	16	2,227	938	1,601	290
2017	4,226	1,084	146	0	258	58	319	146	0	0	60	45	1,987	591	1,110	174	0	0	0	0	387	82	2	10	1,440	459	998	148
2018	3,355	995	110	1	490	75	233	103	0	0	84	26	1,415	560	791	165	0	0	0	0	306	131	39	4	998	386	676	145

Appendix B1. 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	215[a]	10	51	0	19	25	16	65	27	33	25
Gate Creek - Early Winters Creek	M13	ns		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	325[a]	93	180	30	14	34	94	123	91	84	65
Along HWY 20 - Wolf Creek	M8	ns		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 B2. 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 B3. 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 B4. 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.