MONITORING AND EVALUATION OF THE WELLS HATCHERY AND METHOW HATCHERY PROGRAMS

2015 ANNUAL REPORT

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Section 1: Introduction

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

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

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

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

These programs occur at either Wells Hatchery, located on the west bank of the Columbia River adjacent to Wells Dam (Columbia River km 830), or Methow Hatchery, located on the Methow River (Methow River km 83) upstream of the town of Winthrop, Washington. Hatchery programs at these facilities have been categorized within the M&E Plan under three categories; conservation, safety-net, or harvest-augmentation programs. Conservation programs (Methow and Twisp river spring Chinook Salmon; Twisp and Okanogan river steelhead) are integrated hatchery programs intended to increase natural production of targeted fish populations. A fundamental assumption of this strategy is that hatchery fish returning to the spawning grounds are reproductively similar to naturally produced fish. Safety-net programs (Methow and Columbia River steelhead) are an extension of conservation programs, intended to provide a demographic and genetic reserve of hatchery adults in years of low returns. In years of high adult abundance, safety-net programs would function like harvest-augmentation programs (e.g., Wells summer Chinook Salmon); increasing harvest opportunities while limiting interactions with natural origin conspecifics.

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

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

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

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

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

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

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

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

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

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

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

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

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

Each objective has a suite of associated statistical hypotheses tested by analyzing variables derived or measured from the target populations through the implementation of annual work plans approved by the Wells HCP Hatchery Committee. Most of these analyses will be conducted at 5-year intervals specified within the M&E Plan (2013). This report is the tenth annual report, summarizing data collected during 2015 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 2014). Data collection in 2015 was conducted by Washington State Department of Fish and Wildlife (WDFW) personnel through a contract between WDFW and Douglas PUD with the exception of those spring Chinook (sections M6-M8, WN1) and steelhead (WN1) spawning ground surveys conducted by U.S. Fish and Wildlife Service personnel.

Section 2: Summary of Methods

Data collection and fish sampling conducted in 2015 followed the general methods described within the M&E Plans (Wells HCP HC 2005; M&E Plan 2013) or within recent annual reports (e.g., Snow et al., 2012). In some instances, methods and protocols are developed and approved annually through the Wells HCP Hatchery Committee (i.e., broodstock collection protocols) and are included as appendices within this report. In the following section we briefly summarize the methods used for completing specific tasks or objectives within the M&E Plan.

2.1: Broodstock Collection and Sampling

Broodstock collection methods, locations, and numeric targets for 2015 were described in full in annual broodstock collection protocols (Tonseth 2015). Spring Chinook Salmon and steelhead collection at Wells Hatchery attempted to collect broodstock in a manner representing the run-at-large of the target species passing Wells Dam. Collection of broodstock at the Twisp River weir (steelhead), and the Methow (spring Chinook Salmon and steelhead) and Wells (summer Chinook Salmon and summer steelhead) hatchery outlet channels is conducted such that extraction of natural origin fish does not exceed 33% of natural origin returns. Biological sampling of adult fish was conducted during broodstock collection and spawning activities to estimate the migration timing, age-structure, sex ratio, and the estimated total return and extraction rate of hatchery and naturally produced spring Chinook Salmon and steelhead passing Wells Dam. Samples collected include fork and post-eye to hypural plate (POH) lengths (mm), sex, scales, origin, hatchery marks, fecundity, and enzyme-linked immunosorbent assay (ELISA) sampling to assess the relative incidence of bacterial kidney disease in spawned spring Chinook Salmon females. This sampling provided the information necessary to assess age-at-maturity, length-at-maturity, and fecundity-at-age. In addition, all fish were scanned for passive integrated transponder (PIT) tags and coded-wire tags (CWT's). Recorded PIT codes were uploaded to the PTAGIS database (www.ptagis.org), and CWT's were recovered from all lethally spawned fish and reported to the Regional Mark Processing Center website whose collective databases serve as the primary repository for CWT data; known as the Regional Mark Information System (RMIS).

Digital video records of fish passage at Wells Dam between 6 May and 11 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 these 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 used to help explain why the number of fish released did not meet goals despite adequate broodstock collection. The number of juvenile fish released was calculated based on a census of the population during fish tagging or marking, minus mortality that occurred between marking and release. However, the number of steelhead released from Wells Hatchery was calculated as the sum of all fish trucked to a release location. The number of fish within each truckload was determined by applying the mean number of fish per pound (FPP) at truck-loading by the weight of fish loaded as estimated through examination of a gravimetric tube attached to each truck. A sample of 200 fish were collected just prior to release from each stock to estimate pre-release mean fork length, weight, FPP, condition factor (K), and coefficient of variation (CV) of length. Pre-release sampling results were compared to target release values described in Murdoch et al. (2012; Table 2.1). Observed survival rates, size-at-release, and number at release were compared with life-stage specific target survival rates within the M&E plan (Table 2.2).

Table 2.1. Target release values for Wells and Methow hatchery program steelhead and salmon in 2015.

Release location, species	Release number	Fork length		Weight	
		Mean (mm)	CV	Mean (g)	FPP
Twisp River steelhead	48,000	191	9	75.6	6
Methow River steelhead	100,000	191	9	75.6	6
Okanogan River steelhead	100,000	191	9	75.6	6
Columbia River steelhead	160,000	191	9	75.6	6
Wells age-1 summer Chinook	320,000	168	9	45.4	10
Wells age-0 summer Chinook	484,000	116	9	22.7	20
Methow River spring Chinook	133,249	137	9	30.2	15
Twisp River spring Chinook	30,000	135	9	30.2	15

Table 2.2. Life-stage survival rate standards for Wells and Methow hatchery programs.

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

2.3: Natural Origin Juvenile Productivity

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

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

Juvenile spring Chinook Salmon and steelhead were captured by hook-and-line angling or through backpack electroshocking in the Twisp subbasin to estimate over-winter (parr to smolt) and smolt to adult survival and to estimate stray rates of natural-origin adult spawners. Captured fish were held briefly in 19L buckets, then anesthetized in a solution of MS-222 prior to bio-sampling. Fork length (mm) and weight (g) were measured for each fish and those with a fork length greater than 65 mm were PIT tagged prior to release. In general, scale samples were collected from all steelhead with a fork length greater than 89 mm. Each release site was geo-referenced with a hand-held global positioning system (GPS) unit so that approximate river kilometer for each release site could be determined and included within the tagging file uploaded to the PIT tag information system (PTAGIS) website. Parr to smolt survival was calculated from PIT tag detections using the Cormack-Jolly-Seber (CJS) survival estimates obtained from the Data Access Real Time website (DART) maintained by the University of Washington's School of Aquatic and Fishery Sciences. Smolt to adult and stray rate information was calculated from adult PIT tag detections at mainstem Columbia River dams and in-stream PIT tag detection arrays. Additionally, PIT tagged juvenile Chinook were used to estimate Chinook emigration from the Twisp River during periods when the smolt trap was not operating (e.g., winter) by expanding PIT tag detections at the Twisp River PIT tag array by the expected array efficiency as determined by mark/recapture sampling and the expected PIT tag rate determined from smolt trap sampling.

2.4: Spawning Ground Surveys

Spawning ground surveys were used to evaluate spawn timing and spatial distribution of spring Chinook Salmon and steelhead. The Methow River basin was divided into four geographic subbasins: upper Methow River (upstream of Winthrop), lower Methow River (downstream of Winthrop), Chewuch River, and Twisp River. Each subbasin was further divided into survey sections based on stream length and unique natural or anthropogenic features (Tables 2.3-2.6). Spring Chinook Salmon redd surveys were conducted weekly between about 1 August and 30 September throughout their spawning area in the Methow Basin. Steelhead surveys occurred weekly between about 15 March and 31 May throughout the Twisp River subbasin, and were considered total redd counts. Steelhead surveys in the lower Methow subbasin were conducted during the same period, but primarily within selected index areas. River sections outside the selected index areas were surveyed once when spawning was near completion. The application of the surveyor efficiency model previously developed was not applied to redd counts in 2015 therefore redd totals in lower Methow River reaches should be considered minimum values (Attachment D). In general, each redd was individually marked with biodegradable flagging tape and the survey date, redd number, and general stream channel location were recorded on each flag. Steelhead escapement estimates in the Chewuch and upper Methow subbasins, and in the lower Methow River tributaries were produced by expanding PIT tag detections at in-stream PIT tag arrays (Attachment D).

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

Stream	Section	Code	Section length (rkm)		
			Begin	End	Total
Upper Methow	Ballard CG. - Lost River Confluence	M15	121.2	117.2	4.0
	Lost River Confluence - Gate Creek	M14	117.2	112.4	4.8
	Gate Creek - Early Winters Creek	M13	112.4	108.2	4.2
	Early Winters Creek - Mazama Bridge	M12	108.2	105.0	3.2
	Mazama Bridge - Suspension Bridge	**M11**	**105.0**	**101.0**	**4.0**
	Suspension Bridge - Weeman Bridge	**M10**	**101.0**	**95.8**	**5.2**
	Weeman Bridge - Along Hwy 20	M9	95.8	86.8	9.0
	Along Highway 20 - Wolf Creek	M8	86.8	84.6	2.2
	Wolf Creek - Foghorn Dam	M7	84.6	82.8	1.8
	Foghorn Dam - Winthrop Bridge	M6	82.8	80.1	2.7
Lost River	Sunset Creek - Eureka Creek	L3	11.2	6.6	4.6
	Eureka Creek - Lost River Bridge	L2	6.6	0.8	5.8
	Lost River Bridge - Confluence	L1	0.8	0.0	0.8
Early Winters Cr.	Klipchuck CG. - Early Winters Bridge	EW5	7.2	5.8	1.4
	Early Winters Bridge - Hwy 20 Bridge	EW4	5.8	3.7	2.1
	Highway 20 Bridge – Diversion dam	EW3	3.7	0.8	2.9
	Diversion dam - Hwy 20 Bridge	EW2	0.8	0.5	0.3
	Hwy 20 Bridge - Confluence	EW1	0.5	0.0	0.5
Suspension Creek	100m above fork - Confluence	Susp1	0.3	0.0	0.3
Little Susp. Creek	50m above fork - Confluence	Lsusp1	0.1	0.0	0.1
Hancock Cr.	Springs - Wolf Creek Road	HA2	1.1	0.2	0.9
	Wolf Creek Road - Confluence	HA1	0.2	0.0	0.2
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. 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 (e.g., hatchery replacement rate [HRR] and natural replacement rate [NRR]) must be continually updated (Table 2.7).

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	24	30,000	0.004	108	278	4.5
Methow Comp. spring Chinook	88	133,249	0.003	396	336	4.5
DCPUD safety-net steelhead	170	260,000	0.01	3,332	78	19.6
Twisp WxW steelhead	28	48,000	0.01	549	87	19.6
GCPUD-Okanogan steelhead	42	80,000	0.01	823	97	19.6

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

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

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

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

2.5: Harvest Monitoring

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

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

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

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

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

Section 3: Methow Hatchery Spring Chinook

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

3.1: Broodstock Collection and Sampling

Trapping of the 2015 brood Methow Hatchery spring Chinook occurred concurrently with run-at-large evaluation at Wells Dam between 4 May and 15 June, 2015. During this time, a total of 97 wild origin fish were retained for broodstock, representing 13.8% of the estimated wild fish escapement above Wells Dam during the trapping period (N = 705). Trapping and collection of hatchery origin spring Chinook was also conducted at the Methow Hatchery outfall trap. Most fish trapped at that location were shipped to Winthrop National Fish Hatchery for broodstock or surplus purposes, but some hatchery fish were retained for broodstock or were euthanized to reduce pHOS (Table 3.1). No spring Chinook trapping occurred at the Twisp River weir in 2015 because sufficient Twisp broodstock were collected at Wells Dam prior to the typical Twisp Weir trapping season, although two Chinook were captured while the weir was operated as part of the steelhead reproductive success study in May 2015. Historically, most spring Chinook collected have been used for spawning (Table 3.1). Fish collected for broodstock but not utilized (e.g., excess males, non-viable females) were considered surplus.

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

Brood year	Wild Chinook					Hatchery Chinook					Total spawned
	Total	PSM	Mort	Spawn	U	Total	PSM	Mort	Spawn	U	
Methow Composite spring Chinook											
1992	21	0	2	19	0	5	0	0	5	0	24
1993	114	0	4	109	1	100	6	2	87	5	196
1994	10	0	0	10	0	4	0	0	4	0	14
1995	0	0	0	0	0	14	2	0	12	0	12
1996	98	0	0	96	2	146	6	68	72	0	168
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	314	9	129	170	6	197
2002	0	0	0	0	0	426	17	46	363	0	363
2003	2	0	0	2	0	139	7	38	93	1	95
2004	1	0	0	1	0	219	4	1	214	0	215
2005	2	0	0	2	0	264	2	7	255	0	257
2006	9	1	0	8	0	305	13	8	284	0	292
2007	19	0	0	19	0	169	2	31	136	0	155
2008	44	1	0	43	0	296	4	15	277	0	320
2009	97	1	4	92	0	180	0	9	171	0	263
2010	137	1	15	121	0	148	6	6	136	0	257
2011	101	2	2	97	0	280	7	16	257	0	354
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	94	0	0	94	0	1	0	0	1	0	95
2015	77	0	0	77	0	54	1	681	53	0	130
Mean	45	0	1	43	0	168	5	52	135	4	178
Twisp spring Chinook											
1992	24	0	2	22	0	1	0	1	0	0	22
1993	30	0	0	30	0	15	3	0	12	0	42
1994	5	0	0	5	0	0	0	0	0	0	5
1995	0	0	0	0	0	0	0	0	0	0	0
1996	23	0	0	23	0	28	2	6	20	0	43
1997	0	0	0	0	0	15	0	0	15	0	15
1998	1	0	0	1	0	10	0	0	10	0	11
1999	16	0	0	16	0	24	1	0	22	1	38
2000	6	0	0	6	0	63	2	0	61	0	67
2001	18	2	0	16	0	18	1	1	16	0	32
2002	0	0	0	0	0	15	3	1	11	0	11

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						
2003	18	1	0	17	0	18	2	0	16	0	33
2004	47	5	0	42	0	25	0	0	25	0	67
2005	7	0	0	7	0	17	0	6	11	0	18
2006	0	0	0	0	0	28	1	0	27	0	27
2007	4	0	0	4	0	36	0	2	34	0	38
2008	12	1	2	9	0	31	0	2	29	0	38
2009	24	0	1	23	0	17	0	0	17	0	40
2010	32	3	0	29	0	26	1	4	21	0	50
2011	15	2	5	8	0	6	0	2	4	0	12
2012	13	1	0	12	0	20	0	6	14	0	26
2013	7	0	0	7	0	12	0	2	10	0	17
2014	25	0	0	25	0	1	0	0	1	0	26
2015	19	0	0	19	0	0	0	0	0	0	19
Mean	14	1	0	13	0	18	1	1	16	0	29

Length and Age at Maturity

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

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

Brood	Origin	Sex	Age-3			Age-4			Age-5		
			Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Methow / Methow Composite spring Chinook						
1998	H	F	-	-	-	76	8	4	85	23	9
1998	W	F	-	-	-	76	27	4	89	42	6
1999	H	F	-	-	-	78	27	3	-	-	-
1999	W	F	-	-	-	78	13	5	87	4	7
2000	H	F	-	-		75	74	3	-	-	-
2000	W	F	-	-	-	-	-	-	-	-	-
2001	H	F	-	-	-	77	67	4	-	-	-
2001	W	F	-	-	-	-	-	-	-	-	-
2002	H	F	-	-	-	76	145	4	87	6	8
2002	W	F	-	-	-	-	-	-	-	-	-
2003	H	F	-	-	-	75	17	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											
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
Mean	H	F	66	1	-	75	81	4	85	9	6
Mean	W	F	-	-	-	76	21	4	90	11	4
1998	H	M	55	10	4	77	3	3	95	23	5
1998	W	M	52	2	7	75	12	6	93	11	9
1999	H	M	51	67	5	78	44	4	88	1	-
1999	W	M	-	-	-	76	14	5	100	2	10
2000	H	M	51	40	4	73	59	7	-	-	-
2000	W	M	-	-	-	-	-	-	-	-	-
2001	H	M	60	1	-	81	10	5	-	-	-
2001	W	M	-	-	-	-	-	-	-	-	-
2002	H	M	48	7	6	79	88	6	100	1	-
2002	W	M	-	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-	-	-	-

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						
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	-	-	-
Mean	H	M	53	24	4	75	57	6	91	6	6
Mean	W	M	51	16	5	75	22	6	97	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

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					
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
Mean	H	F	-	-	-	75	11	16	87	2	9
Mean	W	F	-	-	-	77	8	5	91	2	2
1998	H	M	-	-	-	80	3	1	87	1	-
1998	W	M	-	-	-	-	-	-	98	1	-
1999	H	M	50	24	4	-	-	-	-	-	-
1999	W	M	-	-	-	-	-	-	-	-	-
2000	H	M	52	1	1	72	23	11	-	-	-
2000	W	M	45	1	-	-	-	-	98	2	1
2001	H	M	63	2	3	79	4	6	-	-	-
2001	W	M	53	2	2	75	22	5	-	-	-
2002	H	M	46	4	5	-	-	-	-	-	-
2002	W	M	-	-	-	-	-	-	-	-	-
2003	H	M	51	3	3	-	-		-	-	-
2003	W	M	50	4	3	67	1	-	-	-	-
2004	H	M	49	1	-	72	6	9	-	-	-
2004	W	M	46	3	2	72	21	7	-	-	-
2005	H	M	50	10	2	-	-	-	-	-	-
2005	W	M	-	-	-	82	1	-	-	-	-
2006	H	M	50	2	2	66	10	10	-	-	-
2006	W	M	-	-	-	-	-	-	-	-	-

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					
2007	H	M	48	7	4	70	10	5	-	-	-
2007	W	M	48	1	-	-	-	-	-	-	-
2008	H	M	53	4	2	73	9	5	-	-	-
2008	W	M	-	-	-	73	3	5	-	-	-
2009	H	M	50	3	7	72	2	2	-	-	-
2009	W	M	52	11	3	71	6	5	96	1	-
2010	H	M	50	8	3	66	2	3	-	-	-
2010	W	M	43	1	-	71	19	6	-	-	-
2011	H	M	52	2	2	67	1	-	-	-	-
2011	W	M	46	4	7	63	5	8	-	-	-
2012	H	M	47	1	-	73	10	7	-	-	-
2012	W	M	-	-	-	74	6	5	-	-	-
2013	H	M	-	-	-	70	6	3	-	-	-
2013	W	M	-	-	-	75	3	6	-	-	-
Mean	H	M	51	5	3	72	7	6	-	-	-
Mean	W	M	48	3	3	72	9	6	97	1	1

Sex Ratio and Fecundity

The overall mean sex ratio of the Methow Composite stock fish retained for broodstock (excludes released fish) favored females (Table 3.3), while the sex ratio for the Twisp program was skewed slightly towards male fish on average. For the 2013 brood, the sex ratio favored female fish in the Methow Composite program, but was close to even for the Twisp program. Of the female fish retained, fecundity of the 2013 brood was generally higher for natural origin fish than for hatchery origin fish within each program. Overall fecundities of the 2013 brood were lower than the value used in broodstock protocol calculations for hatchery (3,719) and wild (4,027) Methow Composite females. Fecundity of Twisp hatchery origin females was below the value used in broodstock protocol (3,626), but the value for wild origin females was above the protocol value (3,715).

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

Return year	Hatchery Chinook				Wild Chinook				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
Methow Composite spring Chinook										
1998	31	36	4,469	0.86:1	25	68	4,606	0.37:1	0.54:1	4,505
1999	34	51	4,121	0.67:1	16	17	4,530	0.94:1	0.74:1	4,279
2000	76	87	3,759	0.87:1	0	0	-	-	0.87:1	3,759
2001	11	44	3,854	0.25:1	0	0	-	-	0.25:1	3,854
2002	32	46	3,809	0.70:1	0	0	-	-	0.70:1	3,809
2003	15	15	3,887	1.00:1	0	0	-	-	1.00:1	3,887
2004	20	33	3,347	0.61:1	0	0	-	-	0.61:1	3,347
2005	37	52	3,455	0.71:1	0	0	-	-	0.71:1	3,455
2006	65	76	3,318	0.86:1	5	2	3,598	2.50:1	0.90:1	3,338
2007	103	64	3,845	1.61:1	10	9	5,048	1.11:1	1.54:1	3,995
2008	108	188	3,726	0.57:1	24	20	3,568	1.20:1	0.63:1	3,711
2009	79	101	3,875	0.78:1	48	49	4,217	0.98:1	0.85:1	3,987
2010	75	67	3,927	1.12:1	66	71	3,846	0.93:1	1.02:1	3,876
2011	136	144	3,773	0.94:1	55	45	4,384	1.22:1	1.01:1	3,920
2012	48	56	3,362	0.86:1	21	27	4,316	0.78:1	0.83:1	3,668
2013	26	26	3,521	1.00:1	18	22	3,657	0.82:1	0.91:1	3,585
Mean	56	68	3,753	0.84:1	18	21	4,177	1.09:1	0.82:1	3,811
Twisp spring Chinook										
1998	3	4	4,116	0.75:1	0	0	-	-	0.75:1	3,122
1999	23	0	-	-	0	16	4,595	0:01	1.44:1	4,595
2000	24	39	3,820	0.62:1	2	3	5,292	0.67:1	0.62:1	3,927
2001	7	10	3,691	0.70:1	10	8	4,689	1.25:1	0.94:1	4,160
2002	9	5	4,224	1.80:1	0	0	-	-	1.80:1	4,224
2003	6	12	3,239	0.50:1	13	5	5,867	2.6:1	1.12:1	4,012
2004	7	17	3,579	0.41:1	26	21	3,811	1.24:1	0.87:1	3,704
2005	17	0	-	-	1	6	4,393	0.17:1	3.00:1	4,393
2006	12	16	3,301	0.75:1	0	0	-	-	0.75:1	3,301
2007	20	16	3,422	1.25:1	1	3	4,529	0.33:1	1.11:1	3,597
2008	13	18	3,590	0.72:1	3	9	3,204	0.33:1	0.59:1	3,471
2009	6	11	4,050	0.55:1	18	6	4,402	3:01	1.41:1	4,174

Table 3.3. Continued.

Return year	Hatchery Chinook				Wild Chinook				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
Twisp spring Chinook										
2010	10	16	3,877	0.63:1	20	12	3,952	1.67:1	1.07:1	3,907
2011	4	2	3,382	2.00:1	9	7	3,466	1.29:1	1.44:1	3,442
2012	11	9	3,224	1.22:1	6	7	3,977	0.86:1	1.06:1	3,525
2013	6	6	3,251	1.00:1	3	4	4,153	0.75:1	0.90:1	3,652
Mean	11	11	3,626	0.92:1	7	7	4,333	1.09:1	1.18:1	3,825

ELISA Monitoring

Adult female Chinook spawned at Methow Hatchery are screened for the presence of Bacterial Kidney Disease (BKD) using an ELISA assay. Results of this test are grouped into four general categories based on the optical density (OD) of each sample. Overall, at least 72% and 65% of OD values from sampled Methow Composite and Twisp program females, respectively have been in the Below-low category. For most broods of Twisp and Methow Composite stock fish, management actions specified in broodstock collection protocols (Tonseth 2012) have increased the proportion of progeny with lower ELISA OD values retained at Methow Hatchery. For the 2013 brood, all Twisp females were in the below-low category, and all Methow Composite females were in the below-low and low 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 ELISA management (i.e., culling), removal of non-viable fish, and release of unfed fry.

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

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 River spring Chinook											
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
1993	H	40.0	40.0	45.7	45.7	2.9	2.9	11.4	11.4	35	35
1993	W	35.8	35.8	50.0	50.0	7.1	7.1	7.1	7.1	14	14
1994	H	44.5	100.0	44.5	0.0	0.0	0.0	11.0	0.0	9	1
1994	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1995	H	14.3	14.3	42.8	42.8	14.3	14.3	28.6	28.6	7	7
1995	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1996	H	84.2	84.2	15.8	15.8	0.0	0.0	0.0	0.0	19	19
1996	W	83.8	83.4	8.1	8.3	0.0	0.0	8.1	8.3	37	36
1997	H	29.6	29.4	50.9	53.0	11.2	15.1	8.3	2.5	169	119
1997	W	20.0	22.2	60.0	66.7	10.0	11.1	10.0	0.0	10	9
Mean	H	42.5	53.5	39.9	31.5	5.7	6.5	11.9	8.5	48	36
Mean	W	46.5	47.1	39.4	41.7	5.7	6.1	8.4	5.1	20	20
Methow Composite spring Chinook											
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

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											
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
Mean	H	71.5	78.4	17.2	15.4	4.3	2.5	7.0	3.8	104	76
Mean	W	95.2	95.3	2.4	2.3	0.0	0.0	2.4	2.4	25	25
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	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

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					
2005	W	83.3	83.3	16.7	16.7	0.0	0.0	0.0	0.0	6	6
2006	H	80.0	80.0	13.3	13.3	0.0	0.0	6.7	6.7	15	15
2006	W	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2007	H	92.9	92.9	0.0	0.0	7.1	7.1	0.0	0.0	14	14
2007	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	3	3
2008	H	94.1	94.1	5.9	5.9	0.0	0.0	0.0	0.0	17	17
2008	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	8	6
2009	H	54.5	54.5	45.5	45.5	0.0	0.0	0.0	0.0	11	11
2009	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	6	6
2010	H	42.9	50.0	50.0	50.0	7.1	0.0	0.0	0.0	14	12
2010	W	90.9	90.9	9.1	9.1	0.0	0.0	0.0	0.0	11	11
2011	H	0.0	0.0	50.0	0.0	50.0	0.0	0.0	0.0	2	0
2011	W	80.0	100.0	0.0	0.0	20.0	0.0	0.0	0.0	5	4
2012	H	75.0	75.0	25.0	25.0	0.0	0.0	0.0	0.0	8	8
2012	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	6	6
2013	H	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	5	5
2013	W	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	4	4
Mean	H	64.5	65.8	23.6	20.5	7.1	3.6	4.8	3.9	12	12
Mean	W	75.4	76.5	15.5	15.5	4.0	2.8	5.1	5.1	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 2000-2013 brood releases (Tables 3.5–3.6). Spring Chinook are acclimated on-station at Methow Hatchery (Methow-release Methow Composite stock) or transferred to the Twisp or Chewuch acclimation ponds prior to release (Twisp releases of Twisp origin and Chewuch-release Methow Composite stocks). Additionally, in some years, fish have been released from Biddle's Pond (Wolf Creek; broods 2002, 2008, and 2009) and/or Mid-Valley Pond (Methow River; broods 2010, 2011, and 2012). Acclimation time averaged 27 days for the Chewuch River releases and 165 days for Methow Hatchery releases (Table 3.5). Twisp River releases have been acclimated for 29 days on average prior to release (Table 3.6).

For the 2013 brood, Twisp River releases achieved 104% of the release goal of 30,000 smolts specified in broodstock collection protocols (Tonseth 2013; Table 3.6). Releases into the Methow River achieved 121% of the release goal of 133,249 smolts specified for Methow Composite stock release in the broodstock collection protocols (Table 3.5). Chewuch River 2013 brood releases were conducted under a separate program operated by Chelan County PUD and achieved 101% of the release goal of 60,516 smolts specified in broodstock collection protocols.

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

Brood	Release date	Days acclimated	CWT code (s)	Total released
			Chewuch River spring Chinook	
1992	18-Apr-94	3	634331, 634332, 634848, 634850, 635121, 635123, 635124, 635133, 635138, 635139, 635140	40,881
1993	17-Apr-95	18	634127, 635161 635350	284,165
1994	21-Apr-96	31	635132, 635415, 635416, 635863, 635903, 635905	11,854
1996	15-Apr-98	21	630233	91,672
1997	19-Apr-99	27	630614	132,759
1998	17-Apr-00	36	631024	435,670
2000	16-Apr-02	18	630776	266,392
2001	23-Apr-03	26	631384, 631440, 631494	261,284
2002	14-Apr-04	22	631976	254,238
2003	18-Apr-05	39	632566, 632569	127,614
2004	18-Apr-06	27	632899	204,906
2005	16-Apr-07	27	633294	232,811
2006	17-Apr-08	31	633884	154,381
2007	21-Apr-09	29	634294, 634471	126,055
2008	15-Apr-10	38	635099	260,344
2009	25-Apr-11	34	635076, 635078, 635491, 635492, 635494, 635495	149,863
2010	23-Apr-12	29	635197	88,788
2011	18-Apr-13	37	635664	93,372
2013	16-Apr-15	28	636707	60,860
			Methow River spring Chinook	
1993	15-Apr-95	227	635410, 635551	210,849
1994	22-Apr-96	29	635417	4,477
1995	15-Apr-97	350	636037, 636038, 636039, 636040, 636041, 636042, 636043	28,878
1996	15-Apr-98	300	630130, 630246, 630248, 636315	202,947
1997	15-Apr-99	300	630613	332,484
1999	17-Apr-01	171	630377, 630380	180,775
2001	21-Apr-03	82	630976, 631179, 631477	130,887
2002	14-Apr-04	42	631524, 631891	181,235
2003	18-Apr-05	169	632568	48,831

Table 3.5. Continued.

Brood	Release date	Days acclimated	CWT code (s)	Total released
			Methow River spring Chinook	
2004	18-Apr-06	169	631187, 632694 (subyearling release)	107,398
2005	16-Apr-07	153	633281, 633395	156,633
2006	16-Apr-08	168	633866	211,717
2007	21-Apr-09	152	634293, 634674	119,407
2008	15-Apr-10	137	634866	201,290
2009	18-Apr-11	139	635077, 635079, 635080, 635299, 635493, 635496, 635497, 635499	347,993
2010	23-Apr-12	146	635687, 636064, 636065, 636066, 636067, 636068	339,540
2011	15-Apr-13	135	636409, 636410, 636411, 636412, 636413, 636414, 636415	396,085
2012	15-Apr-14	139	636284	196,188
2013	15-Apr-15	136	636606, 636640, 636623	161,145

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

Brood	Release date	Days acclimated	CWT code (s)	Total released
1992	15-Apr-94	3	634849, 634851, 635122, 635125, 635134, 635135, 635136, 635137, 635141	35,853
1993	17-Apr-95	20	635329, 635609	116,749
1994	21-Apr-96	36	634515, 635418, 635419, 635420	19,835
1996	15-Apr-98	26	636114, 636316, 636317	76,687
1997	15-Apr-99	30	630434	26,714
1998	17-Apr-00	36	631041	15,470
1999	17-Apr-01	36	630378, 630379, 630381	67,408
2000	23-Apr-02	0	630182, 630994	75,704
2001	21-Apr-03	27	631068, 631478	57,471
2002	13-Apr-04	27	631076, 631077, 631582, 631694, 631695	58,074
2003	18-Apr-05	35	632499, 632564, 632567, 632565	136,998
2004	22-Apr-06	28	631508 (subyearling release), 632878, 632988	100,260
2005	16-Apr-07	34	633483	27,658
2006	21-Apr-08	41	633687, 634068	45,892
2007	25-Apr-09	10	634673, 634675	54,096
2008	15-Apr-10	43	635085	78,656
2009	25-Apr-11	36	635498, 635506, 635509	67,031
2010	23-Apr-12	35	635584	81,380
2011	18-Apr-13	35	636179	18,190
2012	22-Apr-14	31	636464	48,924
2013	15-Apr-15	37	636613	31,333

Juvenile Size and Condition at Release

Size-at-release fork length and weight targets for DCPUD program fish are described in Murdoch et al. (2012). Releases into the Methow, Twisp, and Chewuch rivers attained 103%, 102%, and 98% respectively, of the target fork lengths prior to release (Table 3.7). Coefficient of variation (CV) in length for 2013 brood releases did not exceed the target value of nine for any release location.

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

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
Chewuch River spring Chinook								
1992	141.8	- -	- -	30.0	- -	- -	15.1	1.05
1993	134.5	- -	- -	27.7	- -	- -	16.4	1.14
1994	145.7	- -	- -	35.7	- -	- -	12.7	1.15
1996	129.8	- -	- -	22.7	- -	- -	20.0	1.04
1997	132.7	- -	- -	27.9	- -	- -	16.2	1.19
1998	127.9	8.7	6.8	24.6	5.0	20.3	18.4	1.18
2000	131.3	6.8	5.2	26.8	4.8	17.9	16.9	1.18
2001	133.8	6.7	5.0	30.2	- -	- -	15.0	1.26
2002	142.5	16.1	11.3	35.0	13.2	37.7	12.9	1.21
2003	131.0	11.7	8.9	27.6	7.9	28.6	16.4	1.23
2004	144.1	20.8	14.4	42.4	21.0	49.5	10.7	1.42
2005	126.0	15.3	12.1	24.7	10.2	41.3	18.0	1.23
2006	115.7	10.9	9.4	19.2	6.2	32.3	23.7	1.24
2007	145.5	29.0	19.9	43.3	28.8	66.5	10.4	1.41
2008	133.7	17.1	12.8	30.2	12.1	40.1	14.9	1.26
2009	135.4	19.6	14.5	30.8	14.3	46.4	14.7	1.24
2010	126.2	12.6	10.0	25.2	8.6	34.1	18.0	1.25
2011	130.6	12.8	9.8	26.0	9.0	34.6	17.5	1.17
2013	133.2	7.8	5.8	28.0	5.5	19.7	16.2	1.18
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

Table 3.7. Continued.

Brood	Fork length (mm)			Weight (g)				K
	Mean	SD	CV	Mean	SD	CV	FPP	
				Methow River spring Chinook				
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
Target	137.0	- -	9.0	30.3	- -	- -	15.0	1.18
				Twisp River spring Chinook				
1992	135.0	- -	- -	30.0	- -	- -	15.1	1.22
1993	132.9	- -	- -	29.8	- -	- -	15.2	1.27
1994	138.5	- -	- -	31.4	- -	- -	14.4	1.18
1996	137.2	- -	- -	30.7	- -	- -	14.8	1.19
1997	133.4	- -	- -	28.2	- -	- -	16.1	1.19
1998	138.0	10.6	7.7	30.3	7.6	25.1	15.0	1.15
1999	155.9	15.5	9.9	47.7	15.7	32.9	9.5	1.26
2000	133.4	6.8	5.1	27.2	- -	- -	16.7	1.15
2001	122.5	10.0	8.2	21.6	- -	- -	21.0	1.18
2002	135.9	9.6	7.1	30.3	7.2	23.8	15.0	1.21
2003	132.8	11.1	8.4	28.2	7.9	28.0	16.1	1.20
2004	130.2	14.6	11.2	27.9	12.0	43.0	16.2	1.26
2005	139.0	10.0	7.2	33.9	7.8	23.0	13.0	1.26
2006	134.0	11.1	8.3	29.6	8.3	28.0	15.3	1.23
2007	127.5	13.6	10.7	24.9	9.3	37.3	18.2	1.20
2008	128.7	11.8	9.2	26.8	7.8	29.1	16.8	1.26
2009	144.6	16.0	11.1	37.2	12.0	32.3	12.2	1.23
2010	130.4	17.3	13.3	27.7	12.5	45.1	16.4	1.25
2011	135.6	8.7	6.4	31.1	6.8	21.9	14.6	1.25
2012	135.5	11.7	8.6	29.3	8.1	27.7	15.5	1.18
2013	137.6	7.5	5.5	31.2	5.5	17.7	14.5	1.20
Target	135.0	- -	9.0	30.2	- -	- -	15.0	1.23

Survival Estimates

Survival of Methow Composite and Twisp program fish from the 2013 brood exceeded target values (Wells HCP HC 2005; Table 3.8). Overall (all-year average) mean survival in most categories was also above target values except for Twisp program fish in the transport to release category, which was negatively impacted by a single mortality event during rearing of the 2000 brood (Table 3.8).

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

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
				Methow Composite spring Chinook					
1999	96.0	96.3	97.4	100.0	99.5	99.5	99.2	N/A	92.5
2000	96.2	97.2	96.5	100.0	99.6	99.4	99.0	99.9	92.7
2001	98.9	97.3	96.1	100.0	99.3	99.1	97.0	99.8	90.8
2002	97.7	95.1	93.6	100.0	98.6	98.6	96.5	98.5	92.7
2003	96.3	97.2	90.0	100.0	98.8	98.3	93.0	99.8	77.9
2004	97.7	99.2	94.8	96.2	99.2	99.1	96.1	99.8	84.2
2005	99.0	99.1	96.1	100.0	99.6	99.5	90.4	99.6	87.7
2006	96.8	95.1	94.8	100.0	97.2	97.0	83.0	96.2	77.6
2007	98.6	98.8	92.9	96.0	98.8	98.2	94.5	99.1	84.2
2008	97.6	100.0	95.9	99.7	99.6	97.7	90.2	99.8	84.8
2009	100.0	99.2	95.9	100.0	99.5	99.4	96.8	99.9	92.5
2010	98.6	96.5	92.6	99.9	98.6	98.4	98.0	99.9	90.6
2011	100.0	96.3	93.5	93.6	100.0	99.9	99.5	99.4	87.0
2012	98.8	98.6	95.3	100.0	99.6	99.5	95.4	68.7	91.0
2013	100.0	100.0	95.4	99.6	98.9	98.8	98.2	99.8	93.3
Mean	98.1	97.7	94.7	99.0	99.1	98.8	95.1	97.2	88.0
Target	90.0	85.0	92.0	98.0	97.0	93.0	90.0	95.0	81.0
				Twisp spring Chinook					
1999	100.0	95.7	94.3	100.0	99.2	99.0	98.0	99.7	92.3
2000	96.4	92.9	97.1	100.0	99.6	99.5	47.3	23.9	46.0
2001	93.8	88.2	91.1	100.0	99.0	95.7	90.1	100.0	81.2
2002	100.0	66.7	97.9	100.0	99.3	99.1	98.5	99.9	96.4
2003	100.0	88.2	91.8	99.8	98.8	98.5	95.9	100.0	86.4
2004	97.4	87.9	95.5	97.8	99.1	98.8	78.7	99.5	73.3
2005	100.0	100.0	95.7	98.2	99.6	99.5	99.2	99.9	93.2
2006	85.7	100.0	95.9	100.0	99.6	99.3	94.2	99.7	90.4
2007	100.0	100.0	92.4	96.0	99.4	98.4	88.6	99.7	78.6
2008	96.3	100.0	90.1	99.5	99.9	99.5	96.3	99.9	86.5
2009	100.0	100.0	97.3	99.9	99.8	98.7	97.6	99.6	94.9

Table 3.8. Continued.

Brood	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
				Twisp spring Chinook					
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
Mean	95.8	94.0	94.1	99.4	99.3	98.8	91.8	94.8	85.7
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 2015 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 18 February and 25 November 2015 using smolt traps with a 1.5 m or 2.4 m cone diameter. These traps were operated in two different trapping positions depending on the river discharge at the site. Trapping at the Methow site was interrupted on two occasions for a total of three days because of low flow or fire activity. 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 448 wild yearling spring Chinook emigrants between 18 February and 30 June at the Methow River trapping location, with peak capture on 18 April (N = 25). Overall mortality of wild Chinook captured totaled four of the fish captured (0.89%). We PIT tagged 431 of the wild Chinook emigrants and released 426 after subtracting shed tags and mortalities. We also captured 50,071 hatchery Chinook at the Methow River trap, which included spring and summer races. Overall mortality of the hatchery Chinook captured totaled 53 fish (0.11%).

We captured 243 emigrant Chinook parr between 1 October and 25 November with peak capture occurring on 2 November ($N = 51$). We DNA sampled 239 of the Chinook captured and conducted genetic analysis on 100 of these samples. Of these, 91 (91.0%) were confirmed to be spring Chinook and 9 (9.0%) were summer Chinook. We inserted PIT tags into 234 of the 243 Chinook parr captured and no shed tags or mortalities occurred.

No mark/recapture trials were conducted with Chinook smolts for the low position in the spring at the Methow trap because high discharge enabled the trap to operate in the upper position for most of the spring trapping season. Previous mark/recapture trials in the low position from previous years resulted in a significant relationship ($P < 0.01$; $r^2 = 0.52$), and we used the regression ($y = -2.57\text{E-}05x+0.161723324$) for the low trapping position in 2015. 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 ($P< 0.01$, $r^2 = 0.79$; Table 4) and the regression ($y = -4.30\text{E-}05x + 0.312007862$) was used for this position in 2015. Using both these flow models, the estimated number of yearling spring Chinook emigrants was 15,749 (± 2,355, 95% CI). When combined with the estimate of parr that emigrated past the trap in 2014 (20,493 ± 57,648 95% CI), we estimated that 36,242 (± 57,696 95% CI) 2013 brood wild spring Chinook migrated from the Methow River basin between 1 October 2014 and 30 June 2015 (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.

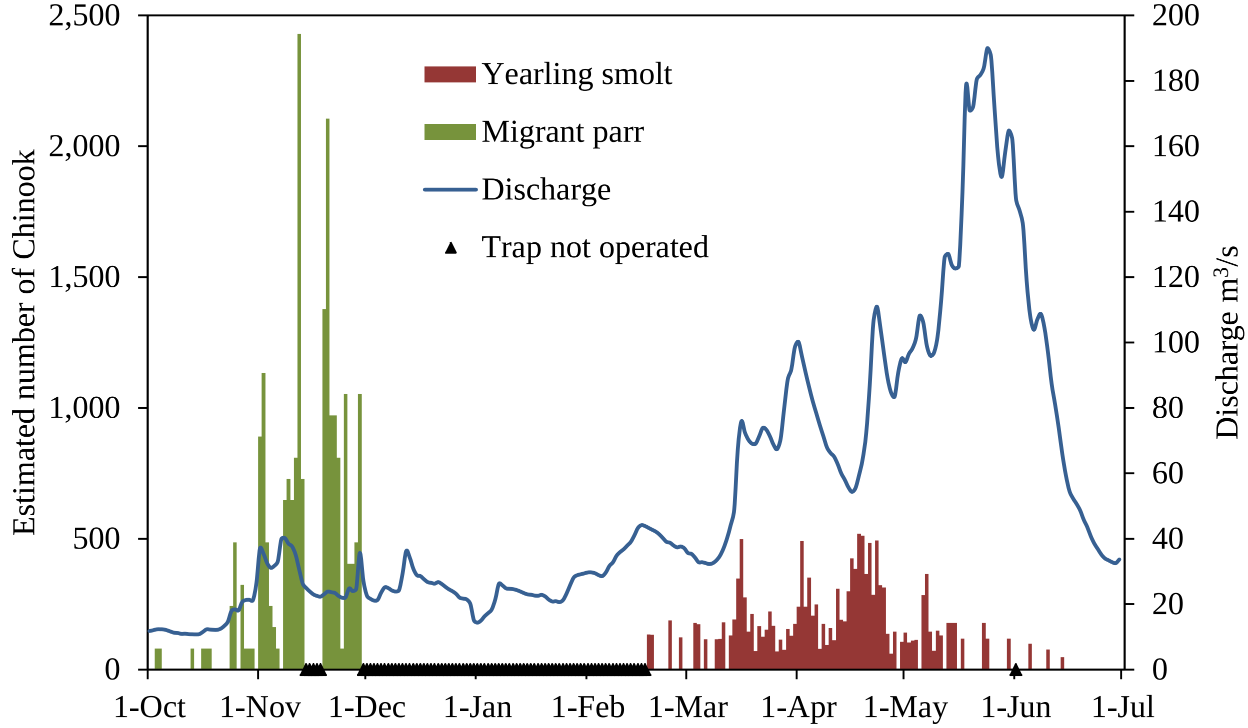

Figure 3.1. Daily emigration of 2013 brood spring Chinook from the Methow River by life stage.

Twisp Trap

Trapping at the Twisp River trap site (rkm 2) occurred between 26 February and 20 November 2015 using a rotary screw smolt trap with a 1.5 m cone diameter. Trapping at the Twisp site was interrupted for a total of 102 days between 22 July and 31 October because of low flow. However, production estimates were likely affected only by the non-trapping period in September and October, during which time emigration was estimated using the Twisp PIT tag array (Attachment A).

We captured 447 wild yearling spring Chinook emigrants at the Twisp trap between 26 February and 30 June. Peak capture occurred on 15 March (*N* = 29). We PIT tagged 437 wild yearling emigrants and released 431 after subtracting mortalities and shed tags. Overall mortality of wild yearling Chinook totaled nine of the 447 fish captured (2.01%). We also captured 4,051 hatchery spring Chinook, from which a single mortality occurred (0.02%).

We captured 3,063 subyearling spring Chinook between 26 February and 20 November at the Twisp trap with peak capture occurring on 1 November (*N* = 503). We implanted 1,099 PIT tags into Chinook parr and no mortalities or shed tags occurred (Attachment A). Overall, eight fry and one parr mortality occurred (0.29%).

One mark/recapture trial was conducted with hatchery Chinook smolts at the Twisp trap in the spring of 2015. A significant efficiency/discharge relationship existed when this trial was added to all other release groups greater than 100 conducted since 2008 ($P < 0.01$, $r^2 = 0.64$). Using the flow model regression ($y = -0.00056877x + 0.529960351$) derived from these trials, we estimated that 6,298 (± 1,351, 95% CI) smolts emigrated from the Twisp River between 26 February and 30 June 2015. One redd was identified downstream of the Twisp trap in 2013 producing an estimated 75 migrants resulting in a total production estimate of 6,373 (± 1,359, 95% CI) yearling Chinook smolts. An estimated 16,122 (± 2,695, 95% CI) 2013 brood spring Chinook parr emigrated from the Twisp River in the fall of 2014 (Attachment A). Adding an estimated 192 migrants from one redd below the trap resulted in a total estimate of 16,314 (± 2,711, 95% CI) 2013 brood spring Chinook parr emigrants in 2014.

We used the Twisp PIT tag array to estimate that 3,299 (± 469, 95% CI) spring Chinook emigrated between 30 November 2014 and 25 February 2015 when the smolt trap was not operating. An additional 39 over-winter migrants were estimated from redds below the trap to produce a total over-winter migrant estimate of 3,338 ((± 472, 95% CI) over-winter migrants. Thus the total emigration estimate for the 2013 brood was 26,025 (± 3,069, 95% CI; Table 3.9), about 13% of which were estimated to have emigrated over the winter period when the smolt trap was not operating (Figure 3.2). Utilizing the completed production estimates from both trap sites and the estimated spring Chinook redd count within each production area for which production estimates were complete (Twisp 2004-2013 broods, Methow 2003, 2005-2013 broods), the mean number of emigrants produced from each redd in the Twisp and Methow basins was 174 and 50, respectively (Table 3.9).

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

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants			Egg to emigrant (%)	Emigrants per redd
				Age-0	Age-1	Total		
Twisp	2003	18	81,395	DNOT	900	900	1.1	50
Twisp	2004	139	510,220	1,219	5,224	6,443	1.3	46
Twisp	2005	55	237,729	3,245	3,329	6,574	2.8	120
Twisp	2006	87	298,074	1,531	16,415	17,946	6	206
Twisp	2007	30	128,182	4,181	5,547	9,728	7.6	324
Twisp	2008	79	268,771	7,139	4,793	11,932	4.4	151
Twisp	2009	24	100,694	3,282	1,842	5,124	5.1	214
Twisp*	2010	145	568,266	4,874	3,917	9,682	1.7	67
Twisp*	2011	63	269,855	6,431	3,617	12,759	4.7	203
Twisp*	2012	139	466,182	3,953	6,043	13,690	2.9	98
Twisp*	2013	85	281,719	16,314	6,373	26,025	9.2	306
Twisp	2014	138	490,824	18,290	--	18,290	--	--
Twisp	Mean 2003-2013	79	291,917	5,217	5,273	10,982	4.3	162
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	--	34,402	--	--
Methow	Mean 2003-2013	716	2,710,375	8,468	24,940	31,996	1.2	46

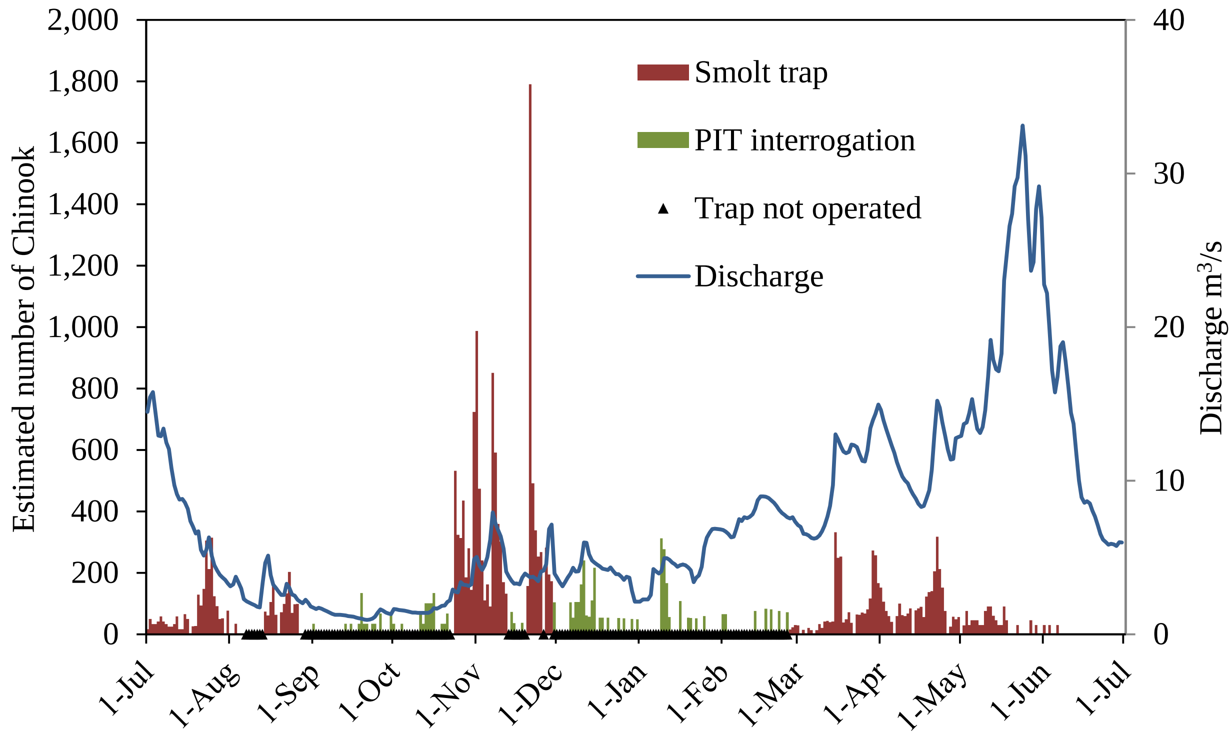

Figure 3.2. Daily emigration of 2013 brood spring Chinook from the Twisp River by estimation method.

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 0.58% and 0.73%, respectively for the 2003-2010 broods (Table 3.10). However, sample sizes for some release years and trap sites were likely too low to produce accurate estimates.

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

Brood	Release year	Release *N*	Age at return (*N*) to Bonneville Dam			Total	SAR %
			Age-3	Age-4	Age-5		
			Twisp trap				
2003	2005	110	0	0	0	0	0.00
2004	2006	818	0	1	0	1	0.12
2005	2007	271	0	1	0	1	0.37
2006	2008	2,494	5	18	8	31	1.24
2007	2009	630	0	9	0	9	1.43
2008	2010	953	1	4	1	6	0.63
2009	2011	304	0	1	0	1	0.33
2010	2012	606	1	1	1	3	0.50
2011	2013	435	0	1	--	1	0.23
2012	2013	664	0	--	--	0	0.00
2003-2010 brood mean							0.58
			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	--	2	0.26
2012	2014	883	0	--	--	0	0.00
2003-2010 brood mean							0.73

In-stream PIT Tagging

Natural origin juvenile spring Chinook were primarily PIT tagged in the Twisp subbasin in 2015 (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 2010-2014 (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 four years (2011-2014 tag years) for which emigration is complete (Table 3.11). Standard error (SE) values generated for individual estimates of some groups were high however, indicating that tag rates or capture probability was not high enough for some locations and years.

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

Tag year	Parr tagged	Recovered at RRJ		CJS estimate from DART	
		Age-1 smolt	%	Probability of survival	SE
		Twisp River			
2010	141	7	4.9	0.25	0.21
2011	1,059	23	2.2	0.52	0.27
2012	983	26	2.6	0.15	0.03
2013	1,103	43	3.9	0.23	0.05
2014	924	42	4.5	0.15	0.04
2015	1,120	--	--	--	--
Mean 2010-2014		28	3.6	0.26	0.12
		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	--	--	--	--
Mean 2010-2014		23	3.2	0.19	0.09
		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	--	--	--	--
Mean 2011-2014		48	2.7	0.24	0.08

3.4 Spawning Ground Surveys

Spring Chinook spawning ground surveys were conducted in the Methow River basin between 25 July and 30 September 2015 (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 979 spring Chinook redds were constructed in the Methow Basin in 2015, much greater than the overall mean number of redds found in the 2003-2015 spawning years (Table 3.12). Redd counts in most individual spawning areas were greater than the overall mean totals except for the Methow Hatchery outfall (Table 3.12). Spawner abundance in this area may have been lowered in 2015 relative to previous years by removal of adult Chinook at Methow Hatchery to reduce pHOS. Within the 2015 spawning year, most redds were found in the Methow River and tributaries (66.8%). The Chewuch and Twisp rivers accounted for 21.0% and 12.2% 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
Mean	369	8	32	27	17	86	194	732

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* = 294; Table 3.13). This section typically has the highest annual redd count within the basin (Attachment C). Spawning in the Twisp River was primarily in section T6 (47.1%) and in section C2 of the Chewuch River (29.2%). Spawning was observed in Methow River tributaries (e.g., Early Winters Creek, Lost River), but no spawning tributaries have been identified in the Chewuch or Twisp river watersheds (Table 3.13).

Table 3.13. Spawning distribution (redd counts) and proportion of redds within primary tributaries and reaches of the Methow Basin in 2015.

Methow				Twisp				Chewuch			
Reach	Redds	Redds/ km	% within basin	Reach	Redds	Redds/ km	% within basin	Reach	Redds	Redds/ km	% within basin
M15	1	0.3	0.2	T10	0	0.0	0.0	C13	2	0.5	1.0
M14	6	1.3	0.9	T9	0	0.0	0.0	C12	12	2.6	5.8
M13	2	0.5	0.3	T8	5	1.6	4.2	C11	1	0.2	0.5
M12	13	4.1	2.0	T7	17	2.5	14.3	C10	6	1.5	2.9
M11	10	2.5	1.5	T6	56	7.6	47.1	C9	0	0.0	0.0
M10	84	15.8	12.8	T5	30	5.1	25.2	C8	10	4.2	4.9
M9	294	32.7	45.0	T4	4	1.1	3.4	C7	17	3.3	8.3
M8	14	6.4	2.1	T3	5	1.4	4.2	C6	33	5.7	16.0
M7	68	37.8	10.4	T2	2	0.4	1.7	C5	21	5.7	10.2
M6	19	7.0	2.9	T1	0	0.0	0.0	C4	36	9.7	17.5
M5,4	13	0.8	2.0					C3	0	0.0	0.0
Lost R.	30	2.7	4.6					C2	61	8.1	29.6
Early Winters Cr.	10	1.4	1.5					C1	7	1.4	3.4
Hatchery outfalls	58	72.5	8.9								
Other tributaries	32	12.3	4.9								
Total	654	8.3			119	2.6			206	3.8	

Spawn Timing

Fish were actively spawning in all three subbasins by the week starting with 9 August, and peak redd counts occurred in different weeks for all three major subbasins (Table 3.14; Figure 3.3). Spawning in all subbasins was completed by late-September (Attachment C).

Table 3.14. Redd counts by subbasin and week starting date for spring Chinook spawning in the Methow, Twisp, and Chewuch subbasins in 2015.

Subbasin	Week starting date (Sunday)								Total
	26-Jul	2-Aug	9-Aug	16-Aug	23-Aug	30-Aug	6-Sep	13-Sep	
Chewuch	0	0	1	2	9	74	97	15	206
Methow	0	0	12	66	179	229	143	17	654
Twisp	0	0	3	13	50	29	21	3	119

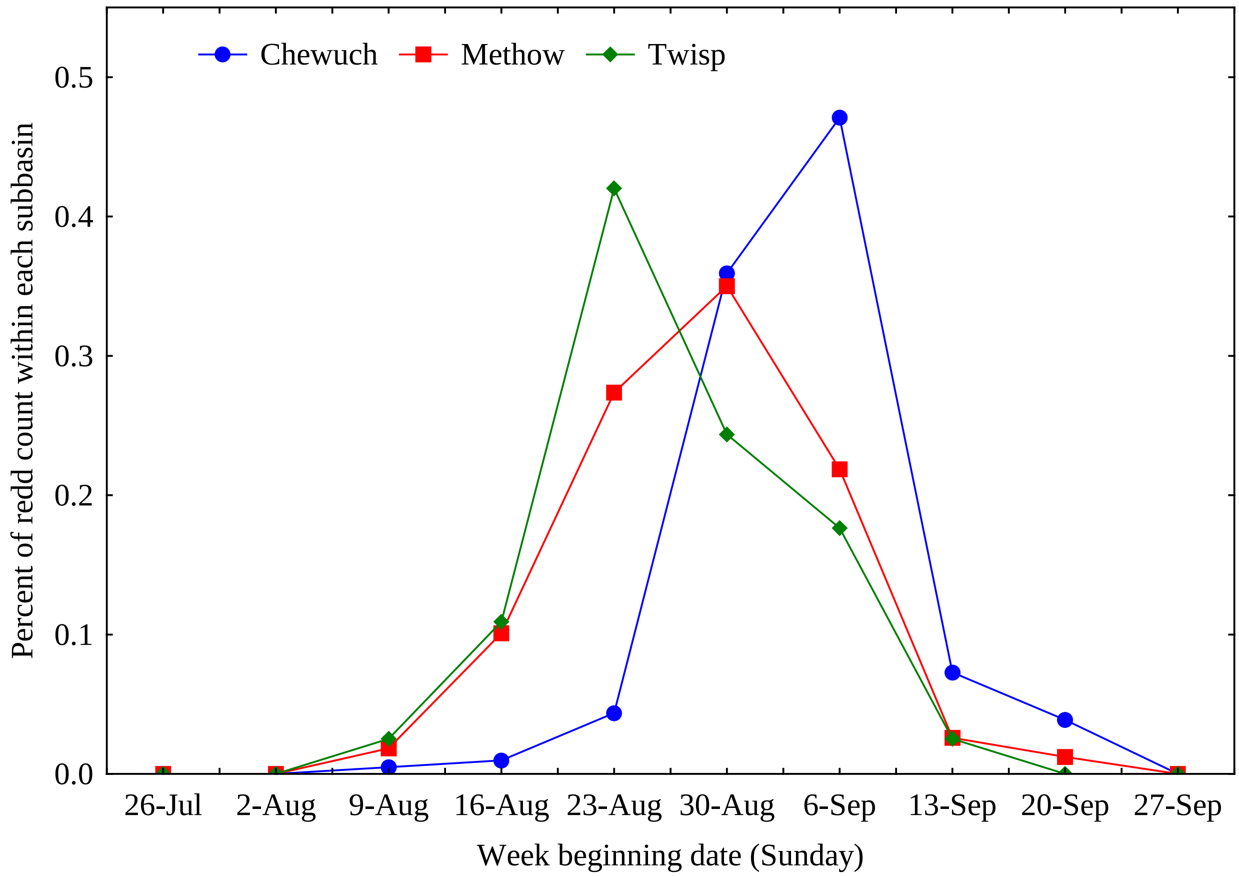

Figure 3.3. Percent of completed spring Chinook redds by subbasin and week of detection in 2015.

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 2015 FPR value (1.38) there were an estimated 1,353 spawners in the Methow River basin in 2015, of which 398 (29.4%) were estimated to be wild (NOR) fish (Table 3.15). Estimated spawning escapement does not include hatchery or wild fish collected for broodstock. Wild fish comprised 46.9%, 67.1%, and 17.1% of the estimated spawning escapement in the Chewuch, Twisp, and Methow subbasins, respectively (Attachment C).

Table 3.15. Estimated spawning escapement by stream in the Methow River Basin in 2015.

Survey stream	Redds	Estimated spawning escapement		
		H	W	Total
Chewuch River	206	152	134	286
Early Winters Creek	10	7	6	13
Hancock Creek	4	5	1	6
Lost River	30	24	17	41
Methow River	524	610	114	724
MH outfall	19	24	2	26
Suspension Creek	25	27	8	35
Twisp River	119	54	110	164
WNFH outfall	39	49	5	54
Wolf Creek	3	3	1	4
Total	979	955	398	1,353

Carcass Sampling and Distribution

In general, all salmon carcasses encountered during spawning ground surveys were sampled for sex, age, origin, egg retention, hatchery marks and tags, and their location was recorded using hand-held GPS devices. Most carcasses recovered in the Methow and Chewuch river basins were hatchery origin fish, while most carcasses recovered in the Twisp River basin were natural origin fish (Table 3.17). Surveyors (WDFW and USFWS) sampled 60.8% of the overall Methow Basin estimated spawning population in 2015 (Attachment C).

Egg retention was estimated for 455 of the 539 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 3,867,031 eggs were deposited in the Methow River basin in 2015 (Table 3.18).

Table 3.17. Carcass recoveries and expanded count by tributary and reach from Methow Basin spring Chinook surveys in 2015.

Reach	Redds	Carcasses					Estimated spawning escapement
		Recoveries			Expanded count		
		H	W	Total	H	W	
Methow River mainstem							
M15	1	0	2	2	0[b]	1[b]	1
M14	6	19	11	32[a]	5[b]	3[b]	8
M13	2	0	2	2	0	3	3
M12	13	3	5	8	7	11	18
M11	10	1	0	1	14	0	14
M10	84	41	8	50[a]	97	19	116
M9	294	177	38	218[a]	337	70	407
M8	14	18	1	19			19
M7	68	67	3	70	132	7	94
M6	19	37	2	39			26
M5,4	13	7	0	7	18	0	18
Total	524	370	72	448[a]	610	114	724
Lost River							
L2	29	6	5	11	24[b]	17[b]	40
L1	1	0	0	0			1
Total	30	6	5	11	24	17	41
Early Winters Creek							
EW5,4	0	0	0	0	0	0	0
EW3	9	8	5	13	7	5	12
EW2,1	1	0	1	1	0	1	1
Total	10	8	6	14	7	6	13
Methow River tributaries							
HA2	0	0	0	0	0	0	0
HA1	4	3	1	4	5	1	6
MH1	19	13	1	15[a]	24	2	26
Lsusp1	0	0	0	0	0	0	0
Susp1	25	7	2	10[a]	27	8	35
W3	0	0	0	0	0	0	0
W2	0	0	0	0	0	0	0
W1	3	2	1	3	3	1	4
WN1	39	19	2	22[a]	49	5	54
Total	90	44	7	54[a]	108	17	125
Grand total	654	428	90	527[a]	749	154	903

[a] Includes fish of unknown origin.

[b] Expanded count from combined recoveries in M15, M14 and L2.

Table 3.17. Continued.

Reach	Redds	Carcasses: Recoveries H	Recoveries W	Recoveries Total	Expanded count H	Expanded count W	Estimated spawning escapement
Chewuch River mainstem							
C13	2	0	1	1	0	3	3
C12	12	6	6	12	8	9	17
C11	1	1	0	2[a]	1	0	1
C10	6	3	4	7	3	5	8
C9	0	0	0	0	0	0	0
C8	10	3	4	7	12	25	14
C7	17	8	18	27[a]			23
C6	33	9	14	24[a]	18	28	46
C5	21	9	12	21	12	17	29
C4	36	12	9	22[a]	29	22	51
C3	0	1	1	2			0
C2	61	51	22	73	59	25	84
C1	7	8	0	8	10	0	10
Total	206	111	91	206[a]	152	134	286
Twisp River mainstem							
T10	0	0	0	0	0	0	0
T9	0	0	0	0	0	0	0
T8	5	1	2	3	2	5	7
T7	17	2	16	18	3	20	23
T6	56	8	34	44[a]	15	62	77
T5	30	18	12	30	25	16	41
T4	4	3	1	4	5	1	6
T3	5	3	2	5	4	3	7
T2	2	0	1	1	0	3	3
T1	0	0	0	0	0	0	0
Total	119	35	68	105[a]	54	110	164

[a] Includes fish of unknown origin.

[b] Expanded count estimated from carcass recoveries in C12 and C11.

Table 3.18. Estimated egg deposition for spring Chinook in the Methow Basin in 2015. Mean fecundities were derived from Methow Hatchery broodstock (MetComp or Twisp) and adjusted according to hatchery and wild proportions by age class in each subbasin.

Subbasin	Females with egg retention estimated	Mean fecundity	Mean egg retention (%)	Redds	Subbasin proportion (%)	Estimated egg deposition		
						2013	2014	2015
Chewuch	109	4,020	1.1	206	21.0	609,061	907,636	819,011
Methow	288	3,882	0.6	654	66.8	1,185,499	2,813,070	2,523,595
Twisp	58	4,438	0.7	119	12.2	281,719	490,824	524,425
Total	455			979		2,076,279	4,211,530	3,867,031

3.5: Life History Monitoring

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

Age at Maturity

Methow River basin spring Chinook adults, regardless of origin, primarily return at age-4 (Table 3.19). Average age-4 returns across river basins ranged from 73 – 77% for hatchery fish and 70 – 77% for natural origin fish. Hatchery origin fish were more likely to return at age-3 and less likely to return at age-5 than natural origin fish, on average (Table 3.19).

Table 3.19. Proportion of adult returns by total age of the 1998-2009 broods of Methow Hatchery spring Chinook and Methow Basin natural origin Chinook. Data for hatchery origin fish (H) is derived from expanded CWT recoveries from broodstock, fisheries, and spawning grounds. Chewuch releases from the 1998 and 2000 broods are included in the Methow spring Chinook category for those years. Data for natural origin fish (W) is derived from expanded escapement estimates from spawning ground surveys.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Methow spring Chinook			
1998	H	0.08	0.53	0.39	2,279
1998	W	0.31	0.65	0.04	52
1999	H	0.10	0.83	0.07	143
1999	W	0.60	0.40	0.00	5
2000	H	0.14	0.81	0.05	850
2000	W	0.02	0.82	0.16	241
2001	H	0.22	0.73	0.05	513
2001	W	0.01	0.82	0.16	222
2002	H	0.09	0.84	0.08	532
2002	W	0.00	0.51	0.49	189
2003	H	0.04	0.83	0.13	52
2003	W	0.00	0.69	0.31	86
2004	H	0.23	0.75	0.02	308
2004	W	0.06	0.77	0.17	211
2005	H	0.17	0.83	0.00	326
2005	W	0.04	0.94	0.01	253
2006	H	0.29	0.67	0.04	1,667
2006	W	0.06	0.61	0.33	594
2007	H	0.11	0.86	0.03	512
2007	W	0.03	0.88	0.09	304
2008	H	0.41	0.56	0.02	931
2008	W	0.17	0.62	0.21	92
2009	H	0.09	0.90	0.01	749
2009	W	0.00	0.85	0.15	121
Mean	H	0.16	0.76	0.07	739
Mean	W	0.11	0.71	0.18	198
		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

Table 3.19. Continued.

Brood year	Origin	Age at return			Total
		Age-3	Age-4	Age-5	
		Chewuch spring Chinook			
2005	H	0.16	0.83	0.01	308
2005	W	0.02	0.96	0.03	295
2006	H	0.30	0.64	0.06	703
2006	W	0.06	0.43	0.51	440
2007	H	0.04	0.91	0.05	810
2007	W	0.04	0.82	0.15	224
2008	H	0.43	0.53	0.04	879
2008	W	0.20	0.66	0.14	110
2009	H	0.10	0.88	0.03	349
2009	W	0.03	0.91	0.06	98
Mean	H	0.17	0.77	0.07	515
Mean	W	0.05	0.70	0.25	289
		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	0.14	0.80	0.06	70
2009	H	0.16	0.82	0.02	121
2009	W	0.15	0.76	0.09	33
Mean	H	0.18	0.73	0.09	137
Mean	W	0.10	0.77	0.13	103

Length at Maturity

Length at maturity of Methow Composite spring Chinook was similar to wild spring Chinook from the Methow and Chewuch Rivers (combined in Methow Composite category) for the long-term mean (1992-2009 broods; Table 3.20). Length at maturity of Twisp spring Chinook recovered in the Twisp River were similar to their wild counterparts of the same sex and age, although for both stocks, sample sizes for some sex, age, and origin comparisons were small.

Table 3.20. Mean post-eye to hypural plate (POH) length (cm) of adult Chinook Salmon by sex, age, origin, and release location (hatchery fish) or stream of recovery (wild fish). Adult data for wild fish includes fish retained for broodstock at Wells Dam for which stock was determined through genetic assessment.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Methow River males										
1992	W	--	--	--	--	--	--	75	8	8
1993	H	41	3	12	61	27	3	73	13	2
1993	W	--	--	--	63	7	1	--	--	--
1995	H	45	8	2	62	44	3	74	1	--
1995	W	--	--	--	57	1	--	85	1	--
1996	H	41	45	4	60	33	5	74	2	0
1996	W	--	--	--	59	4	9	72	12	4
1997	H	43	4	3	65	166	4	78	22	4
1997	W	44	4	2	62	15	3	79	8	7
1998	W	55	2	0	73	4	5	79	1	--
1999	H	39	10	3	59	5	4	74	1	--
1999	W	58	1	--	--	--	--	66	1	--
2000	W	38	3	1	59	27	6	72	4	2
2001	H	39	73	3	58	81	5	70	3	5
2001	W	40	1	--	59	26	5	72	5	5
2002	H	42	16	3	59	75	4	73	7	6
2002	W	--	--	--	58	14	6	70	6	3
2003	H	38	2	1	55	15	5	75	1	--
2003	W	--	--	--	55	2	1	78	2	4
2004	H	39	19	2	58	36	4	--	--	--
2004	W	38	2	6	61	9	6	--	--	--
2005	H	44	31	3	61	48	4	--	--	--
2005	W	41	3	4	62	25	4	75	1	--

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Methow River males					
2006	H	43	178	4	62	145	4	75	2	5
2006	W	40	7	4	62	46	6	75	19	7
2007	H	39	19	3	60	21	5	69	1	--
2007	W	38	4	3	58	18	5	71	2	4
2008	H	40	73	3	57	67	6	--	--	--
2008	W	40	3	3	57	10	6	--	--	--
2009	H	39	30	3	58	18	6	--	--	--
2009	W	--	--	--	60	9	3	75	2	8
Mean	H	41	37	3	60	56	5	74	5	4
Mean	W	43	3	3	60	14	5	75	5	5
					Methow River females					
1992	W	--	--	--	--	--	--	74	4	6
1993	H	--	--	--	59	61	3	73	16	6
1993	W	--	--	--	63	15	2	--	--	--
1994	H	--	--	--	59	1	--	--	--	--
1995	H	--	--	--	65	57	3	--	--	--
1995	W	--	--	--	61	7	3	74	1	--
1996	H	--	--	--	62	66	3	74	8	3
1996	W	--	--	--	64	2	6	73	12	6
1997	H	--	--	--	63	283	3	70	19	4
1997	W	--	--	--	63	29	2	74	14	6
1998	W	--	--	--	68	9	6	80	1	--
1999	H	--	--	--	61	30	4	68	2	11
1999	W	--	--	--	62	2	1	--	--	--
2000	W	--	--	--	58	41	4	71	8	3
2001	H	--	--	--	60	95	3	66	9	5
2001	W	--	--	--	58	28	4	69	5	6
2002	H	--	--	--	58	157	4	68	11	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
2005	H	53	2	9	61	76	3	--	--	--
2005	W	--	--	--	59	24	2	72	24	5

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Methow River females										
2006	H	--	--	--	61	273	3	69	5	3
2006	W	--	--	--	59	75	5	--	--	--
2007	H	45	1	--	61	47	4	68	5	3
2007	W	--	--	--	60	35	3	70	8	4
2008	H	--	--	--	58	163	3	68	2	1
2008	W	--	--	--	59	16	3	69	5	2
2009	H	--	--	--	58	45	2	62	1	--
2009	W	--	--	--	58	17	3	71	5	4
Mean	H	48	2	6	60	98	3	69	7	4
Mean	W	--	--	--	60	22	3	72	8	4
Chewuch River males										
1992	H	--	--	--	58	15	5	--	--	--
1992	W	--	--	--	--	--	--	77	4	7
1993	H	40	16	2	58	18	4	75	6	3
1993	W	--	--	--	61	8	3	--	--	--
1996	H	42	3	3	60	5	4	70	1	
1996	W	--	--	--	--	--	--	69	11	2
1997	H	42	25	4	63	111	5	69	5	7
1997	W	--	--	--	61	81	4	77	11	4
1998	W	47	2	8	74	5	6	77	4	3
2000	W	37	3	3	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	109	5	74	12	3
2002	W	40	1	--	57	16	8	68	5	7
2003	H	34	2	1	54	16	4	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	58	50	7	74	5	1

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Chewuch River males					
2008	H	40	89	3	55	62	6	70	2	0
2008	W	42	4	7	56	13	7	--	--	--
2009	H	39	9	4	59	37	5	67	2	11
2009	W	46	2	6	58	17	5	70	1	--
Mean	H	40	26	3	59	47	5	71	4	4
Mean	W	41	2	5	60	20	5	74	6	5
					Chewuch River females					
1992	H	--	--	--	59	22	3	--	--	--
1992	W	--	--	--	--	--	--	73	1	--
1993	H	--	--	--	60	24	3	71	7	3
1993	W	--	--	--	60	16	3	--	--	--
1994	H	--	--	--	65	2	3	--	--	--
1995	W	--	--	--	--	--	--	74	3	3
1996	H	--	--	--	62	10	3	75	2	4
1996	W	--	--	--	65	3	2	68	6	1
1997	H	60	1	--	63	175	4	73	4	5
1997	W	--	--	--	62	71	3	75	8	4
1998	W	53	1	--	66	3	3	73	6	3
1999	W	--	--	--	61	1	--	--	--	--
2000	W	--	--	--	59	5	3	72	5	4
2001	H	--	--	--	59	130	4	66	8	5
2001	W	--	--	--	59	52	3	67	10	3
2002	H	--	--	--	57	156	3	69	17	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	69	7	5
2006	W	--	--	--	60	37	4	72	26	4
2007	H	--	--	--	61	114	3	70	20	4
2007	W	--	--	--	61	13	5	69	11	2

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Chewuch River females					
2008	H	--	--	--	58	197	4	66	9	4
2008	W	--	--	--	58	25	3	69	6	2
2009	H	--	--	--	58	69	3	67	1	--
2009	W	--	--	--	57	18	3	67	1	--
Mean	H	60	1	--	60	82	3	69	7	4
Mean	W	53	1	--	60	21	3	70	7	3
					Twisp River males					
1992	H	--	--	--	54	7	7	--	--	--
1992	W	--	--	--	--	--	--	70	3	3
1993	H	39	6	2	58	3	10	68	1	
1994	H	--	--	--	60	3	1	--	--	--
1996	H	40	23	2	58	19	8	83	1	
1996	W	--	--	--	--	--	--	70	5	2
1997	H	42	3	3	63	21	4	--	--	--
1997	W	--	--	--	61	55	4	74	5	4
1998	H	50	2	3	65	5	5	74	1	--
1998	W	42	6	2	--	--	--	77	1	--
1999	H	38	8	2	64	2	9	--	--	--
1999	W	--	--	--	59	2	8	--	--	--
2000	H	40	12	2	57	13	7	--	--	--
2000	W	40	14	2	56	48	6	--	--	--
2001	H	39	1	--	59	2	6	--	--	--
2001	W	36	8	2	56	10	4	71	1	--
2002	H	37	11	3	52	7	5	--	--	--
2002	W	--	--	--	54	3	9	70	2	3
2003	H	44	1	--	50	8	8	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	1	--	--	--	--

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Twisp River males										
2007	W	39	1	--	54	10	3	--	--	--
2008	H	41	26	3	58	28	5	70	1	
2008	W	41	1	--	56	9	4	--	--	--
2009	H	37	6	2	58	6	6	--	--	--
2009	W	35	2	2	54	3	3	--	--	--
Mean	H	40	11	3	58	9	6	71	1	--
Mean	W	39	5	2	57	16	5	73	3	4
Twisp River females										
1992	H	--	--	--	61	13	3	--	--	--
1992	W	--	--	--	--	--	--	67	1	--
1993	H	--	--	--	61	4	5	71	2	1
1993	W	--	--	--	56	3	4	--	--	--
1994	H	--	--	--	61	2	1	--	--	--
1995	W	--	--	--	--	--	--	69	1	--
1996	H	--	--	--	61	57	4	75	3	6
1996	W	--	--	--	64	1	--	69	4	3
1997	H	--	--	--	61	20	2	--	--	--
1997	W	--	--	--	63	38	3	75	10	6
1998	H	--	--	--	66	8	2	66	1	--
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	--	--	--	59	18	4	67	1	--
2002	W	--	--	--	56	6	5	74	3	5
2003	H	--	--	--	60	8	4	73	1	--
2004	H	--	--	--	60	46	4	71	5	4
2004	W	--	--	--	60	20	3	68	1	--
2005	H	--	--	--	60	12	3	71	1	--
2005	W	--	--	--	61	8	6	74	2	0
2006	H	--	--	--	61	32	3	68	1	--

Table 3.20. Continued.

Brood	Origin	Mean length (POH; cm), number (*N*) and standard deviation (SD) of adult returns								
		Age-3			Age-4			Age-5		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Twisp River females										
2006	W	--	--	--	61	26	4	69	8	3
2007	H	--	--	--	57	3	4	--	--	--
2007	W	--	--	--	63	7	4	73	3	1
2008	H	--	--	--	60	57	3	70	1	--
2008	W	--	--	--	57	10	3	70	1	--
2009	H	--	--	--	59	21	3	73	1	--
2009	W	--	--	--	54	5	7	65	1	--
Mean	H	--	--	--	60	21	3	69	2	4
Mean	W	--	--	--	60	14	4	71	4	3

Contribution to Fisheries

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

Table 3.21. Adult returns of coded-wire tagged Methow Hatchery spring Chinook by brood and release location. Recoveries are expanded by tag rate and sample rate, and include estimated impacts of post-release mortality in selective fisheries for adipose-present releases (broods 2000-2009). 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
Mean	237	204	1	0	0	8	27	28	505	7.8
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	32	12.5
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	72	136	0	0	0	0	0	3	211	1.4
2003	10	34	0	0	0	0	0	0	44	0.0
2004	35	124	0	0	0	2	0	19	180	11.7
2005	11	34	0	0	0	0	0	0	45	0.0

Table 3.21. Continued.

Brood	Hatchery	Spawning ground	Ocean fishery			Freshwater fishery			Total	Harvest %
			Comm.	Sport	Tribal	Comm.	Sport	Tribal		
					Twisp spring Chinook					
2006	42	181	0	0	0	0	0	25	248	10.1
2007	18	19	0	0	0	0	0	0	37	0.0
2008	56	285	0	0	0	8	68	29	446	23.5
2009	40	81	0	0	0	0	1	1	123	1.6
Mean	31	74	0	0	0	1	5	6	115	10.3
					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	63	638	0	0	0	0	0	2	703	0.3
2002	153	473	0	0	0	1	3	1	631	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
Mean	75	266	1	0	0	4	22	17	384	9.1

Migration Timing

The 2015 spring Chinook migration to Wells Dam was monitored between 4 May and 15 June to evaluate the run composition and age structure of returning adults (Attachment C), and to facilitate hatchery broodstock collection. However, migration timing evaluations at Wells Dam represent pooled hatchery and wild stocks because individual hatchery stocks (e.g., Methow Composite, WNFH) have received the same external mark, and CWT's are typically not collected or extracted from fish sampled at Wells Dam. Using these data, wild fish (NOR) migrated to Wells Dam similarly to hatchery fish (HOR) within each age class, but an average of two days earlier than HOR fish overall (Table 3.22). However, comparisons of age-3 fish were not robust because of the small sample size of wild fish. Although the migration trend is typical, the arrival time at Wells Dam was closer for hatchery and wild fish from the 2010-2015 broods, than for the 2006-2009 broods, and mean arrival time in 2015 was the earliest in the past decade, most likely due to low flow conditions in the Columbia River during the adult migration period (Figure 3.4).

Table 3.22. Mean migration date of hatchery (H) and wild (W) spring Chinook to Wells Dam by age and percentile of the overall age-class return in 2015. Totals do not include fish of unknown origin or age.

Age	Origin	Percentile					Mean	*N*
		10	25	50	75	90		
3	H	19-May	26-May	28-May	2-Jun	3-Jun	28-May	122
3	W	27-May	27-May	30-May	3-Jun	3-Jun	30-May	2
4	H	6-May	11-May	13-May	19-May	28-May	15-May	1,280
4	W	6-May	11-May	13-May	20-May	27-May	15-May	119
5	H	4-May	6-May	11-May	19-May	26-May	12-May	54
5	W	4-May	6-May	6-May	11-May	19-May	8-May	17
All	H	6-May	11-May	13-May	20-May	28-May	16-May	1,456
All	W	6-May	6-May	12-May	19-May	27-May	14-May	138

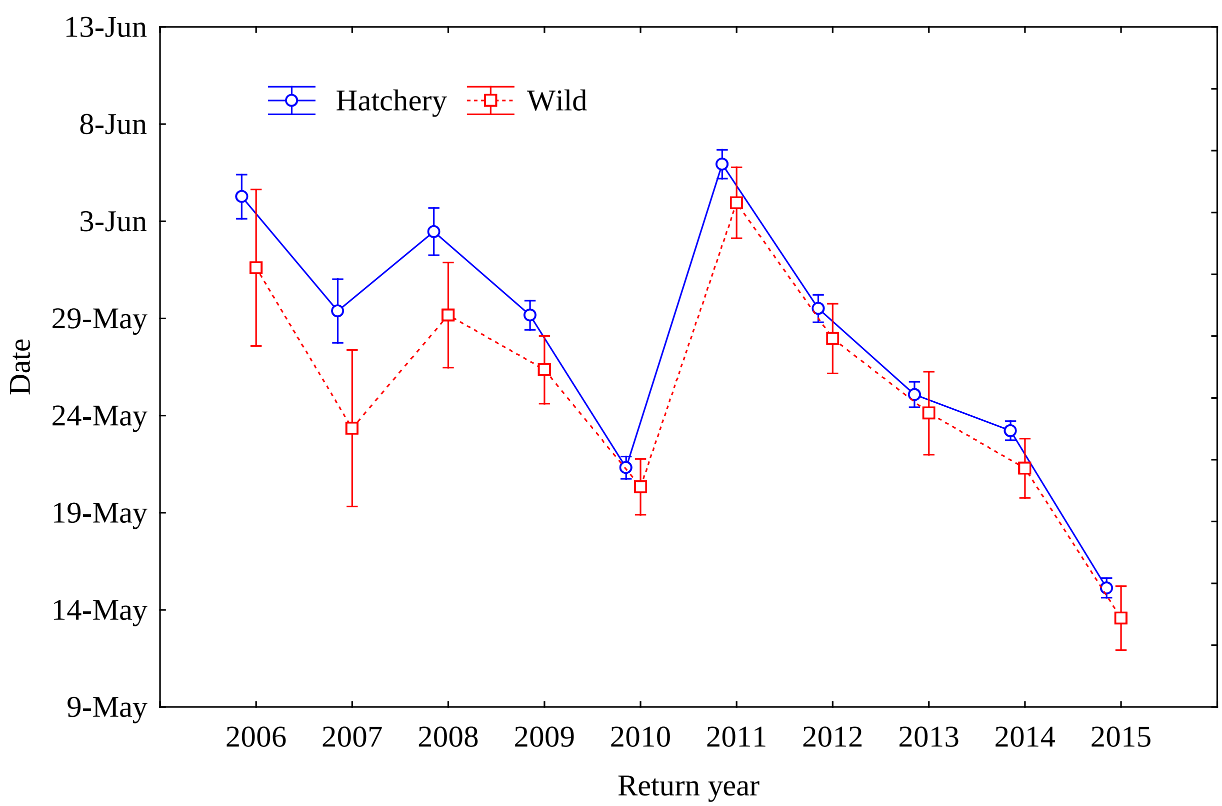

Figure 3.4. Mean (+/- 95% CI) arrival day of the year at Wells Dam of hatchery and wild spring Chinook by return year.

Straying

Stray rates from adult returns of Chewuch and Twisp River releases were much higher than the 5% target value specified in the M&E Plan (2014) in most years (Table 3.23). Conversely, adult returns from Methow River (on-station) releases rarely strayed into non-target recipient populations (Table 3.23). Methow Hatchery spring Chinook have constituted less than 5% of the spawning escapement by return year of other spring Chinook populations, and have not been recorded in other spring Chinook populations since the 2010 return year (Table 3.24).

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

Release location	Brood year	Total return	Recipient (stray) area			% stray
			Stream	Hatchery	Total	
Chewuch River	1992	39	0	1	1	2.56
Chewuch River	1993	115	3	19	22	19.13
Chewuch River	1994	3	0	0	0	0.00
Chewuch River	1996	37	4	15	19	51.35
Chewuch River	1997	330	27	39	66	20.00
Chewuch River	2001	703	321	0	321	45.66
Chewuch River	2002	631	299	1	300	47.54
Chewuch River	2003	55	22	0	22	40.00
Chewuch River	2004	194	70	0	70	36.08
Chewuch River	2005	307	148	0	148	48.21
Chewuch River	2006	730	262	1	263	36.03
Chewuch River	2007	811	338	1	339	41.80
Chewuch River	2008	1,068	409	0	409	38.30
Chewuch River	2009	357	116	2	118	33.05
Chewuch River	Mean	384	144	6	150	32.84
Methow River	1993	191	1	0	1	0.52
Methow River	1994	1	0	0	0	0.00
Methow River	1995	122	0	0	0	0.00
Methow River	1996	501	8	0	8	1.60
Methow River	1997	716	1	0	1	0.14
Methow River	1998	924	- -	- -	0	0.00
Methow River	1999	144	7	0	7	4.86
Methow River	2000	32	- -	- -	0	0.00
Methow River	2001	503	23	0	23	4.57
Methow River	2002	603	26	2	28	4.64
Methow River	2003	52	0	0	0	0.00
Methow River	2004	304	33	0	33	10.86

Table 3.23. Continued.

Release location	Brood year	Total return	Recipient (stray) area			% stray
			Stream	Hatchery	Total	
Methow River	2005	326	10	1	11	3.37
Methow River	2006	1,707	106	1	107	6.27
Methow River	2007	515	10	0	11	2.14
Methow River	2008	1,206	39	0	39	3.23
Methow River	2009	761	13	2	15	1.97
Methow River	Mean	506	18	0	17	2.60
Twisp River	1992	21	0	0	0	0.00
Twisp River	1993	27	1	3	4	14.81
Twisp River	1994	5	0	0	0	0.00
Twisp River	1996	274	17	33	50	18.25
Twisp River	1997	54	0	6	6	11.11
Twisp River	1998	21	2	8	10	47.62
Twisp River	1999	60	20	25	45	75.00
Twisp River	2000	145	37	12	49	33.79
Twisp River	2001	43	7	0	7	16.28
Twisp River	2002	211	66	59	125	59.24
Twisp River	2003	44	13	2	15	34.09
Twisp River	2004	180	27	7	34	18.89
Twisp River	2005	45	9	1	10	22.22
Twisp River	2006	248	59	27	86	34.68
Twisp River	2007	37	7	9	16	43.24
Twisp River	2008	446	129	39	168	37.67
Twisp River	2009	124	24	29	53	42.74
Twisp River	Mean	117	25	15	40	29.98

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

Return year	Chiwawa River	Entiat River	Similkameen River
1997	0	1[a]	0
2000	0	6 (3.43)	3
2001	0	3 (0.62)	10
2002	0	5 (1.35)	5
2003	0	6 (2.32)	1
2006	2 (0.38)	4 (1.56)	0
2007	0	6 (2.45)	0
2010	6 (0.55)	12 (2.44)	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0	0	0
Mean *N* (%)	0.67 (0.08)	3.82 (1.29)	1.58 (--)

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

Smolt to Adult Survival and HRR

The overall smolt-to-adult return of Methow Hatchery spring Chinook stocks was calculated from expanded CWT recoveries and averaged 0.22%, 0.33%, and 0.23%, respectively for Twisp, Methow, and Chewuch river releases (Table 3.25). Survival (SAR) of 2009 brood fish released into the Chewuch River was slightly above the overall mean value for that location, but releases into the Methow and Twisp rivers were below overall mean values. Similarly, HRR values calculated as the number of adult returns divided by the number of adult broodstock, were also higher than average for the 2009 brood Chewuch releases, but below the long-term average for Methow and Twisp river releases (Table 3.25). Only Methow River releases had an overall mean HRR value above the target value of 4.5 (Table 3.25).

Table 3.25. Smolt to adult return (SAR) and hatchery replacement rate (HRR) of Methow Hatchery spring Chinook stocks by brood year. Methow River brood years 1998 and 2000 represent combined Methow and Chewuch River releases.

Brood year	Number of broodstock	Smolts released	Adult returns	SAR (%)	# Smolts/ adult	HRR
			Twisp spring Chinook			
1992	25	35,853	21	0.059	1,707	0.8
1993	45	116,749	27	0.023	4,324	0.6
1994	5	19,835	5	0.025	3,967	1.0
1995	-	-	-	-	-	-
1996	51	76,687	275	0.359	279	5.4
1997	15	26,714	54	0.202	495	3.6
1998	11	15,470	22	0.142	703	2.0
1999	40	67,408	61	0.091	1,105	1.5
2000	64	74,717	173	0.232	432	2.7
2001	36	51,652	44	0.085	1,174	1.2
2002	15	20,541	120	0.589	171	8.0
2003	36	50,627	49	0.097	1,033	1.4
2004	72	71,617	174	0.243	412	2.4
2005	24	27,658	46	0.166	601	1.9
2006	28	45,892	250	0.545	184	8.9
2007	40	54,096	37	0.068	1,462	0.9
2008	43	78,656	446	0.567	176	10.4
2009	41	67,031	123	0.183	545	3.0
Mean	35	53,012	113	0.216	1,104	3.3
			Methow spring Chinook			
1993	99	210,849	192	0.091	1,098	1.9
1994	2	4,477	1	0.022	4,477	0.5
1995	14	28,878	122	0.422	237	8.7
1996	150	202,947	500	0.246	406	3.3
1997	266	332,484	821	0.247	405	3.1
1998	181	435,670	2,300	0.528	189	12.7
1999	182	180,775	145	0.080	1,247	0.8
2000	255	266,392	852	0.320	313	3.3
2001	135	130,787	508	0.388	257	3.8
2002	110	181,235	599	0.331	303	5.4

Table 3.25. Continued.

Brood year	Number of broodstock	Smolts released	Adult returns	SAR (%)	# Smolts/ adult	HRR
			Methow spring Chinook			
2003	47	48,831	57	0.117	857	1.2
2004	81	65,146	316	0.485	206	3.9
2005	122	156,633	328	0.209	478	2.7
2006	182	211,717	1,714	0.810	124	9.4
2007	90	119,407	515	0.431	232	5.7
2008	137	175,699	1,206	0.686	146	8.8
2009	160	288,013	680	0.236	424	4.3
Mean	130	178,820	639	0.332	671	4.7
			Chewuch spring Chinook			
1992	26	40,881	39	0.095	1,048	1.5
1993	115	284,165	116	0.041	2,450	1.0
1994	12	11,854	2	0.017	5,927	0.2
1995	-	-	-	-	-	-
1996	95	91,672	37	0.04	2,478	0.4
1997	68	132,759	295	0.222	450	4.3
2001	164	261,284	738	0.282	354	4.5
2002	169	254,238	699	0.275	364	4.1
2003	94	127,614	61	0.048	2,092	0.6
2004	165	204,906	194	0.095	1,056	1.2
2005	170	232,811	308	0.132	756	1.8
2006	152	154,381	735	0.476	210	4.8
2007	98	126,055	811	0.643	155	8.3
2008	203	260,344	1,608	0.618	162	7.9
2009	83	149,863	357	0.238	420	4.3
Mean	115	166,631	429	0.230	1,280	3.2

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 (2009 brood) was < 1 and substantially less than the overall mean NRR values in all three subbasins (Table 3.26).

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

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
			Chewuch River				
1992	422	0	25	14	41	0.1	1.5
1993	184	2	69	21	96	0.5	1.0
1994	63	0	15	3	19	0.3	0.2
1995	6	1	12	19	34	5.5	- -
1996	8	0	13	86	102	12.8	0.4
1997	123	1	662	55	921	7.5	4.3
1998	7	11	23	19	63	9.0	12.7
1999	21	0	2	0	2	0.1	- -
2000	83	6	47	13	70	0.8	3.3
2001	2,493	0	205	49	265	0.1	4.5
2002	666	2	91	60	169	0.3	4.1
2003	490	0	15	33	53	0.1	0.7
2004	335	4	63	11	92	0.3	1.2
2005	508	5	282	8	313	0.6	1.8
2006	513	25	191	224	575	1.1	4.8
2007	277	8	183	33	287	1.0	8.3
2008	252	22	76	16	142	0.6	7.9
2009	771	3	89	6	107	0.1	4.3
Mean	401	5	115	37	186	2.3	3.8
			Methow River				
1992	924	0	44	43	92	0.1	- -
1993	760	5	79	32	120	0.2	1.9
1994	172	0	23	7	30	0.2	0.5
1995	27	1	54	18	77	2.8	8.7
1996	15	1	30	230	268	17.9	3.3
1997	152	21	348	50	538	3.5	3.1
1998	23	16	34	2	61	2.6	12.7
1999	70	3	2	0	4	0.1	0.8
2000	639	5	197	39	257	0.4	3.3

Table 3.26. Continued.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
Methow River							
2001	7,588	3	183	36	231	0.0	3.8
2002	1,730	0	96	93	209	0.1	5.5
2003	605	0	59	27	95	0.2	1.2
2004	821	13	163	35	248	0.3	3.9
2005	747	11	239	3	269	0.4	2.7
2006	1,070	33	363	198	774	0.7	9.4
2007	697	9	268	27	390	0.6	5.7
2008	584	16	57	19	119	0.2	8.8
2009	1,741	0	103	18	131	0.1	4.3
Mean	1,020	8	130	49	217	1.7	4.7
Twisp River							
1992	317	0	54	37	96	0.3	0.8
1993	426	5	27	17	50	0.1	0.6
1994	74	0	13	9	23	0.3	1.0
1995	12	0	26	12	39	3.2	- -
1996	8	0	11	56	69	8.6	5.4
1997	72	0	460	109	729	10.2	3.6
1998	11	24	72	21	138	12.6	2.0
1999	25	0	7	0	7	0.3	1.5
2000	256	37	264	17	339	1.3	2.7
2001	890	27	77	20	129	0.1	1.2
2002	241	0	47	35	91	0.4	8.0
2003	43	0	1	0	1	0.0	1.4
2004	341	8	48	9	76	0.2	2.4
2005	121	4	28	5	39	0.3	1.9
2006	165	19	179	61	338	2.1	8.9
2007	105	5	105	8	151	1.4	0.9
2008	166	10	56	4	91	0.6	10.4
2009	129	5	25	3	35	0.3	3.0
Mean	189	8	83	24	136	2.3	3.3

Proportionate Natural Influence

The Hatchery Scientific Review Group (HSRG) developed guidelines for salmon and steelhead hatchery programs intended to provide a foundation of hatchery reform principals that should aid hatcheries in the Pacific Northwest in meeting conservation and sustainable harvest goals (HSRG 2008). These guidelines provide a means of indexing the genetic risk of hatchery programs to natural populations by calculating the proportionate natural influence (PNI) of a population. The PNI is calculated as: (the proportion of natural origin fish within the broodstock [pNOB])/(pHOS+pNOB). A PNI value > 0.5 indicates that genetic selection pressures from the natural environment have a stronger influence on the population than those from the hatchery environment. A PNI value ≥ 0.67 was recommended for conservation programs. Data necessary to calculate PNI values are derived from spawning ground surveys (i.e., pHOS; Attachment C) and from hatchery broodstock sampling (i.e., pNOB; Attachment C). For the 2003-2015 broods, mean PNI was higher in the Twisp Basin than in the Methow or Chewuch river basins (Table 3.27). However, values for all basins are low and indicate that most genetic selection pressure on progeny produced from naturally spawning adults comes from the hatchery environment (Table 3.27).

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

Year	Chewuch				Methow				Twisp				Total			
	H	W	pHOS	PNI	H	W	pHOS	PNI	H	W	pHOS	PNI	H	W	pHOS	PNI
2003	465	25	0.95	0.37	597	8	0.99	0.29	18	25	0.42	0.47	1,080	58	0.95	0.33
2004	289	46	0.86	0.04	622	199	0.76	0.07	98	243	0.29	0.28	1,009	488	0.67	0.11
2005	289	219	0.57	0.37	526	221	0.70	0.30	34	87	0.28	0.66	849	527	0.62	0.36
2006	378	135	0.74	0.05	942	128	0.88	0.01	100	65	0.61	0.00	1,420	328	0.81	0.02
2007	203	74	0.73	0.00	545	152	0.78	0.07	65	40	0.62	0.45	813	266	0.75	0.09
2008	166	86	0.66	0.01	412	172	0.71	0.01	126	40	0.76	0.44	704	298	0.7	0.08
2009	500	271	0.65	0.03	1,480	261	0.85	0.02	97	32	0.75	0.18	2,077	564	0.79	0.03
2010	341	155	0.69	0.04	1,331	290	0.82	0.03	96	156	0.38	0.07	1,768	601	0.75	0.03
2011	499	370	0.57	0.15	1,391	432	0.76	0.13	85	159	0.35	0.17	1,975	961	0.67	0.14
2012	261	81	0.76	0.21	691	63	0.92	0.19	146	56	0.72	0.23	1,098	200	0.85	0.20
2013	226	89	0.72	0.34	505	113	0.82	0.33	117	39	0.75	0.42	848	241	0.78	0.34
2014	267	166	0.62	0.41	1,130	251	0.82	0.32	157	92	0.63	0.49	1,556	507	0.75	0.36
2015	152	134	0.53	0.32	749	154	0.83	0.22	54	110	0.33	0.66	955	398	0.71	0.27
Mean	311	142	0.7	0.18	840	188	0.82	0.15	92	88	0.53	0.35	1,242	418	0.75	0.18

Section 4: Wells Hatchery Summer Chinook Salmon

This section focuses on the last brood for which hatchery releases were completed during the report year (2013 brood) and includes data from historic broods where appropriate. Broodstock for the Wells Hatchery summer Chinook Salmon program are primarily collected from the Wells Hatchery volunteer channel trap, but natural origin fish have also been retained from the West fish ladder at Wells Dam in some years. Broodstock collected from these sources have been used for multiple programs in addition to the Wells Hatchery yearling and subyearling releases. These programs include the Turtle Rock Hatchery yearling and subyearling programs, Lake Chelan sport fish enhancement program, and reintroduction programs in the Entiat and Yakima rivers. Because broodstock for these various programs are from the same collection location, most adult-based metrics (e.g., extraction rate, length at age, sex composition, etc.,) include all broodstock spawned, regardless of program. However, fecundity and ELISA values are generated solely from female Chinook spawned for the Wells yearling program because individual females for subyearling programs are not typically incubated separately to allow individual fecundity estimates and the relatively short rearing period for subyearling program fish negates the need for virology sampling of adult females.

4.1: Broodstock Collection and Sampling

Trapping of the 2013 brood of Wells Hatchery summer Chinook Salmon occurred between 1 July and 28 August, 2013. During this time a total of 2,639 hatchery origin and 15 wild origin fish were collected. The overall collection represented 33% of the estimated Chinook Salmon escapement between the Wells and Rocky Reach Dams during the trapping period. Most fish collected have been used for broodstock, but recent collections of adult fish have included surplus fish provided to local tribes (Table 4.1).

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

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

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 2013 return year, age-4 and age-5 fish were 49% and 46% of the total fish sampled, respectively. Natural origin fish within this return year had a greater mean fork length than hatchery fish of the same sex and age for most comparisons but sample sizes of wild fish were very low, precluding robust comparisons for all sex, age, and origin groupings (Table 4.2).

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

Return year	Sex	Age-3			Age-4			Age-5			Age-6		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
Hatchery origin													
1998	M	58	39	7	75	130	9	95	216	8	101	19	10
1998	F	--	--	--	80	34	5	95	424	5	98	32	9
1999	M	62	115	10	77	202	8	94	80	8	98	17	9
1999	F	74	20	6	83	119	6	91	169	6	98	58	6
2000	M	54	68	7	77	363	7	92	136	8	109	1	--
2000	F	72	1	--	86	214	6	92	227	5	98	8	12
2001	M	63	20	11	81	453	7	95	85	8	100	2	8
2001	F	--	--	--	83	316	5	94	198	5	99	12	6
2002	M	60	13	10	80	281	6	95	279	7	100	6	6
2002	F	78	2	7	85	81	5	94	524	5	100	10	3
2003	M	61	14	6	80	61	7	92	343	8	98	6	15
2003	F	--	--	--	84	71	5	92	494	5	97	23	4
2004	M	70	12	9	79	267	5	89	127	7	99	39	10
2004	F	68	1	--	80	106	5	90	197	5	97	104	5
2005	M	64	5	8	80	214	7	88	332	7	93	9	9
2005	F	--	--	--	82	128	5	90	443	5	95	26	5
2006	M	62	9	9	79	228	7	92	218	7	91	51	8
2006	F	75	1	--	83	94	5	92	327	5	94	120	7
2007	M	70	61	6	78	150	7	93	255	8	95	15	10
2007	F	75	11	3	81	88	6	91	415	5	93	39	5
2008	M	71	128	10	82	328	7	94	74	9	103	23	6
2008	F	75	16	6	85	262	5	91	233	5	98	58	6
2009	M	66	119	7	79	269	8	90	148	8	99	6	10
2009	F	71	4	2	86	226	6	91	362	5	94	20	7
2010	M	65	50	11	79	377	7	92	55	8	--	--	--
2010	F	74	4	7	82	275	5	91	87	5	96	9	5
2011	M	65	97	6	76	159	8	89	223	10	101	4	5
2011	F	82	5	10	82	78	6	89	428	7	91	10	8
2012	M	70	27	7	78	240	6	89	60	7	90	6	8
2012	F	79	2	3	81	209	4	88	109	5	93	16	6
2013	M	71	27	4	78	225	6	90	105	7	--	--	--
2013	F	76	1	--	82	119	4	90	225	5	90	3	9
Natural origin													
1998	M	65	11	4	85	29	7	99	11	6	--	--	--
1998	F	--	--	--	85	18	7	98	9	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
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	--	--	--	--

Sex Ratio and Fecundity

The long-term mean sex ratio of fish retained for broodstock (excludes released fish) favored females (Table 4.3), although the sex ratio of the 2013 brood was slightly skewed towards male fish. Of the 2013 brood female Chinook sampled, overall fecundity (4,509) was less than the long-term mean fecundity (Table 4.3), but greater than the mean fecundity value (4,487) used to estimate broodstock collection quotas in the broodstock collection protocols. Fecundity data from the 2013 brood was only collected from hatchery origin females because no wild females were spawned for the Wells yearling Chinook program.

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

Return year	Hatchery Chinook Salmon				Wild Chinook Salmon				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
1994	303	290	NS	1.04:1	3	4	NS	0.75:1	1.04:1	NS
1995	417	493	NS	0.85:1	41	67	NS	0.61:1	0.82:1	NS
1996	382	289	4,373	1.32:1	46	44	5,553	1.05:1	1.29:1	4,672
1997	147	210	4,788	0.70:1	22	36	4,702	0.61:1	0.69:1	4,778
1998	433	521	5,236	0.83:1	77	37	--	2.08:1	0.91:1	5,236
1999	438	408	4,015	1.07:1	112	124	3,703	0.90:1	1.03:1	3,974
2000	594	486	4,418	1.22:1	82	100	4,673	0.82:1	1.15:1	4,448
2001	590	549	4,693	1.07:1	11	11	5,415	1.00:1	1.07:1	4,713
2002	582	633	5,225	0.92:1	5	2	--	2.50:1	0.92:1	5,225
2003	441	602	4,638	0.73:1	28	14	4,368	2.00:1	0.76:1	4,630
2004	465	426	NS	1.09:1	57	94	NS	0.61:1	1.00:1	NS
2005	590	629	4,220	0.94:1	45	43	3,897	1.05:1	0.94:1	4,198
2006	525	567	4,414	0.93:1	34	31	4,155	1.10:1	0.93:1	4,421
2007	515	586	4,605	0.88:1	34	21	2,906	1.62:1	0.90:1	4,616
2008	593	605	4,652	0.98:1	106	71	4,370	1.49:1	1.03:1	4,639
2009	599	626	4,412	0.96:1	172	148	5,047	1.16:1	1.00:1	4,478
2010	532	457	4,244	1.16:1	82	78	4,371	1.05:1	1.15:1	4,259
2011	489	539	4,348	0.91:1	109	85	4,195	1.28:1	0.96:1	4,323
2012	355	352	3,894	1.00:1	50	58	4,856	0.86:1	1.01:1	3,948
2013	363	354	4,093	1.03:1	11	4	NS	2.75:1	1.04:1	4,093
Mean	468	481	3,894	0.97:1	56	54	4,444	1.05:1	0.98:1	4,509

ELISA Monitoring

Adult female Chinook Salmon spawned for yearling-release programs are screened for the presence of Bacterial Kidney Disease (BKD) using an ELISA assay. Results of this test are grouped into four general categories based on the optical density (OD) of each sample. Overall, 95% of OD values from sampled females have been in the Below-low category. For the 2013 brood, 19 females had OD values in the Low category (Table 4.4), but all other sampled females were in the Below-low category.

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

Return year	Below-low	Low	Med	High	Total number
	<0.099	0.099 - 0.199	0.20 - 0.449	> 0.450	
1993	100.0	0.0	0.0	0.0	132
1994	97.2	1.7	0.0	1.1	181
1995	78.8	12.9	1.8	6.5	170
1996	99.0	0.5	0.0	0.5	196
1997	88.6	7.6	1.1	2.7	185
1998	91.7	5.5	1.8	0.9	109
1999	99.1	0.9	0.0	0.0	106
2000	87.9	8.8	3.3	0.0	91
2001	99.3	0.0	0.0	0.7	139
2002	93.9	2.4	0.0	3.7	82
2003	94.9	2.0	2.0	1.0	99
2004	95.0	5.0	0.0	0.0	20
2005	98.9	0.5	0.0	0.5	190
2006	100.0	0.0	0.0	0.0	167
2007	98.2	1.8	0.0	0.0	166
2008	99.6	0.4	0.0	0.0	239
2009	99.7	0.3	0.0	0.0	272
2010	98.6	1.4	0.0	0.0	293
2011	98.7	1.3	0.0	0.0	312
2012	97.8	0.7	0.7	0.7	138
2013	86.1	13.9	0.0	0.0	137
Mean	95.4	3.3	0.5	0.87	163

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 97.8% and 95.3% 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 (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 2013 brood fish were similar, with subyearling program fish below the goal and yearling program fish above the release goal, although releases of both groups fell within ± 10% of the release goals (Table 4.5).

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

Brood year	Subyearling Chinook Salmon				Yearling Chinook Salmon			
	CWT code (s)	Mark rate	Release start	Released	CWT code (s)	Mark rate	Release start	Released
1992	- -	- -	- -	- -	5005	0.632	27-Apr-94	331,353
1993	5145	0.978	28-Jun-94	187,382	4610, 5702	0.973, 0.953	15-Apr-95	388,248
1994	5546, 5703	0.972	15-Jun-95	450,935	5324, 5838	0.932, 0.979	1-Apr-96	365,000
1995	5841, 6044	0.954	13-Jun-96	408,000	4129, 4130	0.984, 0.977	1-Apr-97	290,000
1996	6054, 6323	0.978	18-Jun-97	473,000	0134, 0217	0.984	15-Apr-98	356,707
1997	602	0.975	4-Jun-98	541,923	611	0.981	15-Apr-99	381,687
1998	1018	0.978	18-Jun-99	370,617	1061	0.955	18-Apr-00	457,770
1999	267	0.964	19-Jun-00	363,600	468	0.98	16-Apr-01	312,098
2000	775	1	20-Jun-01	498,500	995	0.978	15-Apr-02	343,423
2001	1423	0.98	17-Jun-02	376,027	1549	0.991	21-Apr-03	185,200
2002	1368, 1370	0.992, 0.981	16-Jun-03	473,100	1890	0.987	19-Apr-04	306,810
2003	2370, 2371	0.955, 0.898	11-May-04	425,271	2580	0.979	11-Apr-05	313,509
2004	2285, 2286	0.978, 0.963	18-May-05	471,123	2799, 2864	0.947	21-Apr-06	312,980
2005	3298, 3299	0.978, 0.990	12-May-06	430,203	3596	0.967	23-Apr-07	333,587
2006	3385, 3386	0.992, 0.993	16-May-07	396,538	3799	0.994	6-Apr-08	311,880
2007	3872, 3871	0.978, 0.990	13-May-08	402,527	4390, 4287	0.989	15-Apr-09	310,063
2008	4876	0.972	11-May-09	427,131	5092, 5093	0.984	16-Apr-10	336,881
2009	5375	0.995	14-May-10	471,286	5280, 5364	0.707	15-Apr-11	446,313
2010	5775	1	19-May-11	442,821	5770, 5964	0.999	16-Apr-12	350,218
2011	6370	0.998	15-May-12	492,777	5773	0.998	15-Apr-13	289,998
2012	6505, 6463	0.984, 0.984	20-May-13	499,365	6504	0.998	15-Apr-14	318,902
2013	6680	0.989	16-May-14	443,636	6678	0.988	16-Apr-15	339,236
Mean	--	0.978	--	430,751	--	0.953	--	335,539

Juvenile Size and Condition at Release

Size-at-release fork length and weight targets for DCPUD program fish are described in Murdoch et al. (2012). The 2013 brood yearling program fish were 101% of the target release fork length goal. Mean size-at-release of the 2013 brood subyearling program fish was 78.8 mm, but specific size-at-release targets for this program have not yet been developed that reflect the earlier release date initiated with the 2008 brood (Table 4.6). The coefficient of variation (CV) for the 2013 brood subyearling and yearling programs were at or below the target value of nine.

Table 4.6. Mean fork length (mm), weight (g), coefficient of variation (CV), standard deviation (SD), and condition factor (K) of Wells Hatchery summer Chinook Salmon by release type and brood year prior to release. Data for subyearling program fish from the 1998-2007 broods are from mid-June release groups, and data from the 2008-2012 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
Target	162.0	- -	9.0	45.4	- -	- -	10.0	1.07
				Wells subyearling Chinook Salmon				
1998	116.5	8.0	6.9	18.3	5.1	27.9	24.7	1.16
1999	122.1	9.2	7.5	24.5	6.6	27.1	18.5	1.35
2000	111.3	8.5	7.6	16.9	4.9	28.9	26.7	1.23

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	7.62	8.6	2.3	26.7	52.9	1.24
2009	84.0	10.9	12.9	6.7	- -	- -	67.5	1.13
2010	89.4	6.8	7.6	10.0	2.3	23.0	45.6	1.40
2011	92.1	5.9	6.4	9.1	1.9	21.1	49.9	1.17
2012	87.6	6.4	7.3	8.2	1.7	21.2	55.4	1.22
2013	78.8	4.8	6.0	5.8	1.1	19.0	77.6	1.19
Target	- -	- -	- -	- -	- -	- -	- -	- -

Survival Estimates

Survival from fertilization to release of the 2013 brood subyearling fish was less than the target value, but survival of yearling program fish was greater than the target value (Table 4.7). Apparent survival was lower than expected for subyearling program fish primarily because of losses after the eyed egg stage. Overall, yearling program fish were above the overall survival target value in most years, while subyearling program fish were below the target in most years. Yearling program fish typically did not meet this target value 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
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

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									
2008	- -	- -	95.0	84.2	99.4	94.3	94.1	- -	75.3
2009	- -	- -	94.9	98.6	92.0	86.9	85.9	- -	80.3
2010	- -	- -	95.2	98.4	82.8	81.7	80.4	- -	75.3
2011	- -	- -	94.8	99.9	85.6	85.5	85.5	- -	90.0
2012	--	--	95.0	99.5	92.3	81.6	81.5	--	77.1
2013	--	--	96.1	90.0	91.1	90.8	90.5	--	78.3
Target	90.0	85.0	92.0	98.0	97.0	93.0	90.0	95.0	81.0

4.3: Life History Monitoring

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

Age at Maturity

Wells Hatchery summer Chinook Salmon are considered a segregated harvest program where comparisons between the hatchery stock and naturally-produced fish are not applicable. Releases of subyearling fish from the 2008 brood returned primarily as age-4 adults, while those released as yearlings returned equally at age-4 and age-5 (Table 4.8). Overall, yearling fish typically had an older total age at return than subyearling program fish, but subyearling fish spent more of their life in saltwater (Figure 4.1).

Table 4.8. Proportion of adult returns by total age of the 1992-2008 broods of Wells Hatchery summer Chinook Salmon released as subyearling or yearling migrants. Data is from RMIS recovery of CWTs in the broodstock, freshwater fisheries (sport, commercial, and tribal), and spawning ground categories, although juvenile fish captured within their year of release were excluded.

Brood year	Release type	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Total
1992	Yearling	0.000	0.029	0.357	0.559	0.052	0.002	411
1993	Subyearling	0.000	0.040	0.404	0.537	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	0.743	0.273	0.000	0.000	11
1994	Yearling	0.000	0.019	0.372	0.576	0.029	0.000	104
1995	Subyearling	0.014	0.101	0.671	0.207	0.000	0.000	70
1995	Yearling	0.007	0.040	0.314	0.569	0.07	0.000	651
1996	Subyearling	0.052	0.211	0.661	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	0.838	0.082	0.000	0.000	106
1997	Yearling	0.006	0.019	0.476	0.480	0.018	0.001	3,535
1998	Subyearling	0.054	0.105	0.743	0.100	0.000	0.000	110
1998	Yearling	0.005	0.015	0.272	0.556	0.151	0.001	2,360
1999	Subyearling	0.005	0.115	0.391	0.446	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	0.424	0.522	0.000	0.000	99
2000	Yearling	0.000	0.002	0.233	0.586	0.176	0.003	4,236
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	0.091	0.811	0.091	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	0.772	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	0.527	0.089	0.002	0.000	1,722
2005	Yearling	0.015	0.070	0.364	0.518	0.033	0.000	1,025
2006	Subyearling	0.037	0.199	0.644	0.119	0.000	0.000	366
2006	Yearling	0.003	0.045	0.547	0.395	0.009	0.000	4,964
2007	Subyearling	0.004	0.218	0.718	0.061	0.000	0.000	821
2007	Yearling	0.006	0.095	0.429	0.438	0.032	0.000	792
2008	Subyearling	0.105	0.391	0.450	0.054	0.000	0.000	367
2008	Yearling	0.003	0.100	0.446	0.446	0.005	0.000	2,593
Mean	Subyearling	0.024	0.150	0.620	0.202	0.003	0.000	338
Mean	Yearling	0.008	0.045	0.367	0.524	0.055	0.001	1,829

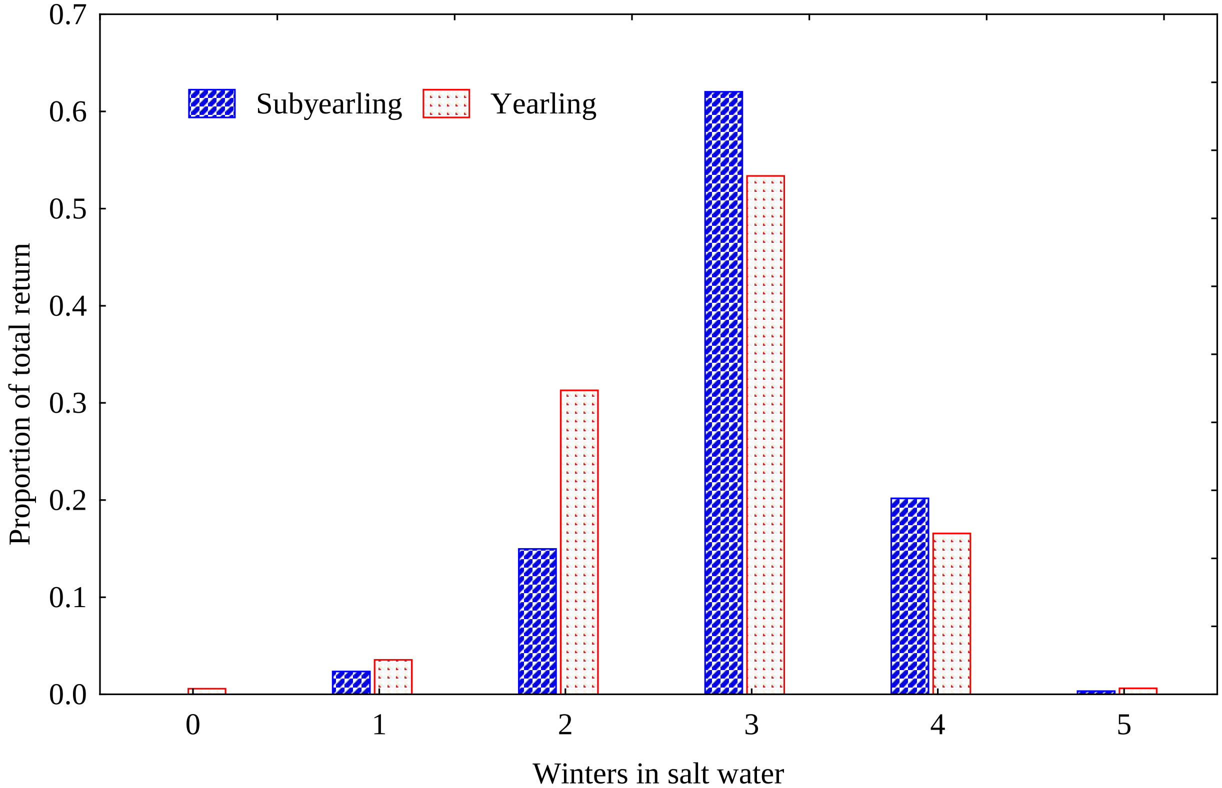

Figure 4.1. Mean salt water age of Wells Hatchery summer Chinook Salmon from the 1992-2008 broods released as subyearling or yearling program fish. Adult returns are from broodstock, spawning ground, or freshwater sport, commercial, and tribal fisheries.

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 1993-2008 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	--	--	--
Mean	M	57	24	5	67	20	6	77	4	4	78	1	0
Mean	F	69	6	7	68	28	3	74	18	4	75	5	3
Yearling program													
1993	M	41	22	5	59	2	11	73	145	7	78	16	6
1993	F	--	--	--	60	5	4	75	127	4	78	53	6
1994	M	33	1	0	61	17	9	75	24	7	--	--	--
1994	F	--	--	--	63	2	0	72	30	4	76	3	14

Table 4.9. Continued.

Brood	Sex	Mean length (POH; cm) of adult returns											
		Age-3			Age-4			Age-5			Age-6		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
					Yearling program								
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	--	--	--
Mean	M	45	19	3	62	149	5	73	115	6	77	12	6
Mean	F	--	--	--	66	76	4	76	191	29	78	27	5

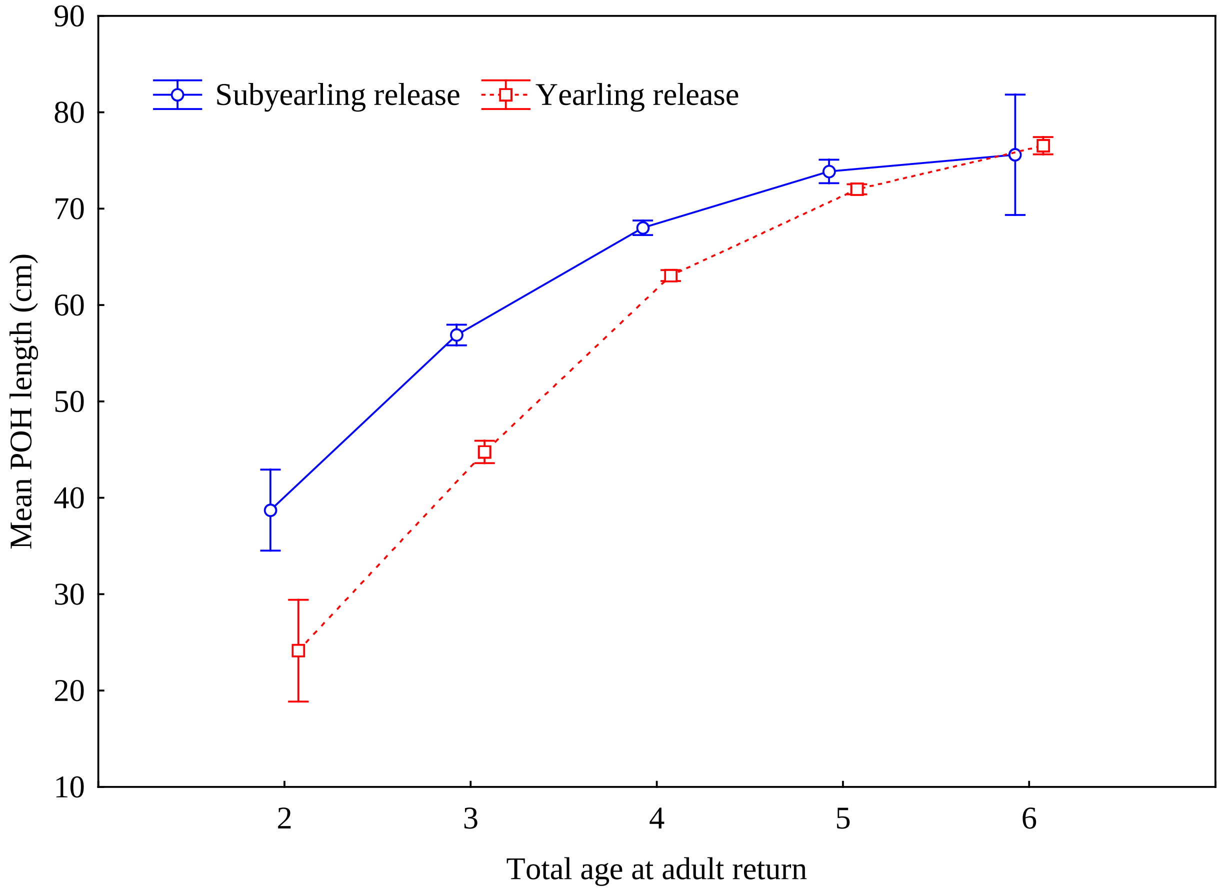

Figure 4.2. Mean (+/- 95% CI) POH length (cm) of adult returns of summer Chinook Salmon released as subyearling or yearling fish from the 1992-2008 broods.

Contribution to Fisheries

Based on expanded CWT recoveries, most Wells Hatchery summer Chinook Salmon prior to 2002 were captured in ocean fisheries, regardless of release type (Table 4.10). However, for the last five broods for which complete adult return data are available (2004-2008), harvest was primarily in freshwater fisheries for subyearling releases (36% freshwater; 28% ocean) and about equal between the fishery categories for yearling releases (30% freshwater; 33% ocean; Table 4.10). This change is primarily attributable to increases in freshwater sport and tribal harvest rates, and a reduction in ocean harvest.

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

Brood year	Broodstock		Freshwater commercial		Freshwater sport		Freshwater tribal		Ocean fisheries		Spawning ground		Total
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*
Subyearling program													
1993	22	54	0	0	0	0	3	7	16	39	0	0	41
1994	8	57	0	0	0	0	3	21	3	21	0	0	14
1995	67	53	1	1	0	0	3	2	53	42	2	2	126
1996	288	42	2	0	5	1	3	0	309	45	79	12	686
1997	47	20	1	0	23	10	6	3	125	54	30	13	232
1998	44	13	3	1	19	5	8	2	236	68	39	11	349
1999	97	19	0	0	30	6	32	6	325	63	31	6	515
2000	64	34	2	1	5	3	20	11	88	47	8	4	187
2001	294	37	15	2	62	8	68	8	338	42	24	3	801
2002	37	29	3	2	16	13	21	16	51	40	0	0	128
2003	66	43	7	5	12	8	15	10	49	32	3	2	152
2004	248	35	13	2	114	16	106	15	166	23	63	9	710
2005	628	27	80	3	304	13	499	21	597	26	232	10	2,340
2006	138	26	38	7	49	9	112	21	168	31	32	6	537
2007	279	22	57	4	158	12	282	22	433	34	60	5	1,269
2008	169	32	4	1	57	11	124	24	148	28	24	5	526
Mean	156	34	14	2	53	7	82	12	194	40	39	6	538
Yearling program													
1993	1,175	72	2	0	14	1	60	4	322	20	54	3	1,627
1994	95	67	0	0	0	0	10	7	35	25	2	1	142
1995	415	37	7	1	37	3	21	2	457	41	183	16	1,120
1996	530	34	2	0	7	0	0	0	734	46	309	20	1,582
1997	1,538	14	25	0	217	2	81	1	7,191	67	1,730	16	10,782
1998	1,238	12	21	0	420	4	223	2	7,670	76	565	6	10,137
1999	176	11	3	0	259	16	103	6	1,000	62	66	4	1,607
2000	2,200	26	143	2	990	12	649	8	3,992	48	345	4	8,319
2001	900	33	96	4	340	12	177	7	1,171	43	39	1	2,723
2002	1,303	34	149	4	578	15	401	10	1,325	35	75	2	3,831
2003	566	29	45	2	242	13	305	16	721	38	43	2	1,922
2004	1,414	39	146	4	479	13	505	14	923	26	147	4	3,614
2005	595	35	49	3	137	8	203	12	665	39	66	4	1,715
2006	2,592	38	394	6	669	10	1,167	17	1,785	26	159	2	6,766
2007	385	33	45	4	160	14	193	16	386	33	14	1	1,183
2008	1,209	27	103	2	705	16	521	12	1895	42	97	2	4,530
Mean	1,021	34	77	2	328	9	289	8	1,892	42	243	6	3,850

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 1992-2008 broods averaged 7.9%, slightly above the 5% target value (Table 4.11). Returns from Wells releases seldom constituted greater than 5% of the spawning escapement by return year of other recipient summer Chinook populations, with the exception of the Chelan River, which is not considered an extant population (Table 4.12).

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

Brood year	Total brood return	Recipient category			% stray
		Stream	Hatchery	Total	
1992	835	61	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	11,014	1,760	129	1,889	17.15
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	2,452	74	115	189	7.71
2008	5,056	121	356	477	9.43
Mean	4,179	270	58	328	7.85

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

Return year	Entiat River		Methow River		Okanogan River		Similkameen River		Wenatchee River		Chelan River	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
1997	0	0.0	0	0.0	61	11.3	0	0.0	0	0.0	0	0.0
1998	0	0.0	42	6.2	12	4.4	0	0.0	3	0.1	0	0.0
1999	0	0.0	6	0.6	0	0.0	0	0.0	0	0.0	16	11.3
2000	0	0.0	40	3.4	110	8.3	0	0.0	8	0.2	124	26.5
2001	0	0.0	509	18.4	329	7.2	21	0.3	0	0.0	332	33.8
2002	42	8.5	532	11.5	310	5.1	0	0.0	11	0.1	173	29.8
2003	65	9.4	146	3.7	25	1.0	0	0.0	21	0.2	87	20.9
2004	0	0.0	47	2.1	47	1.6	7	0.2	6	0.1	25	5.9
2005	11	3.0	83	3.2	69	1.5	9	0.2	14	0.2	83	15.9
2006	0	0.0	48	1.8	13	0.2	0	0.0	0	0.0	32	7.6
2007	3	1.2	46	3.4	3	0.1	0	0.0	0	0.0	22	11.8
2008	12	3.6	67	3.4	70	1.9	7	0.2	6	0.1	46	9.9
2009	3	1.3	128	7.3	78	1.8	0	0.0	0	0.0	0	0.0
2010	10	2.3	71	2.9	71	2.5	4	0.1	6	0.1	98	8.8
2011	0	0.0	32	1.1	12	0.2	5	0.1	0	0.0	38	3.2
2012	0	0.0	52	1.8	29	0.6	0	0.0	0	0.0	42	2.9
2013	0	0.0	93	2.6	0	0.0	0	0.0	0	0.0	18	1.1
2014	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Mean	8	1.6	108	4.1	69	2.7	3	0.1	4	0.1	63	10.5

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 1.0% and 0.1%, respectively (Table 4.13). The mean HRR, calculated as the number of adult returns divided by the number of adult broodstock, was also much greater for yearling releases (19.0) than for subyearling releases (2.0). Yearling releases on average were greater than the M&E Plan HRR target of 5.3, while subyearling releases were below the M&E Plan HRR target of 2.2. For the latest brood for which adult return information is expected to be complete (2008 brood) the HRR rate was above expected values for yearling releases, but below the expected value for subyearling releases.

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

Brood	Program	Broodstock	Released	Adult returns	SAR (%)	HRR
1992	Yearling	205	331,353	527	0.159	2.6
1993	Yearling	225	388,248	1,568	0.404	7.0
1994	Yearling	185	365,000	138	0.038	0.7
1995	Yearling	144	290,000	1,099	0.379	7.6
1996	Yearling	193	356,707	1,556	0.436	8.1
1997	Yearling	189	381,867	10,529	2.757	55.7
1998	Yearling	207	457,770	9,608	2.099	46.4
1999	Yearling	176	312,098	1,571	0.503	8.9
2000	Yearling	175	343,423	8,101	2.359	46.3
2001	Yearling	248	185,200	2,723	1.470	11.0
2002	Yearling	182	306,810	3,796	1.237	20.9
2003	Yearling	144	313,509	1,922	0.613	13.3
2004	Yearling	176	312,980	3,614	1.155	20.5
2005	Yearling	164	333,587	1,657	0.497	10.1
2006	Yearling	200	311,880	6,750	2.164	33.8
2007	Yearling	179	318,902	1,174	0.368	6.6
2008	Yearling	191	336,881	4,513	1.345	23.7
Mean	Yearling	187	332,130	3,579	1.058	19.0
1993	Subyearling	173	187,382	40	0.021	0.2
1994	Subyearling	255	450,935	15	0.003	0.1
1995	Subyearling	221	408,000	120	0.029	0.5
1996	Subyearling	336	473,000	671	0.142	2.0
1997	Subyearling	274	541,923	228	0.042	0.8
1998	Subyearling	179	370,617	341	0.092	1.9
1999	Subyearling	212	363,600	498	0.137	2.3
2000	Subyearling	257	498,500	186	0.037	0.7
2001	Subyearling	210	376,027	801	0.213	3.8
2002	Subyearling	265	473,100	128	0.027	0.5
2003	Subyearling	224	425,271	152	0.036	0.7
2004	Subyearling	293	471,123	710	0.151	2.4
2005	Subyearling	262	430,203	2,337	0.543	8.9
2006	Subyearling	333	396,538	537	0.135	1.6
2007	Subyearling	334	499,365	1,262	0.253	3.8
2008	Subyearling	279	427,131	526	0.123	1.9
Mean	Subyearling	257	424,545	535	0.124	2.0

Section 5: Wells Hatchery Summer Steelhead

This section focuses on the last brood for which releases were completed during the report year (2014 brood) and includes data from historic broods where appropriate. Broodstock for the Wells Hatchery summer steelhead program are primarily collected from the fish ladders at Wells Dam, or more recently, from the Twisp River Weir. Returning adult steelhead from the Wells Hatchery and Twisp River programs support salmon recovery goals and provide harvest opportunities in years of high abundance.

5.1: Broodstock Collection and Sampling

Trapping of the 2014 brood of Wells Hatchery summer steelhead occurred between 5 August and 29 October 2013. During this time a total of 204 hatchery origin fish were retained, representing 4.4% of the estimated hatchery fish returning to Wells Dam during the trapping period. However, an accidental discharge of cleaning compound at the hatchery prior to spawning resulted in the mortality of an estimated 178 of the retained hatchery origin adults. Because of this, additional hatchery origin adults were collected from the Wells Hatchery volunteer ladder, the Omak weir, through hook and line angling, or were Wells-stock adults collected and transferred from Ringold Hatchery. Overall, pre-spawn mortality totaled 37% of the total hatchery fish collected and no mortality of wild fish from either the Twisp River or Omak Creek programs was recorded (Table 5.1).

Table 5.1. Collection of summer steelhead at Wells Hatchery and the prespawn mortality (PSM), surplus mortality (Mort), spawning (Spawn), and release (Rel.) totals by brood and fish origin (hatchery or wild). Table excludes fish released prior to the implementation of spawning. Wild fish for the Omak Creek program are listed under the Wells Hatchery broodstock category starting with the 2014 brood.

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

Table 5.1. Continued.

Brood year	Wild steelhead					Hatchery steelhead					Total spawned
	Total	PSM	Mort	Spawn	Rel.	Total	PSM	Mort	Spawn	Rel.	
Wells Hatchery broodstock											
2008	94	2	0	88	4	277	6	0	264	7	352
2009	73	1	2	67	3	302	27	0	230	45	297
2010	91	2	2	69	18	277	6	39	232	0	301
2011	56	3	0	50	3	270	4	10	256	0	306
2012	63	4	3	56	0	261	23	22	216	0	272
2013	19	2	0	17	0	230	5	12	212	0	229
2014	0	0	0	0	0	452	179	33	240	0	240
Mean	55	2	0	49	3	316	21	8	277	10	326
Okanogan broodstock											
2014	0	0	0	0	0	42	2	0	40	0	40
Omak Creek broodstock											
2014	16	1	0	15	0	0	0	0	0	0	15
Twisp River broodstock											
2011	26	1	0	25	0	--	--	--	--	--	25
2012	26	0	0	26	0	--	--	--	--	--	26
2013	23	0	0	23	0	--	--	--	--	--	23
2014	23	0	0	23	0	--	--	--	--	--	23
Mean	25	0	0	24	0	--	--	--	--	--	24

Age at Maturity

Most summer steelhead collected for Wells Hatchery broodstock were fish that had spent a single winter in salt water before returning to Wells Dam (1-salt; Table 5.2). The overall mean proportion of 1-salt and 2-salt fish was similar between hatchery and natural origin fish, although differences within years were observed. Broodstock collected at the Twisp River weir were entirely natural origin fish, and were mostly 1-salt fish on average, while the overall mean salt-age for the four broods sampled favored 2-salt fish (Table 5.2).

Table 5.2. Proportion of hatchery and wild steelhead by saltwater age retained for broodstock at Wells Dam or the Twisp River weir (T).

Brood	Hatchery			Wild		
	1-salt	2-salt	*N*	1-salt	2-salt	*N*
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	--	--	--
Average	0.55	0.45	303	0.53	0.47	52
2011 T	--	--	--	0.16	0.84	25
2012 T	--	--	--	0.54	0.46	26
2013 T	--	--	--	0.29	0.71	23
2014 T	--	--	--	0.57	0.43	23
Average T	--	--	--	0.39	0.61	24

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, and the sex ratio of the 2014 brood was generally similar to the overall mean for hatchery fish, but wild fish were skewed towards female fish at a higher rate than the overall mean likely due to the small sample size of fish retained for broodstock (Table 5.3). Of the female fish spawned, fecundity of the 2014 brood was below the overall mean values for hatchery and wild females at both collection locations and below mean values used in broodstock protocol calculations for hatchery (5,836) and wild (5,522) females (Table 5.3).

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

Brood year	Hatchery steelhead				Wild steelhead				Overall	
	Male	Female	Mean fecundity	Sex ratio	Male	Female	Mean fecundity	Sex ratio	Sex ratio	Mean fecundity
2000	146	188	5,497	0.78:1	17	24	4,813	0.71:1	0.77:1	5,452
2001	149	174	5,686	0.86:1	16	10	4,815	1.60:1	0.90:1	5,639
2002	174	200	6,255	0.87:1	4	14	5,921	0.29:1	0.83:1	6,232
2003	119	155	6,236	0.77:1	9	18	6,954	0.50:1	0.74:1	6,312
2004	186	133	4,743	1.40:1	53	65	4,627	0.82:1	1.21:1	4,704
2005	147	169	6,214	0.87:1	24	45	6,098	0.53:1	0.80:1	6,191
2006	156	154	6,550	1.01:1	37	54	6,028	0.69:1	0.93:1	6,377
2007	147	197	5,027	0.75:1	18	26	5,644	0.69:1	0.74:1	5,108
2008	142	128	6,090	1.11:1	34	56	5,612	0.61:1	0.96:1	5,946
2009	130	128	6,221	1.02:1	30	40	5,752	0.75:1	0.95:1	6,102
2010	138	139	5,930	0.99:1	44	29	5,366	1.52:1	1.08:1	5,836
2011	129	141	6,153	0.91:1	20	33	6,681	0.61:1	0.86:1	6,252
2012	121	136	5,868	0.89:1	21	46	5,615	0.46:1	0.78:1	5,796
2013	78	151	5,950	0.52:1	8	11	6,372	0.73:1	0.53:1	5,975
2014	115	125	5,257	0.92:1	--	--	--	--	0.92:1	5,257
Mean	138	155	5,845	0.91:1	24	34	5,736	0.75:1	0.87:1	5,812
Okanogan broodstock										
2014	19	21	5,615	0.90:1	--	--	--	--	0.90:1	5,615
Omak Creek broodstock										
2014	--	--	--	--	7	8	4,248	0.88:1	0.88:1	4,248
Twisp River broodstock										
2011	--	--	--	--	13	12	5,258	1.08:1	1.08:1	5,258
2012	--	--	--	--	13	13	5,629	1.00:1	1.00:1	5,629
2013	--	--	--	--	9	14	5,825	0.64:1	0.64:1	5,825
2014	--	--	--	--	10	13	4,573	0.77:1	0.77:1	4,573
Mean	--	--	--	--	11	13	5,321	0.87:1	0.87:1	5,321

5.2: Within-hatchery Monitoring

Juvenile Marking and Tagging

Juvenile releases from the 2014 brood were slightly below the overall release goal of 408,000 fish for PUD programs (Tonseth 2013), but releases in most locations slightly exceeded release goals (range 0.3-13.0%; Table 5.4). The overall release goal was under the target because releases into the Columbia River were only 81% of the target goal of 160,000 fish. Steelhead releases into the Okanogan River basin from the 2014 brood were marked and tagged with adipose fin-clips, and coded- and blank-wire tags in the snout or in the caudle peduncle in various combinations to evaluate mark and tag loss. Twisp River releases received a snout CWT, but were not adipose fin-clipped (Table 5.5). All other fish released by Wells Hatchery were marked with an adipose fin-clip but were not tagged prior to release.

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

Brood	Release location										Total
	Methow R.	Twisp R.	Chewuch R.	Columbia R.	Similk. R.	Omak Cr.	Okan. R.	Salmon Cr.	Aeneas Cr.	Antoine Cr.	
1992	392,815	0	0	0	51,360	0	67,120	0	0	0	511,295
1993	324,200	0	0	0	49,800	0	46,110	0	0	0	420,110
1994	359,170	0	0	0	50,350	0	40,875	0	0	0	450,395
1995	242,400	0	0	18,200	37,500	0	30,000	0	0	0	328,100
1996	310,480	0	0	17,500	49,800	0	49,920	0	0	0	427,700
1997	127,020	126,000	125,300	64,703	50,002	10,005	39,998	0	0	0	543,028
1998	350,431	113,583	116,403	34,099	71,820	10,635	73,401	4,900	0	0	775,272
1999	139,900	136,680	138,300	47,782	68,580	19,440	46,235	10,395	0	0	607,312
2000	116,830	109,950	99,490	0	82,415	19,950	112,605	13,800	0	0	555,040
2001	94,020	84,475	85,615	0	39,545	0	87,310	0	0	0	390,965
2002	96,420	105,323	117,495	0	50,860	25,110	65,920	0	0	0	461,128
2003	80,580	117,545	78,205	0	57,750	9,855	12,000	0	0	0	355,935
2004	86,041	96,405	82,280	0	68,940	10,000	0	0	0	0	343,666
2005	99,820	107,245	119,500	0	146,862	0	0	0	0	0	473,427
2006	96,219	111,770	107,545	0	106,024	0	16,403	13,120	0	0	451,081
2007	99,464	100,446	92,670	0	108,477	0	14,200	25,105	0	0	440,362
2008	103,236	104,903	100,373	0	120,230	0	0	26,403	0	0	455,145
2009	125,801	74,766	92,760	0	61,090	0	0	40,000	0	0	394,417
2010	154,370	93,227	83,858	0	73,623	0	3,960	50,000	0	0	459,038
2011	205,330	41,170	0	31,860	10,080	41,423	0	50,000	0	0	379,863

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.	
2012	99,933	51,473	0	55,541	26,350	9,070	0	40,032	2,010	0	275,339
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

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

Brood year	Mark	CWT code(s)	Release location	Mark rate	*N*
1998	BWT		Chewuch River	Unknown	105,903
1998	BWT		Twisp River	Unknown	113,583
1999	BWT		Chewuch River	0.9312	138,300
1999	BWT		Twisp River	0.9312	136,680
1999	FB		Methow River	0.9574	139,900
2000	FB		Methow Basin	0.9222	326,270
2001	LYE		Methow Basin	0.9411	264,110
2002	RYE		Twisp River	0.8679	105,323
2003	LYE		Twisp River	0.8970	117,545
2004	LYE		Twisp River	0.9324	96,405
2005	Ad+CWT	632895	Methow Basin	0.9712	235,126
2005	Ad+CWT	632895	Okanogan Basin	0.9712	85,180
2005	RYE		Methow Basin	0.9290	91,439
2006	LYE		Methow Basin	0.9317	86,994
2007	Ad+CWT	633398	Methow Basin	0.6229	185,654
2007	RYE		Methow Basin	0.9012	106,926
2008	LYE		Methow Basin	0.9035	89,469
2009	Ad+CWT	635083	Okanogan Basin	0.5493	101,090
2009	LYE		Methow Basin	0.8789	76,044
2009	RYE		Methow Basin	0.8789	13,419
2010	Ad+CWT		Methow Basin	0.9521	232,796
2010	LYE		Methow Basin	0.7512	98,659

Table 5.5. Continued.

Brood year	Mark	CWT code(s)	Release location	Mark rate	*N*
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

Juvenile Size and Condition at Release

Size-at-release fork length and weight targets for DCPUD program fish are described in Murdoch et al. (2012). The 2014 brood Wells and Twisp program fish were 99.3% and 86.2% of the target release fork length goal, respectively (Table 5.6). Coefficient of variation (CV) of fork length for Wells 2014 brood releases was higher than the target value of nine for both Wells and Twisp program releases.

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

Brood	Stock	Fork length (mm)			Weight (g)				K
		Mean	SD	CV	Mean	SD	CV	FPP	
1999	Wells HxH	189.4	18.1	9.6	76.8	20.8	27.1	5.9	1.13
1999	Wells HxW	195.4	18.2	9.3	83.0	21.3	25.7	5.4	1.11
2000	Wells HxH	172.9	22.4	13.0	60.0	21.3	35.5	7.5	1.16
2000	Wells HxW	178.6	20.9	11.7	66.7	21.7	32.5	6.7	1.17
2001	Wells HxW	181.8	26.9	14.8	72.9	30.5	41.9	6.2	1.21
2001	Wells HxH	194.7	15.4	7.9	87.3	20.7	23.7	5.1	1.18

Table 5.6. Continued.

Brood	Stock	Fork length (mm)			Weight (g)				K
		Mean	SD	CV	Mean	SD	CV	FPP	
2002	Wells HxW	187.9	24.1	12.8	73.1	26.7	36.5	6.2	1.10
2002	Wells HxH	188.5	19.6	10.4	75.9	22.6	29.8	5.9	1.13
2003	Wells HxW	163.2	29.7	18.2	62.1	--	--	7.3	1.42
2003	Wells HxH	189.9	19.4	10.2	79.9	23.4	29.3	5.6	1.16
2004	Wells HxW	184.5	24.3	13.1	72.2	29.1	40.2	6.2	1.14
2004	Wells HxH	192.4	21.7	11.3	82.4	28.8	34.9	5.4	1.15
2005	Wells HxW	168.4	16.4	9.7	53.3	15.0	28.3	8.5	1.12
2005	Wells HxH	171.4	18.7	10.9	56.8	17.1	30.1	7.9	1.13
2006	Wells HxW	181.5	20.4	11.2	68.8	23.1	33.1	6.5	1.15
2006	Wells HxH	180.6	21.9	12.1	65.7	22.3	33.8	6.9	1.12
2007	Wells HxW	178.3	16.1	9.0	63.5	17.4	27.4	7.1	1.12
2007	Wells HxH	181.4	15.3	8.4	67.3	16.6	24.7	6.7	1.13
2008	Wells HxW	189.7	22.4	11.8	77.0	27.2	35.3	5.8	1.13
2008	Wells HxH	185.7	24.5	13.1	69.0	26.8	38.9	6.5	1.10
2009	Wells HxW	183.4	29.2	15.9	74.8	35.7	47.7	6.1	1.21
2009	Wells HxH	172.5	28.6	16.6	63.6	32.5	51.1	7.1	1.24
2010	Wells HxW	199.3	22.9	11.5	83.5	27.7	33.2	5.4	1.05
2010	Wells HxH	192.3	23.7	12.3	76.8	27.3	35.5	5.9	1.08
2011	Wells HxW	189.9	24.9	13.1	72.5	28.6	39.4	6.3	1.06
2011	Wells HxH	187.3	24.9	13.5	72.8	31.3	43.0	6.2	1.11
2011	Twisp WxW	179.1	28.7	16.0	61.5	25.1	40.8	7.4	1.07
2012	Wells HxW	187.9	25.9	13.8	75.3	31.7	42.1	6.0	1.14
2012	Twisp WxW	182.3	18.1	9.9	67.9	19.2	28.3	6.7	1.12
2012	Omak WxW	179.0	30.4	17.0	56.4	24.9	44.1	6.6	0.98
2013	Wells HxW	194.2	25.4	13.1	81.2	33.3	41.1	5.6	1.11
2013	Twisp WxW	159.9	18.8	11.8	43.5	14.1	32.5	10.5	1.06
2013	Omak WxW	179.3	27.8	15.5	62.3	24.6	39.5	7.8	1.08
2014	Wells SN	189.7	24.1	12.7	74.1	28.2	38.0	6.1	1.08
2014	Twisp WxW	164.6	18.4	11.2	47.3	15.8	33.4	9.6	1.06
2014	Omak WxW*	172.7	24.1	13.9	55.8	22.2	39.7	8.1	1.08
Target		191.0	17.2	9.0	75.6	- -	- -	6.0	1.08

Survival Estimates

Collection to spawning survival of adult broodstock has historically been above target levels. However, survival of the 2014 brood adults for the Wells programs was very low because of a single event at the hatchery where a cleaning chemical was inadvertently introduced into the adult holding pond, resulting in significant loss of hatchery origin adult broodstock (Table 5.7). Survival from fertilization to release of the 2014 brood summer steelhead was below the target value (Table 5.7) for the Wells and Twisp River programs. For Wells program fish, survival was impacted primarily during the ponding-to-release period, specifically after fish have been moved to the earthen rearing ponds. Twisp River progeny were reared in raceways at Wells Hatchery and were primarily impacted during the post-ponding rearing period.

Table 5.7. Survival (%) of Wells Hatchery, Twisp River (T), and Omak Creek (O) 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							
1999	99.3	99.8	77.0	98.0	97.1	96.6	92.8	- -	70.0
2000	98.0	99.2	85.2	97.4	98.1	98.7	95.3	- -	79.1
2001	98.0	99.0	83.9	98.6	97.0	96.9	95.0	- -	78.6
2002	98.0	99.5	82.2	96.2	99.0	98.7	97.8	- -	77.3
2003	99.0	99.3	83.5	99.9	93.6	77.6	73.5	- -	61.3
2004	98.6	98.4	86.2	94.0	99.4	95.5	94.0	- -	76.1
2005	96.4	99.5	87.4	95.9	96.9	92.2	85.7	- -	71.8
2006	95.2	93.3	86.6	99.5	92.7	89.8	80.4	- -	69.3
2007	92.8	95.8	80.8	99.0	97.8	96.2	85.6	- -	68.4
2008	98.9	96.6	85.2	85.2	99.3	99.5	92.9	- -	67.5
2009	91.2	93.1	79.8	99.1	97.7	97.2	88.4	- -	69.9
2010	97.2	98.4	84.6	99.7	93.7	90.2	84.0	- -	67.9
2011	95.4	94.0	83.9	80.4	92.1	91.3	76.5	- -	51.6
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
2014-O	87.5	100.0	79.3	94.7	96.8	96.4	95.8	99.8	72.0
2011-T	92.3	100.0	81.3	100.0	95.3	94.7	93.9	99.9	76.4
2012-T	100.0	100.0	90.5	84.8	96.1	95.8	95.2	99.9	73.0
2013-T	100.0	100.0	75.0	94.6	92.4	91.5	90.9	100.0	64.5
2014-T	100.0	100.0	94.8	97.4	93.2	87.7	83.3	99.9	76.9
Target	90	85	92	98	97	93	90	95	81

5.3 Natural Origin Juvenile Productivity

Smolt trapping was conducted in 2015 in the Methow and Twisp Rivers to estimate the productivity (smolts per redd) of steelhead spawning in the Methow and Twisp river basins.

Because steelhead juveniles spend an extended period of time rearing in freshwater prior to migrating seaward, smolts captured each spring from these rivers represent multiple broods of spawning adults. Complete productivity estimates, therefore, require multiple years of smolt monitoring.

Emigrant and Smolt Estimates

Methow Trap

Trapping at the Methow River trap site (rkm 30) occurred between 18 February and 25 November 2015 using smolt traps with a 1.5 m or 2.4 m cone diameter. These traps were operated in two different trapping positions depending on the river discharge at the site. Trapping at the Methow site was interrupted on two occasions for a total of three days because of low flow or fire activity. 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 448 wild summer steelhead emigrants (smolt and transitional) between 18 February and 30 June in the Methow River trap, with peak capture on 22 April (N = 41). We PIT tagged 428 wild steelhead emigrants and released 426 after subtracting shed tags and mortalities. Overall mortality of emigrant steelhead totaled two of the 448 fish captured (0.45%). We also captured 3,295 hatchery steelhead juveniles at the Methow River trap, and no mortalities occurred.

We captured 35 wild fry and 67 wild summer steelhead parr between 18 February and 25 November at the Methow trap site. Steelhead parr greater than 65 mm and in good physical condition were PIT tagged (N = 54), and no mortalities or shed tags of any captured fry or parr occurred prior to release.

No significant flow regression model resulted from several mark/recapture trials conducted with steelhead in 2015 at the Methow trap. Because no significant regression model existed for steelhead, we used the yearling Chinook flow models to estimate steelhead production for each trap position. Combining estimates from all positions, we calculated that 19,215 (± 3,980, 95% CI) summer steelhead emigrated from the Methow River basin. However, an additional 619 migrants were estimated from redds located downstream of the trap in 2011 through 2014, which resulted in a total estimated migration of 19,834 (± 4,044, 95% CI) summer steelhead from the Methow River basin in 2015. We estimated the entire 2011 brood migration to be 12,501 (± 3,008, 95% CI) fish, including 453 migrants that were expected from redds (N = 31) located downstream of the Methow trap in 2011. The mean number of emigrants (smolts) produced per redd in the Methow Basin for the 2003-2011 broods was 17 (Table 5.8).

Twisp Trap

Trapping at the Twisp River trap site (rkm 2) occurred between 26 February and 20 November 2015 using a rotary screw smolt trap with a 1.5 m cone diameter. Trapping at the Twisp site was interrupted for a total of 102 days between 22 July and 31 October because of low flow, but production estimates were likely not affected since steelhead emigration is typically over by 22 July. 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 274 wild summer steelhead emigrants at the Twisp trap between 26 February and 30 June. Peak capture occurred on 22 April ($N = 37$). We PIT tagged 241 wild steelhead emigrants and released 239 after subtracting two shed tags (Attachment A). Non-migrant summer steelhead captured at the Twisp trap included 97 wild fry and 408 wild parr. We PIT tagged 384 steelhead parr with a fork length greater than 65 mm and released 383 of these fish with PIT tags after subtracting one mortality (Attachment A). Overall mortality of fry ($N = 0$) and parr ($N = 1$) represented 0.20% of the total fry and parr captured ($N = 505$). Wild summer steelhead parr had a mean fork length of 100.6 mm. A total of 3,641 juvenile hatchery summer steelhead were captured at the Twisp River trap, of which, 26 died prior to release (0.71%).

Numerous mark/recapture trials were conducted with wild summer steelhead at the Twisp site in 2015, but none of them contained more than 50 fish. A flow efficiency relationship from previous years' release groups was used to estimate steelhead emigration at the Twisp site in 2015. The flow model regression ($y = -0.00029758x + 0.410040455$; $P < 0.01$, $r^2 = 0.52$) was used to estimate that 5,427 (± 1,486, 95% CI) wild summer steelhead migrated past the Twisp River trap between 26 February and 30 June 2015. An additional 366 migrants were estimated from redds located downstream of the trap in 2011 through 2014, which provides a total estimated migration of 5,793 (± 1,535, 95% CI) summer steelhead from the Twisp River in 2015. Most 2015 migrants were age-2 fish (78.4%) from the 2013 brood (Table 5.8). Combining numbers from the last four years, the entire 2011 brood migration is estimated to be 6,367 (± 2,016, 95% CI) fish, which includes 135 expected migrants produced from redds ($N = 4$) that were identified downstream of the Twisp trap in 2011. The mean number of emigrants (smolts) produced per redd in the Twisp Basin for the 2004-2011 broods was 34 (Table 5.8).

Table 5.8. Estimated emigrant-per-redd and egg-to-emigrant survival of Methow Basin steelhead. Methow Basin and Twisp River estimates are for redds deposited upstream and downstream of the respective trap sites. 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	--	5,843	--	--
Twisp	2013	140	835,660	183	4,542	--	--	4,725	--	--
Twisp	2014	144	759,465	288	--	--	--	288	--	--
Mean 2003-2010		329	1,983,714	101	4,338	1,592	141	6,161	0.62	34
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	--	25,625	--	--
Methow	2013	810	4,834,890	1,649	15,155	--	--	16,804	--	--
Methow	2014	878	4,630,572	1,008	--	--	--	1,008	--	--
Mean 2003-2010		1,202	7,133,587	1,778	11,529	3,061	360	16,729	0.29	17

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 1.3% and 1.1%, respectively for the 2006-2013 release years (Table 5.9). However, sample sizes for some release years and trap sites were likely too low to produce accurate estimates.

Table 5.9. 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	--	1	0.30
Mean 2006-2013					1.29
		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	--	2	0.34
Mean 2006-2013					1.14

In-stream PIT Tagging

Natural origin juvenile steelhead were primarily PIT tagged in the Twisp subbasin in 2015 (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, calculating parr to smolt survival rates is premature for most of the fish tagged in the last six 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 5.10).

Table 5.10. In-stream PIT tagging and recovery at Rocky Reach Dam juvenile bypass detector of natural origin juvenile summer steelhead (SHR) from the Methow, Twisp, and Chewuch rivers. Cormack-Jolly-Seber (CJS) survival estimates with standard error (SE) and probability of survival were obtained from the Data Access Real Time website (DART) maintained by the University of Washington's School of Aquatic and Fishery Sciences.

Tag year	SHR tagged	Recovered at Rocky Reach juvenile bypass						CJS survival (SE)
		2011	2012	2013	2014	2015	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	0.23 (0.02)
2014	2,890	--	--	--	--	253	253	0.14 (0.02)
2015	3,803	--	--	--	--	--	--	--
				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	0.21 (0.04)
2014	0	--	--	--	--	--	--	--
2015	35	--	--	--	--	--	--	--
				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	253	0.21 (0.02)
2014	0	--	--	--	--	--	--	--
2015	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 5 March and 8 June 2015 in the Twisp River and in the Methow River between about the town of Winthrop and the confluence with the Columbia River. Some smaller sections of tributaries were also surveyed if spawning areas existed downstream of active PIT tag arrays.

Escapement estimates

Overall, a total of 2,433 steelhead were estimated to have spawned in the Methow River Basin in 2015 (Table 5.11), with most spawners found in the Lower Methow subbasin (*N* = 1,110). The 2015 escapement estimates were derived from redd counts and from PIT tag detections at arrays located throughout the Methow Basin (Attachment D). Escapement estimates in all subbasins except the Upper Methow in 2015 were higher than the overall mean values (Table 5.11).

Table 5.11. Estimated steelhead escapement by sample year for the four major subbasins in the Methow River watershed. Upper and Lower Methow subbasins are divided by the Highway 20 bridge in Winthrop, Washington.

Sample year	Steelhead escapement				Total
	Upper Methow	Lower Methow	Twisp	Chewuch	
2002	774	128	648	210	1,760
2003	1,185	574	1,204	529	3,492
2004	1,053	414	564	165	2,196
2005	1,158	1,061	860	104	3,183
2006	287	304	653	112	1,356
2007	597	308	143	240	1,288
2008	577	479	388	403	1,847
2009	512	390	628	307	1,837
2010	1,081	1,196	710	693	3,680
2011	594	264	295	172	1,325
2012	503	295	247	60	1,105
2013	442	306	224	325	1,297
2014	340	534	237	336	1,447
2015	394	1,110	629	300	2,433
Mean	678	526	530	283	2,017

Redd Distribution

Because most of the spawning escapement of steelhead in 2015 was determined through the use of PIT tag arrays, assessing redd distribution by stream reach is not possible for most spawning areas (Attachment D). Based on spawning escapement estimates from stream surveys and PIT tag expansions in the Lower Methow subbasin, tributaries such as Gold Creek and Beaver Creek were important spawning areas (Table 5.12). In the Twisp River, most redds were found in the mainstem, and relatively few redds were found in tributary sections (Table 5.13).

As part of an on-going reproductive success study in the Twisp River, female steelhead captured and release upstream of the Twisp River weir received a Floy tag and an abdominal-planted PIT tag prior to release. Subsequent observations of Floy-tagged fish on the spawning grounds, or detection of PIT tags in completed redds allowed us to evaluate the spawning distribution of hatchery and wild steelhead in the Twisp River. Using these methods, we were able to determine female origin for 22 of 161 redds (13%) based on Floy tag observations. Similar to 2014, wild female steelhead spawned significantly farther upstream than hatchery steelhead females in 2015 (Kolmogorov-Smirnov tests $P < 0.02$; Figure 5.1), but no differences were found in spawning location between hatchery and wild females from 2009-2013 (Kolmogorov-Smirnov tests P = 0.116–0.870; Figure 5.1).

Table 5.12. 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 (K. See, unpublished data) using 1.47 fish per redd. Ns = not surveyed.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Methow River (MRW PIT array – Red Barn)	MRW8	12	656	101
Methow River (Red Barn – Halderman Hole)	MRW7	10		
Methow River (Halderman Hole – Braids)	MRW6	10		
Methow River (Braids – Carlton Bridge)	MRW5	6		
Methow River (Carlton Bridge – WDFW Access)	MRW4	5		
Methow River (WDFW Access – Upper Burma Br.)	MRW3	0		
Methow River (Upper Burma Br. – Lower Burma Br.)	MRW2	1		
Methow River (Lower Burma Bridge – Pateros)	MRW1	1		
Chewuch River (CRW PIT array to – Confluence)	CRW1	0	--	--
Methow Hatchery outfall	MH1	17	--	--
Winthrop NFH Outfall	WN1	56	--	--
Beaver Creek (above PIT antenna)	Beaver	102	47 (23-94)	103 (59-153)

Table 5.12. Continued.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Beaver Creek (below PIT antenna)	BV1	Ns	--	--
Libby Creek (above PIT antenna)	Libby	23	21 (6-52)	13 (3-42)
Gold Creek (above PIT array)	Gold	115	68 (29-163)	101 (50-278)
Total		358	792	318

Table 5.13. Twisp River mainstem and tributary census redd counts by section number and survey year. Ns = not surveyed.

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

[1] Methow Salmon Recovery Foundation pond outfall.

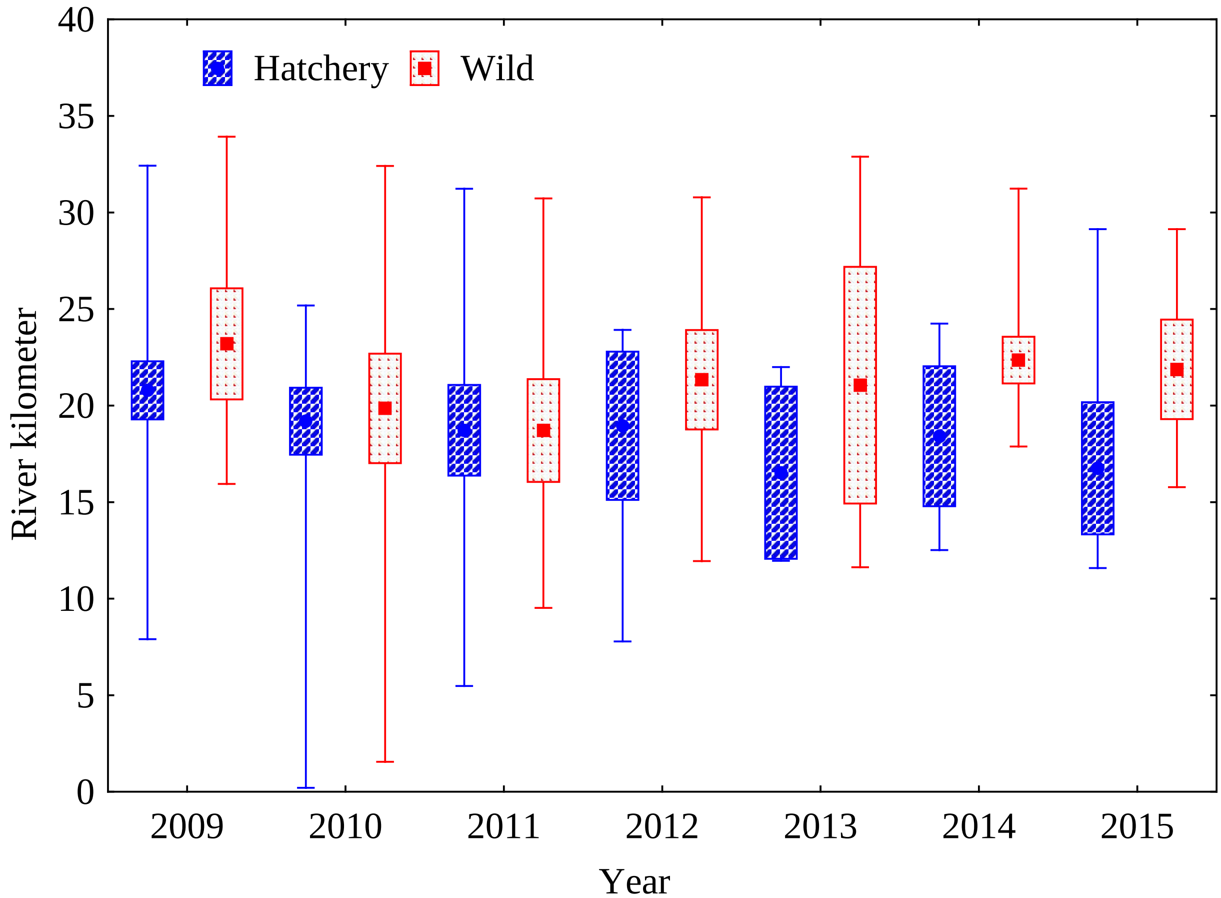

Figure 5.1. Mean spawning location (center point), 95% CI (box), and minimum and maximum values (whiskers) by origin of female steelhead released upstream of the Twisp River weir based on PIT tag detections and Floy tag observations in 2009 (H = 45; W = 19), 2010 (H = 40; W = 27), 2011 (H = 26; W = 20),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

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. No significant differences in spawn timing were observed between hatchery and wild female steelhead in 2015 (Kolmogorov-Smirnov tests; $P = 0.10$). Between 2009 and 2014, spawn timing of hatchery and wild female steelhead was only significantly different for the 2013 brood (Kolmogorov-Smirnov tests; $P = <0.05$; Figure 5.2).

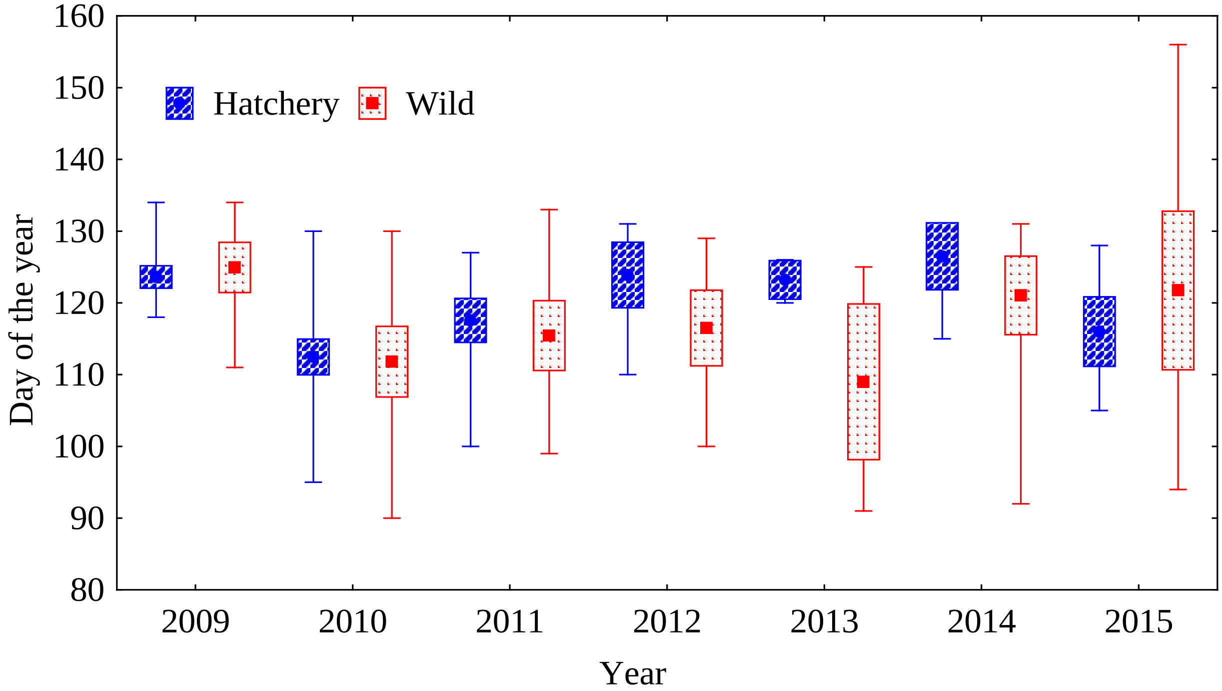

Figure 5.2. Mean spawn timing (center point), 95% CI (box), and minimum and maximum values (whiskers) of female steelhead by origin and year released upstream of the Twisp River weir based on PIT tag detections and Floy tag observations in 2009 (H = 44; W = 17), 2010 (H = 38; W = 24), 2011 (H = 27; W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

5.5: Life History Monitoring

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

Length at Maturity

Wild and hatchery-origin steelhead were sampled at Wells Dam to determine mean length by sex, saltwater-age, and fish origin, although some age and sex categories of wild fish were not represented in some years (Table 5.14). 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 5.14).

Table 5.14. Mean fork length (cm), number (*N*), and standard deviation (SD) by sex, salt-age, and origin of steelhead sampled at Wells Dam by return year.

Return year	Origin	Male						Female					
		1-Salt			2-Salt			1-Salt			2-Salt		
		Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD	Mean	*N*	SD
2002	H	62	30	4	79	89	5	60	17	4	75	133	4
2002	W	64	53	3	82	9	4	-	0	-	76	18	4
2003	H	61	183	3	73	3	7	60	118	3	68	6	3
2003	W	-	0	-	-	0	-	62	55	4	73	9	6
2004	H	60	93	3	74	53	3	59	31	2	72	138	3
2004	W	62	15	3	76	9	3	62	15	3	73	27	4
2005	H	60	98	3	76	58	4	60	22	4	71	123	4
2005	W	65	21	4	77	16	4	61	8	5	73	42	3
2006	H	62	133	3	75	10	5	60	142	3	72	54	5
2006	W	64	8	5	76	6	2	62	17	3	74	17	4
2007	H	63	131	3	78	11	4	61	67	3	72	58	4
2007	W	64	31	4	77	4	1	63	72	3	76	21	4
2008	H	63	116	3	78	12	5	61	66	3	74	57	4
2008	W	63	32	3	82	8	3	62	43	4	74	24	4
2009	H	64	75	4	76	27	4	61	51	4	72	82	3
2009	W	64	42	3	73	8	6	63	37	4	73	19	3
2010	H	61	86	3	76	34	5	60	54	4	72	86	4
2010	W	61	27	4	76	13	6	61	20	3	74	65	4
2011	H	59	77	3	73	39	4	59	53	3	71	83	3
2011	W	61	15	3	76	16	5	61	16	3	72	34	4
2012	H	60	58	3	75	22	5	60	45	4	73	114	4
2012	W	61	19	3	77	14	5	63	6	4	74	32	4
2013	H	59	43	3	73	15	4	58	43	2	70	76	4
2013	W	60	40	3	71	20	5	60	50	3	72	41	5
2014	H	59	43	3	73	15	4	58	43	2	70	76	9
2014	W	60	40	3	71	20	5	60	50	3	72	41	5
Average	H	61	90	3	75	30	5	60	58	3	72	84	4
Average	W	62	26	3	76	11	4	62	30	4	74	30	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 2006-2014 run years overall, wild fish arrived at Wells Dam an average of three days earlier than hatchery fish (Figure 5.3). Hatchery steelhead PIT tagged in 2014 had an earlier mean passage date (18 October) than wild steelhead (1 November) over the Lower Methow PIT array (LMR), but mean run-timing of hatchery and wild fish was similar at most other sites (Figure 5.4), regardless of salt-age at return (Figure 5.5).

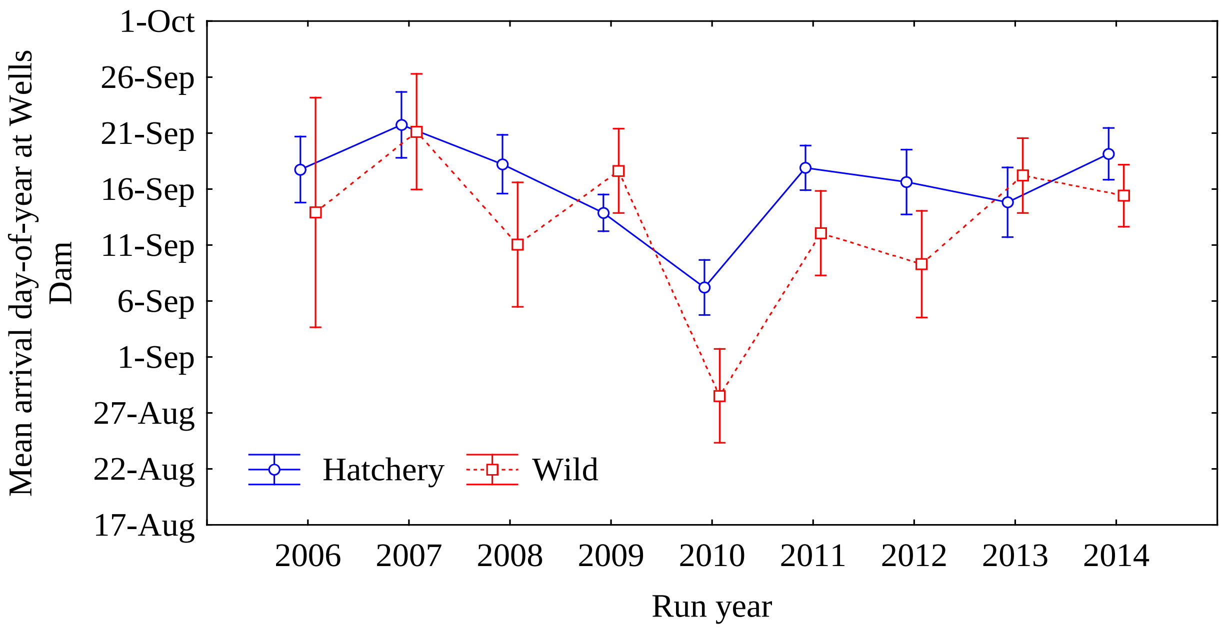

Figure 5.3. Migration timing (mean +/- 95% CI) by run year at Wells Dam of hatchery and wild steelhead PIT tagged and released from Priest Rapids Dam. Hatchery origin fish included those marked with an adipose fin-clip, an adipose fin-clip+CWT, a CWT-only, and left- or right-side yellow elastomer.

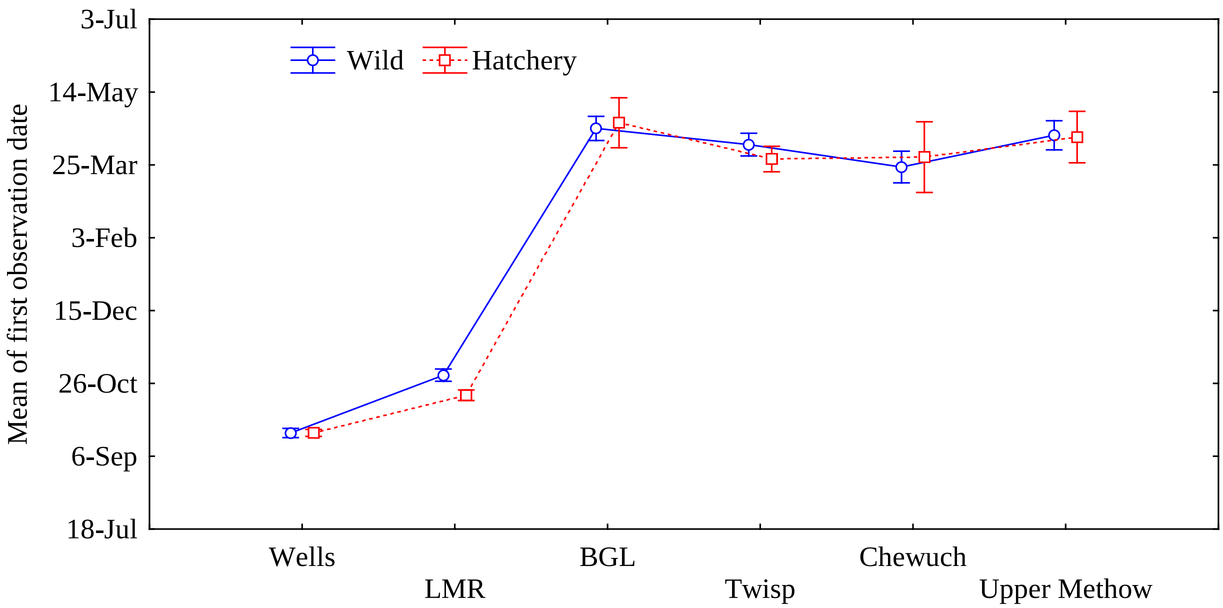

Figure 5.4. Mean (+/- 95% CI) migration timing of hatchery and wild steelhead PIT tagged at Priest Rapids Dam in 2014. Hatchery origin fish included those marked with an adipose fin-clip, an adipose fin-clip+CWT, or a CWT-only. Detection locations include the Lower Methow River (LMR), and the Beaver, Gold, and Libby Creek (BGL) antenna arrays. The Upper Methow category includes the Lost River, Early Winters Creek, Wolf Creek, and the Methow River at Winthrop PIT tag arrays.

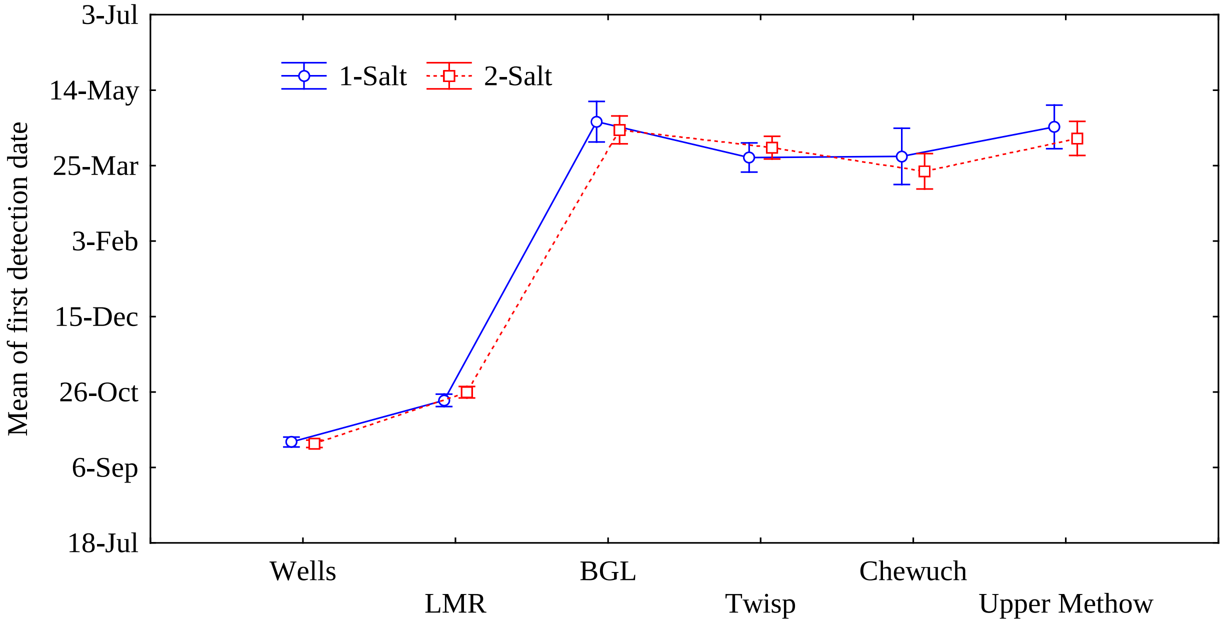

Figure 5.5. Mean (+/- 95% CI) migration timing based on salt-age of hatchery and wild steelhead PIT tagged at Priest Rapids Dam in 2014. Detection locations include the Lower Methow River (LMR), and the Beaver, Gold, and Libby Creek (BGL) antenna arrays. The Upper Methow category includes the Lost River, Early Winters Creek, Wolf Creek, and Methow River at Winthrop PIT tag arrays.

Contribution to Fisheries

Hatchery and wild steelhead returning to Wells Dam are removed for broodstock, may fallback below Wells Dam, or be removed in fisheries in the Columbia River upstream of Wells Dam before entering natal tributaries (Methow and Okanogan rivers). Sport fisheries in the Columbia River upstream of Wells Dam over the past 14 years have allowed the harvest of adipose fin-clipped hatchery origin steelhead, and have estimated the incidental take of wild steelhead through creel monitoring (e.g., WDFW 2015). Columbia River fisheries (including tribal harvest) have extracted about 6% of the hatchery steelhead and 2% of the wild steelhead upstream of Wells Dam on average (Table 5.15).

Table 5.15. Estimated tributary escapement of the hatchery and wild steelhead return to Wells Dam after broodstock removal, removal of fallback and double-counted fish based on PIT tag detections (escapement adjustments), and the impact of sport fisheries in the Columbia River.

Brood	Run to Wells Dam		Wells broodstock		Escapement adjustments		Columbia R. fisheries		Net tributary escapement	
	H	W	H	W	H	W	H	W	H	W
2002	18,241	900	374	18	-	-	23	-	17,844	882
2003	8,962	821	274	27	-	-	455	9	8,233	785
2004	9,388	1,161	325	120	-	-	298	4	8,765	1,037
2005	9,098	861	346	69	-	-	292	1	8,460	791
2006	6,901	765	324	91	-	-	237	1	6,340	673
2007	6,702	631	345	46	-	-	164	6	6,193	579
2008	7,033	1,283	289	90	-	-	978	36	5,766	1,157
2009	9,148	1,236	300	75	557	73	721	32	7,570	1,056
2010	24,091	2,120	279	88	1,790	153	1,787	65	20,235	1,814
2011	11,728	2,085	272	55	839	313	1,304	48	9,313	1,669
2012	11,164	1,732	259	67	1,123	339	731	25	9,051	1,301
2013	9,138	1,288	229	22	692	368	1,229	56	6,988	842
2014	5,530	2,318	209	0	410	499	471	56	4,440	1,763
2015	5,645	2,503	191	0	433	502	567	110	4,454	1,891
Mean	10,198	1,407	287	55	835	321	661	35	8,832	1,160

Fisheries in tributaries upstream of Wells Dam are authorized when certain run composition and abundance measures have been met (see WDFW 2015). Under these criteria, sport fisheries targeting hatchery origin steelhead have been authorized in 12 of the last 14 years (Table 5.16). 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 22% of the estimated hatchery escapement and 3% of the wild escapement within the Methow and Okanogan tributaries between 2002 and 2015 (Table 5.16). Estimates of pHOS for the 2015 brood in both the Methow and Okanogan rivers were the lowest in the 14 years reported, due primarily to the relatively high return of wild fish.

Table 5.16. Estimated hatchery and wild steelhead escapement to the Methow and Okanogan river basins and the proportion of hatchery origin fish on the spawning grounds (pHOS) after local broodstock and fishery extraction. Tributary escapement was estimated utilizing radio-telemetry research (Attachment D), and accounts for 90.4% of hatchery fish and 91.6% of wild fish reported in Table 5.15.

Brood	Tributary escapement		Local broodstock		Tributary fisheries		Net escapement		pHOS
	H	W	H	W	H	W	H	W	
					Methow Basin				
2002	10,350	624	-	-	-	-	10,350	624	0.943
2003	4,775	556	-	-	254	13	4,521	543	0.893
2004	5,084	734	-	-	336	10	4,748	724	0.868
2005	4,907	560	-	-	679	9	4,228	551	0.885
2006	3,677	476	-	-	683	8	2,994	468	0.865
2007	3,592	410	-	-	-	-	3,592	410	0.898
2008	3,344	819	14	-	470	9	2,860	810	0.779
2009	4,391	748	8	8	636	11	3,747	729	0.837
2010	11,736	1,284	322	12	4,002	48	7,412	1,224	0.858
2011	5,402	1,182	141	33	2,913	53	2,348	1,096	0.682
2012	5,250	921	135	46	1,302	20	3,813	855	0.817
2013	4,053	596	117	34	904	14	3,032	548	0.847
2014	2,575	1,248	79	92	791	43	1,694	1,113	0.603
2015	2,583	1,339	289	71	601	32	1,693	1,236	0.578
Mean	5,123	821	138	42	1,131	23	4,074	781	0.811
					Okanogan Basin				
2002	5,781	183	-	-	-	-	5,781	183	0.969
2003	2,667	163	1	4	120	2	2,546	157	0.942
2004	2,840	216	11	5	385	1	2,444	210	0.921
2005	2,741	165	15	3	528	3	2,198	159	0.933
2006	2,054	140	10	3	492	5	1,552	132	0.922
2007	2,007	120	4	7	-	-	2,003	113	0.946
2008	1,868	241	5	3	288	7	1,575	231	0.872
2009	2,453	220	5	11	446	5	2,002	204	0.908
2010	6,556	377	4	13	3,110	16	3,442	348	0.908
2011	3,017	347	-	16	899	15	2,118	316	0.870
2012	2,933	271	10	5	400	5	2,523	261	0.906
2013	2,264	175	8	4	534	3	1,722	168	0.911
2014	1,439	367	42	16	223	8	1,174	343	0.774
2015	1,443	393	42	16	255	11	1,146	366	0.758
Mean	2,862	241	13	8	640	7	2,302	228	0.896

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 2011 and 2012 brood PIT tagged hatchery origin summer steelhead reared at Wells Hatchery and released into the 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 2011 brood, stray rates for Methow Basin steelhead releases averaged 24.6% over the two release locations (Table 5.17). These estimates should be considered preliminary values because efficiency of the antenna arrays are highly variable among sites.

Table 5.17. Detection of adult hatchery summer steelhead released from Wells Hatchery into Methow Basin tributaries. Adult returns were detected in the Twisp River (TWR), Chewuch River (CRW), Methow River (MRW, GLC [Gold Creek], EWC [Early Winters Creek], and LOR [Lost River]) antenna arrays and at Zosel Dam in the Okanogan River basin. Detections of 2012 brood releases are considered incomplete because they include only 1-salt returns.

Brood	Release river (donor pop.)	Recipient river, river area, or tributary						Total	% stray
		Upper Methow	Twisp	Chewuch	Lower Methow tribs	Lower Methow mainstem	Okanogan		
2011	Methow	16	0	0	2	10	1	29	10.3
2011	Twisp	0	10	0	1	1	6	18	38.9
2012	Methow	1	0	0	0	0	1	2	--
2012	Twisp	0	12	0	0	0	1	13	--

Smolt to Adult Survival and HRR

The smolt-to-adult return of Wells 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 (2011 brood) was 23.3 (Table 5.18). This was above the target HRR value of 19.6, but below the mean value for the 1996-2011 broods of 29.2.

Table 5.18. Number of broodstock spawned (including pre-spawn mortalities) and smolts released by brood year from Wells Complex hatchery facilities. 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
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	80	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
Mean	260	543,770	7,541	1.371	103	29.2

Natural Replacement Rates

The natural replacement rate (NRR) of wild summer steelhead in the Methow River basin was calculated as the number of natural origin recruits divided by the overall spawning population of hatchery and natural origin adults of the parent brood (Attachment D). The NRR of the last brood for which complete adult return data was available (2009 brood) was 0.273 (Table 5.19), which is slightly lower than the mean NRR of the 1996-2009 broods (0.294).

Table 5.19. Natural replacement rate (NRR) of Methow River basin steelhead spawners. The NRR is calculated by dividing the number of natural origin return (NOR) recruits produced by the sum of the spawning population of hatchery origin (HOR) and natural origin (NOR) spawners.

Parent brood year	Methow Basin run escapement (parent brood)			Methow Basin recruits	
	HOR	NOR	Total	NOR	NRR
1996	363	66	429	319	0.744
1997	1,787	185	1,972	715	0.363
1998	2,264	77	2,341	745	0.318
1999	1,485	151	1,636	194	0.119
2000	1,806	279	2,085	1,011	0.485
2001	3,385	373	3,758	651	0.173
2002	10,350	624	10,974	395	0.036
2003	4,521	543	5,064	448	0.088
2004	4,748	724	5,472	1,006	0.184
2005	4,228	551	4,779	1,163	0.243
2006	2,994	468	3,462	1,565	0.452
2007	3,338	410	3,748	1,524	0.406
2008	2,860	810	3,670	866	0.236
2009	3,749	729	4,478	1,222	0.273
Mean	3,420	428	3,848	845	0.294

Proportionate Natural Influence

The Hatchery Scientific Review Group (HSRG) developed guidelines for salmon and steelhead hatchery programs intended to provide a foundation of hatchery reform principals that should aid hatcheries in the Pacific Northwest in meeting conservation and sustainable harvest goals (HSRG 2008). These guidelines provide a means of assessing the genetic risk of hatchery programs to natural populations by calculating the proportionate natural influence (PNI) of a population. The PNI is calculated as: (the proportion of natural origin fish within the broodstock [pNOB])/(pHOS+pNOB). A PNI value > 0.5 indicates that genetic selection pressures from the natural environment have a stronger influence on the population than those from the hatchery environment, and a PNI ≥ 0.67 was recommended for conservation programs. For the 2002-2015 broods, PNI has been slightly higher in the Methow Basin than in the Okanogan Basin, but mean values for both basins are low and indicate that most genetic selection pressure on the populations comes from the hatchery environment (Table 5.20).

Table 5.20. The proportionate natural influence (PNI) calculated for specific broods of spawning steelhead in the Methow and Okanogan river basins. The proportion of hatchery origin spawners (pHOS) in the escapement of each tributary was derived from Table 5.16. The net proportion of natural origin fish within each brood (pNOB) was estimated as the sum of the proportion of each salt-age of hatchery origin spawners (HOS) multiplied by the pNOB for that salt age. The PNI was calculated as: pNOB/(pNOB+pHOS).

Brood	Net tributary escapement		HOS age proportion		pNOB		Net pNOB	PNI
	Total	pHOS	1-Salt	2-Salt	1-Salt	2-Salt		
				Methow Basin				
2002	10,974	0.94	0.42	0.58	0.07	0.03	0.05	0.05
2003	5,064	0.89	0.17	0.83	0.10	0.07	0.08	0.08
2004	5,472	0.87	0.97	0.03	0.07	0.10	0.07	0.08
2005	4,779	0.88	0.39	0.61	0.05	0.07	0.06	0.07
2006	3,463	0.86	0.39	0.61	0.09	0.05	0.07	0.07
2007	4,002	0.90	0.81	0.19	0.27	0.09	0.24	0.21
2008	3,670	0.78	0.74	0.26	0.17	0.27	0.20	0.20
2009	4,475	0.84	0.73	0.27	0.23	0.17	0.21	0.20
2010	8,637	0.86	0.54	0.46	0.12	0.23	0.17	0.17
2011	3,443	0.68	0.54	0.46	0.25	0.12	0.19	0.22
2012	4,668	0.82	0.49	0.51	0.23	0.25	0.24	0.23
2013	3,580	0.85	0.42	0.58	0.23	0.23	0.23	0.21
2014	2,807	0.60	0.49	0.51	0.27	0.23	0.25	0.29
2015	2,929	0.58	0.29	0.71	0.28	0.26	0.27	0.32
Mean	4,855	0.81	0.53	0.47	0.17	0.16	0.17	0.17
				Okanogan Basin				
2002	5,965	0.97	0.42	0.58	0.07	0.03	0.05	0.05
2003	2,704	0.94	0.17	0.83	0.10	0.07	0.08	0.07
2004	2,654	0.92	0.97	0.03	0.07	0.10	0.07	0.07
2005	2,357	0.93	0.39	0.61	0.05	0.07	0.06	0.06
2006	1,684	0.92	0.39	0.61	0.09	0.05	0.07	0.07
2007	2,116	0.95	0.81	0.19	0.27	0.09	0.24	0.20
2008	1,806	0.87	0.74	0.26	0.17	0.27	0.20	0.18
2009	2,205	0.91	0.73	0.27	0.23	0.17	0.21	0.19
2010	3,790	0.91	0.54	0.46	0.12	0.23	0.17	0.16
2011	2,435	0.87	0.54	0.46	0.25	0.12	0.19	0.18
2012	2,783	0.91	0.49	0.51	0.23	0.25	0.24	0.21
2013	1,890	0.91	0.42	0.58	0.23	0.23	0.23	0.21
2014	1,495	0.77	0.49	0.51	0.27	0.23	0.25	0.25
2015	1,512	0.76	0.29	0.71	0.28	0.26	0.27	0.23
Mean	2,528	0.90	0.53	0.47	0.17	0.16	0.17	0.15

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Attachment A. 2015 Twisp and Methow River Smolt Estimates.

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1 June, 2016

To: Charlie Snow

From: David Grundy

Subject: 2015 Twisp and Methow River Smolt Estimates.

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

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

Methods

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

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

Biological Sampling

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

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

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

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

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

Population Estimates

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

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

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

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

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

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 =

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

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

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

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

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

The daily emigration estimate was calculated using the formula:

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

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

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

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

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

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

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

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

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

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

<u>Juveniles Per Redd</u>

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

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

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

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

Results

Smolt Trap Operation

Trapping in the Methow River basin in 2015 began at the Methow River site on 18 February and at the Twisp River site on 26 February. Trapping at both locations was interrupted over the course of the trapping season due to low flow, or fire activity. Trapping at the Methow site was interrupted on two occasions for a total of three days between 18 February and 25 November. Trapping at the Twisp site was interrupted by low river discharge for a total of 102 days between 26 February and 20 November. Discharge was above average until mid to late April, and then dropped to near or below average for the remainder of the season except for a few rain events in the late fall (Figures 1 and 2). Because of the lower than average peak in spring discharge, traps at both sites were able to operate through the spring runoff event.

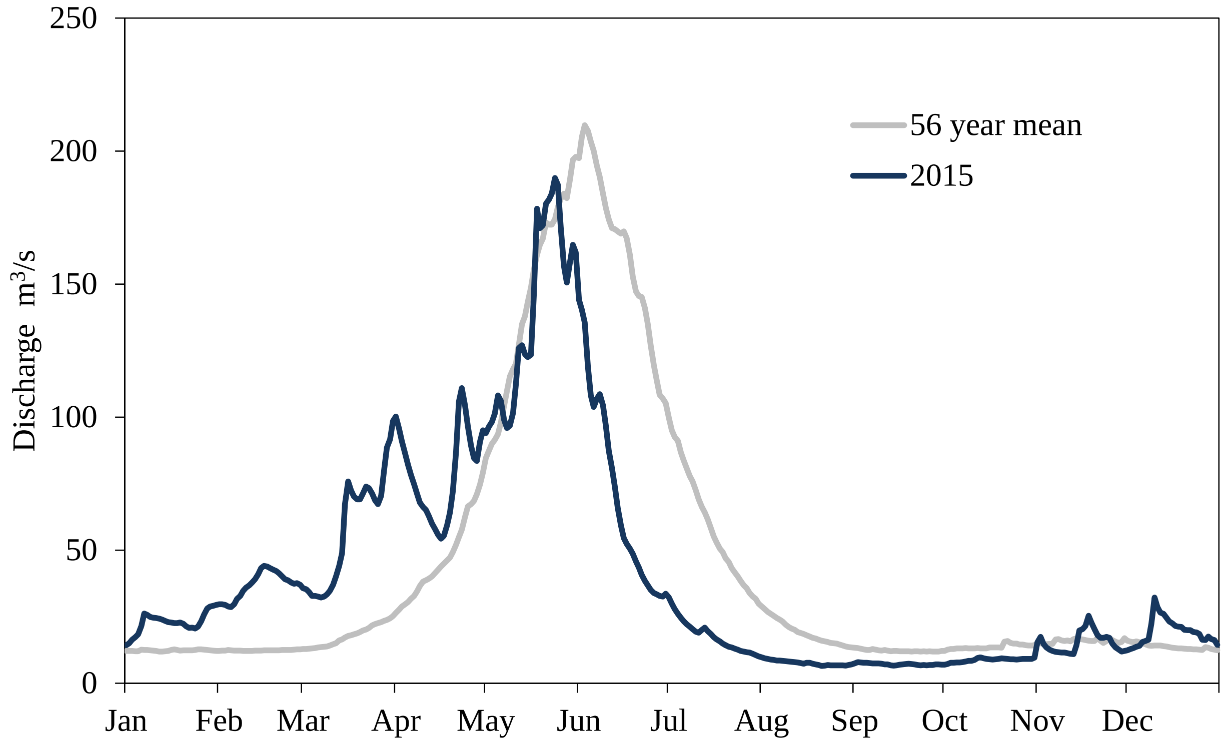

Figure 1. Methow River 2015 daily discharge and 56-year mean as measured at the USGS gauging station No. 12449950 (Methow River near Pateros, Washington).

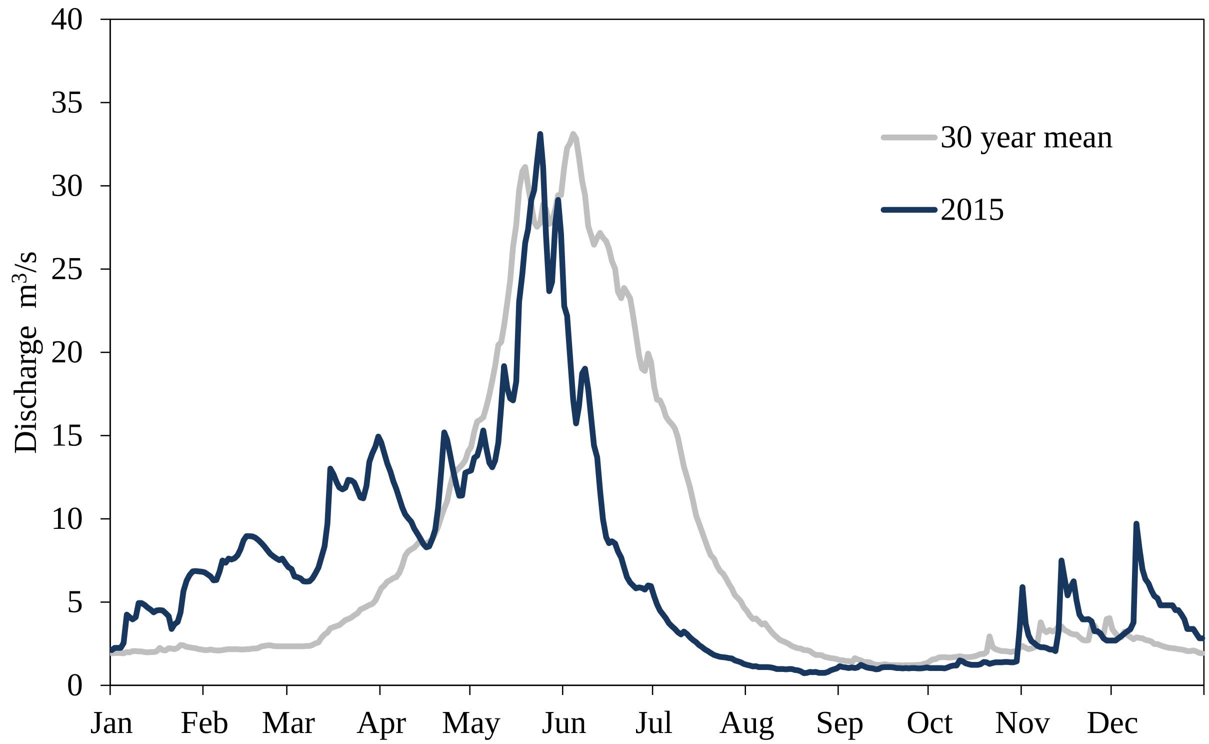

Figure 2. Twisp River 2015 daily discharge and 30-year mean as measured at the USGS gauging station No.12448998 (Twisp River near Twisp, Washington).

Daily Captures and Biological Sampling

2013 Brood Chinook Salmon

A total of 448 wild yearling Chinook Salmon emigrants were captured at the Methow site between 18 February and 30 June, with the peak capture (N = 25) occurring on 18 April (Figure 3). We inserted PIT tags into 431 of the wild smolts captured, and 426 were subsequently released after subtracting four mortalities and one shed tag (Appendix A). Overall mortality of wild yearling Chinook totaled four of the 448 fish captured (0.89%). Instead of PIT tagging hatchery fish, we utilized 908 hatchery spring Chinook salmon that had existing PIT tags to facilitate trap efficiency mark/recapture trials. Overall mortality of hatchery Chinook at the Methow site totaled 53 out of 50,071 fish captured (0.11%). Hatchery smolts had a significantly greater mean fork length (132.8 mm) than wild Chinook smolts (98.7 mm) captured at the Methow trap (Mann-Whitney U-test: $P < 0.001$; Table 2).

The Twisp River trap captured 447 wild yearling spring Chinook salmon smolts between 26 February and 30 June. Peak capture occurred on 15 March (N = 29; Figure 4). We inserted PIT tags into 437 of the captured wild fish and 431 tagged fish were released after subtracting five mortalities and one shed tag (Appendix A). Overall mortality of wild yearling Chinook at the Twisp site totaled nine of the 447 fish captured (2.01%). We used 643 hatchery spring Chinook that has existing PIT tags for mark/recapture trials. Overall mortality of hatchery Chinook salmon at the Twisp trap totaled one fish out of the 4,051 captured (0.02%).

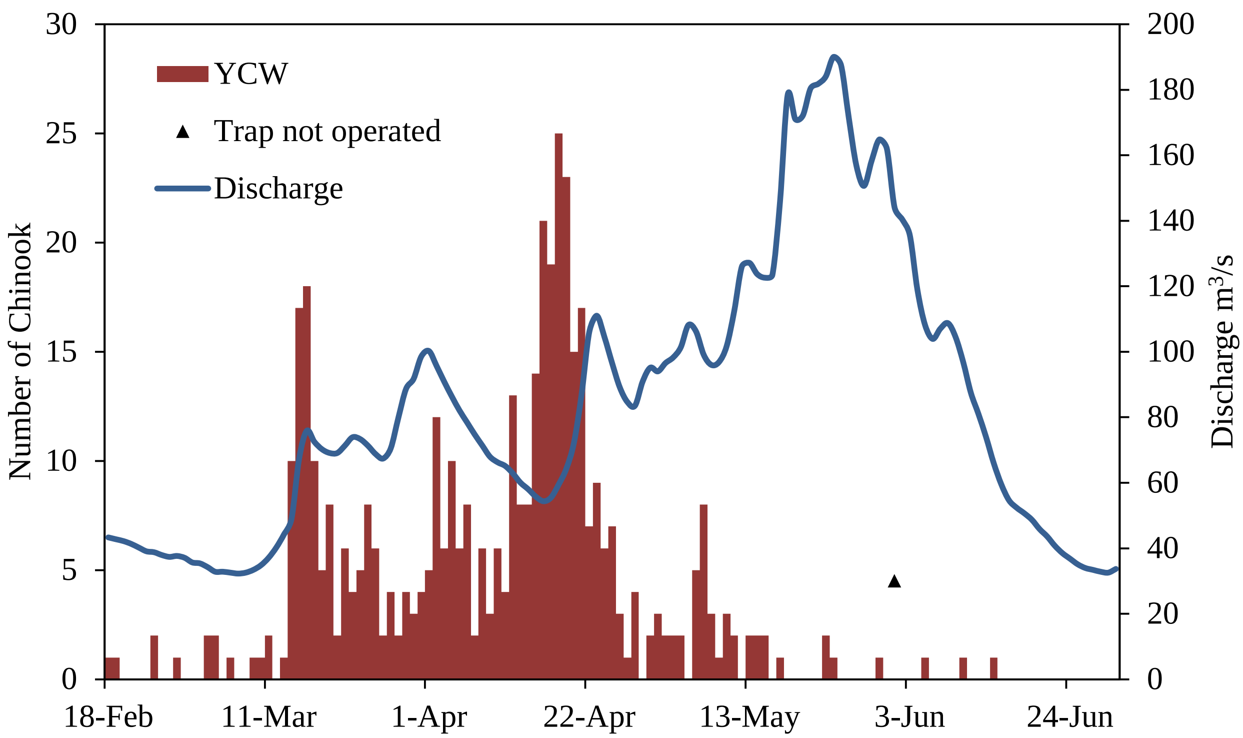

Figure 3. Daily capture of wild Chinook salmon smolts (YCW) at the Methow River smolt trap in 2015.

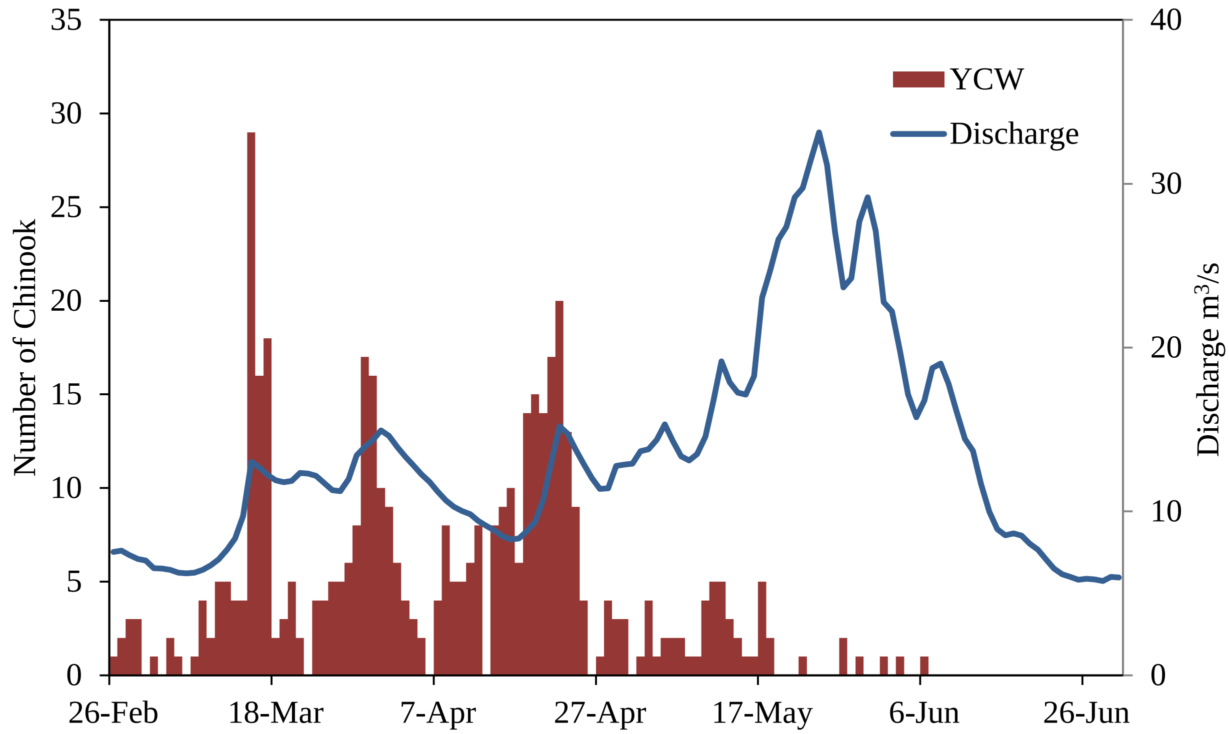

Figure 4. Daily capture of wild spring Chinook Salmon smolts (YCW) at the Twisp River smolt trap in 2015.

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

Subyearling Chinook salmon fry (*N* = 7,338) and parr (*N* = 5,576) captured at the Methow trap between 18 February and 30 September had mean fork lengths of 38.8 mm and 68.6 mm, respectively (Table 2). Mortality during this period totaled 67 fry (0.91%) and nine parr (0.16%). We inserted PIT tags into 12 of these parr and they all survived to release. An additional 243 emigrant Chinook parr were captured during the fall trapping period between 1 October and 25 November. The mean fork length of Chinook parr during this period was 89.7 mm (Table 2), and peak captures occurred on 2 November (*N* = 51). We inserted PIT tags into 234 of the 243 Chinook parr captured during the fall period and no shed tags or mortalities occurred (Appendix A). Seven of the parr captured had existing PIT tags from other studies. Tissue samples were collected from 239 of the fall-captured parr, and genetic analysis was conducted on 100 of those samples. Analysis indicated that 91 (91.0%) of the sampled parr were spring Chinook, and nine (9.0%) were summer Chinook (Appendix B). These results are similar to results from sampling of fall parr in previous years (Table 1).

The Twisp trap captured 3,063 subyearling spring Chinook salmon between 26 February and 20 November, and peak captures occurred on 1 November (*N* = 503; Figure 5). Peak capture was influenced by a heavy rain event that increased Twisp River discharge by over 300% after a relatively long trapping hiatus due to low flow. We inserted PIT tags into 1,099 Chinook parr and they were all released (Appendix A). There were also 33 Chinook parr that had existing PIT tags at capture. Overall, one parr and eight fry mortalities occurred (0.29%). Fall migrant parr had a mean fork length of 84.6 mm (Table 2).

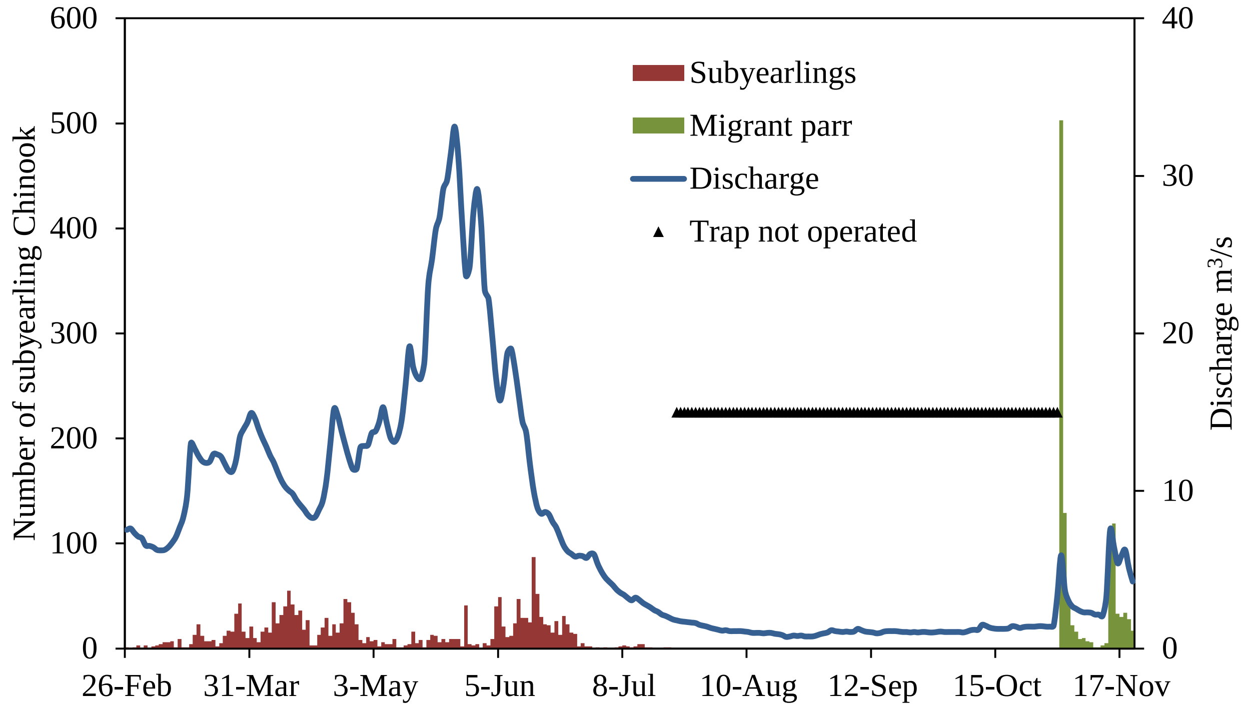

Figure 5. Daily capture of subyearling wild spring Chinook Salmon (Feb – Jul) and migrant parr (November) at the Twisp River smolt trap in 2015.

Table 1. Percent of fish that were assigned to the spring Chinook Salmon race from DNA analysis conducted on age-0 juvenile Chinook Salmon captured at the Methow River smolt trap by trapping year and trapping period. NS = not sampled.

Trapping year	Spring (start-30 Jun)	Summer (1 Jul-30 Sep)	Fall (1 Oct-end)
2006	NS	NS	95.8
2007	NS	NS	86.7
2008	NS	NS	96.7
2009	5.5	11.8	100.0
2010	5.5	11.1	80.5
2011	18.2	NS	92.9
2012	NS	NS	96.8
2013	NS	NS	96.0
2014	NS	NS	97.0
2015	NS	NS	91.0
Mean	9.7	11.5	93.3

Table 2. Summary of length and weight sampling of Chinook Salmon captured at Methow basin smolt traps in 2015.

Brood	Origin/stage	Fork length (mm)			Weight (g)			K-factor
		Mean	*N*	SD	Mean	*N*	SD	
			Methow River trap					
2014	Wild fry	38.8	2,043	3.4	--	--	--	--
2014	Wild parr (Feb-Sep)	68.6	698	13.7	4.6	633	2.8	1.4
2014	Wild parr (Oct-Nov)	89.7	243	9.3	8.0	243	2.5	1.1
2013	Wild smolt	98.7	446	8.3	10.6	439	2.6	1.1
2013	Hatchery smolt	132.8	964	9.0	26.7	964	5.7	1.1
			Twisp River trap					
2014	Wild fry	37.7	713	4.7	--	--	--	--
2014	Wild parr (Mar-Jul)	56.5	144	5.8	2.3	139	0.9	1.3
2014	Wild parr (Nov)	84.6	1,125	8.0	6.8	1,125	2.0	1.1
2013	Wild smolt	92.5	447	8.1	8.8	447	2.4	1.1
2013	Hatchery smolt	134.4	650	8.1	27.6	650	5.3	1.1

Summer Steelhead

The Methow River trap captured 448 wild summer steelhead emigrants (smolt and transitional) between 18 February and 30 June, with peak capture on 22 April (N = 41; Figure 6). We inserted PIT tags into 428 wild steelhead emigrants and 426 were released after subtracting two mortalities (Appendix A). Overall mortality of emigrant steelhead totaled two of the 448 fish captured (0.45%). Most wild summer steelhead migrants were age-2 fish (76.2%), which had a mean fork length of 172.5 mm (Table 3). A total of 3,295 hatchery steelhead juveniles were captured at the Methow River trap, and no mortalities occurred. We utilized 110 hatchery summer steelhead that had existing PIT tags for a mark/recapture trial.

The Methow River trap captured 35 wild summer steelhead fry and 67 wild parr between 18 February and 25 November. Steelhead parr greater than 65 mm and in good physical condition were PIT tagged (N = 54), and all tagged fish were released (Appendix A). There were no mortalities of any wild steelhead parr or fry captured at the Methow trap. Wild steelhead parr and fry had mean fork lengths of 98.3 mm and 34.8 mm respectively.

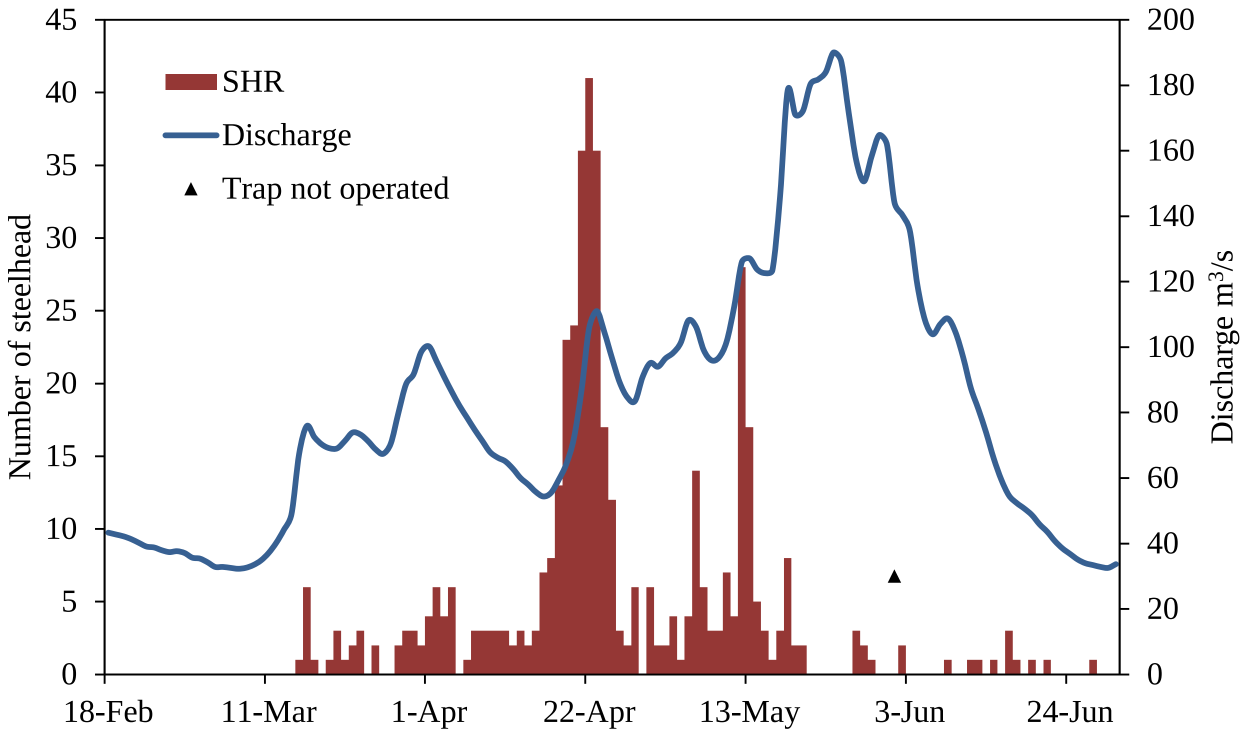

Figure 6. Daily capture of wild steelhead smolt and transitional migrants at the Methow River smolt trap in 2015.

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 2015.

Age	*N* (%)	Fork (mm)			Weight (g)			K-factor
		Mean	*N*	SD	Mean	*N*	SD	
Methow River trap								
1	18 (5.0)	154.2	18	18.1	38.1	17	13.3	1.0
2	276 (76.2)	172.5	276	17.2	50.2	273	16.1	1.0
3	63 (17.4)	185.1	63	22.4	61.7	63	22.2	1.0
4	5 (1.4)	183.6	5	16.2	60.8	5	10.7	1.0
Twisp River trap								
1	12 (4.7)	139.8	12	15.5	28.6	12	8.1	1.0
2	202 (78.9)	164.2	202	14.1	44.8	202	11.3	1.0
3	42 (16.4)	184.5	42	18.0	60.8	42	16.4	1.0
4	0 (0.0)	--	--	--	--	--	--	--

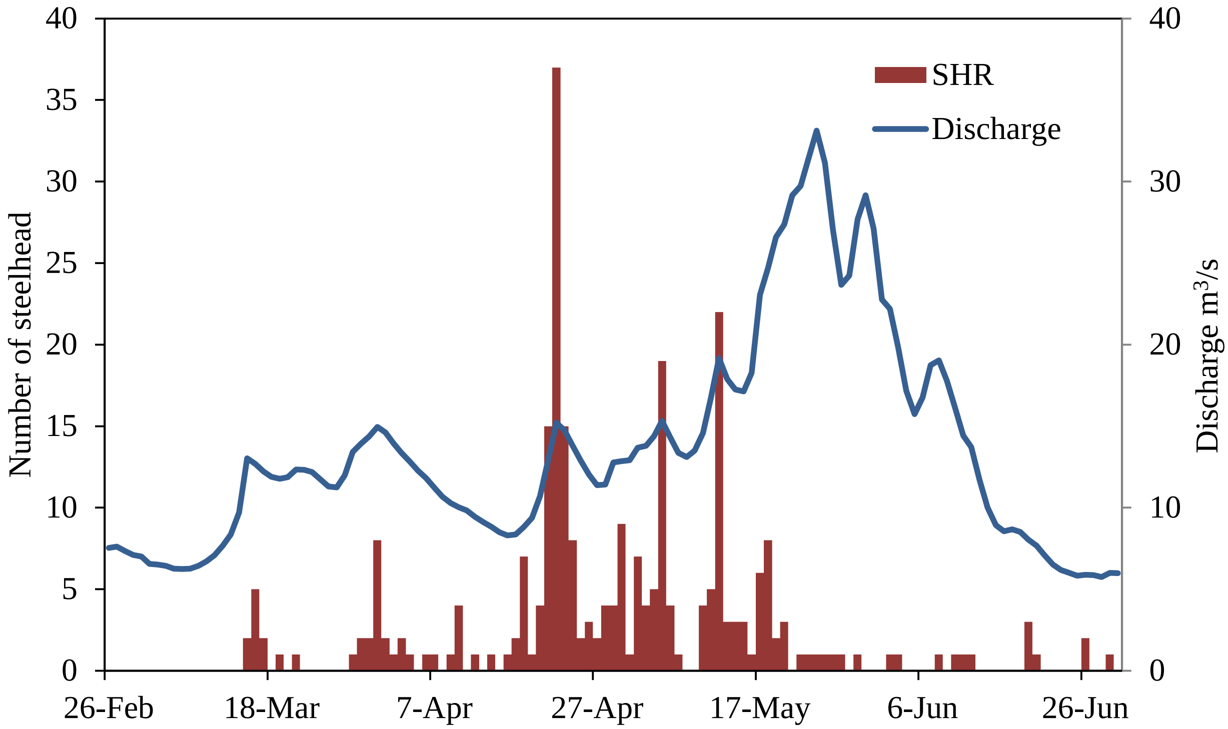

Figure 7. Daily capture of wild steelhead (SHR) smolt and transitional migrants at the Twisp River smolt trap in 2015.

A total of 274 wild summer steelhead emigrants (smolt and transitional) were captured at the Twisp trap between 26 February and 30 June, and the peak capture occurred on 22 April (*N* = 37; Figure 7). Wild emigrants (all ages combined) had a mean fork length of 166.8 mm, and were primarily age-2 fish (78.9%; Table 3). We inserted PIT tags into 241 wild steelhead emigrants and 239 were released after subtracting two shed tags (Appendix A). There was only a single trapping mortality experienced by smolt or transitional steelhead out of the 274 captured at the Twisp site (0.36%). A total of 3,641 hatchery summer steelhead juveniles were captured at the Twisp river trap, and 26 mortalities were experienced (0.71%). We conducted upstream releases of 214 hatchery steelhead that had existing PIT tags to aid in mark/efficiency trials.

Non-migrant summer steelhead captured at the Twisp trap included 97 wild fry and 408 wild parr captured between 26 February and 20 November (Figure 8). We inserted PIT tags into 384 steelhead parr greater than 65 mm and 383 of these fish were released after subtracting one mortality (Appendix A). Overall mortality of fry (*N* = 0) and parr (*N* = 1) represented 0.20% of the total fry and parr captured (*N* = 505). Wild steelhead parr and fry had mean fork lengths of 100.6 mm and 29.1 mm respectively.

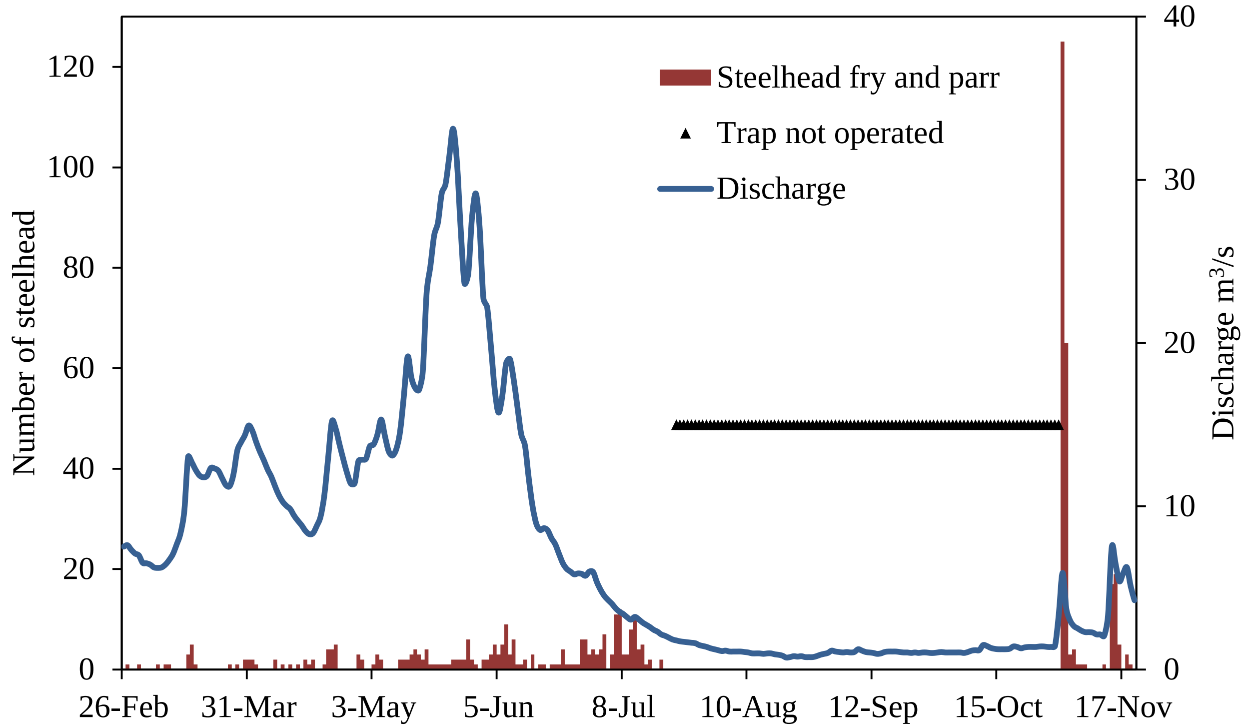

Figure 8. Daily capture of wild steelhead fry and parr at the Twisp River smolt trap in 2015.

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 on incidental species in shown in Table 4.

Table 4. Biological sampling conducted on selected incidental species captured at Methow River basin smolt traps in 2015.

Species	Captured	Fork length (mm)			Weight (g)		
		Mean	*N*	SD	Mean	*N*	SD
Methow River trap							
Hatchery Coho (*O. kisutch*)	7,268	135.3	285	8.1	28.2	282	4.9
Longnose Dace (*Rhinichthys cataractae*)	1,308	43.7	387	27.4	10.5	82	6.5
Sucker (*Catostomus spp.*)	471	46.8	161	13.0	3.5	40	3.6
Pacific Lamprey (*Lampetra tridentata*)	241	163.2	91	13.4	7.7	88	2.0
Mountain Whitefish (*Prosopium williamsoni*)	168	56.7	74	21.5	4.2	34	2.9
Wild Coho fry (*O. kisutch*)	101	38.3	58	4.7	--	--	--
Wild Coho parr (*O. kisutch*)	95	75.7	77	14.5	6.1	74	3.0
Bridgelip Sucker (*Catostomus columbianus*)	94	61.1	85	30.7	13.3	31	20.2
Redside Shiner (*Richardsonius balteatus*)	76	38.5	50	14.8	17.1	2	7.2
Sockeye fry (*O. nerka*)	54	27.1	48	2.4	--	--	--
Sculpin (*Cottus spp.*)	51	45.9	34	28.6	14.6	8	9.3
Wild Coho smolt (*O. kisutch*)	12	104.8	12	9.8	13.3	12	3.3
Northern Pikeminnow (P. oregonensis)	8	26.0	8	6.1	--	--	--
Cutthroat Trout (*O. clarki*)	6	189.0	6	25.9	69.3	6	28.7
Umatilla Dace (*Rhinichthys umatilla*)	5	44.6	5	31.7	--	--	--
Bull Trout (*Salvelinus confluentus*)	3	260.0	1	--	157.1	1	--
Twisp River trap							
Longnose Dace (*Rhinichthys cataractae*)	2,242	101.1	675	16.3	15.6	655	5.9
Sculpin (*Cottus spp*.)	86	55.8	80	27.3	11.1	31	9.3
Wild Coho parr (*O. kisutch*)	86	87.8	84	14.2	8.2	83	3.2
Wild Coho fry (*O. kisutch*)	72	37.8	58	4.6	--	--	--
Mountain Whitefish (*Prosopium williamsoni*)	34	51.5	31	44.4	33.3	8	82.3
Bull Trout (*Salvelinus confluentus*)	21	157.1	14	20.2	37.2	14	15.0
Wild Coho smolt (*O. kisutch*)	9	106.8	9	13.6	13.5	9	4.6
Bridgelip Sucker (*Catostomus columbianus*)	9	74.4	8	28.7	7.2	8	10.4
Hatchery Coho (*O. kisutch*)	3	123.5	2	2.1	21.0	2	3.0
Sucker (*Catostomus spp.*)	3	89.3	3	27.8	9.5	3	8.6
Cutthroat Trout (*O. clarki*)	2	154.0	1	--	34.9	1	--
Brook Trout (*Salvelinus fontinalis*)	1	91.0	1	--	7.6	1	--
Brown Bullhead (*Ictalurus nebulosus*)	1	--	--	--	--	--	--

Population Estimates

2013 Brood 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, no efficiency trials were conducted with wild Chinook Salmon. We were unable to conduct any mark/recapture trials for the low trap position because higher than average river discharge enabled operation in the upper position for most of the spring trapping season. A significant relationship did exist ($P < 0.01$; $r^2 = 0.52$; Table 5) from trials conducted during previous seasons, and the regression (y = -2.57E-05x+0.161723324) was used for the low trapping position in 2015. For the upper trapping position, two mark/recapture trials were conducted with hatchery Chinook. Adding these groups to the previous year's model resulted in a significant relationship ($P < 0.01$, $r^2 = 0.79$; Table 5) and the regression (y = -4.30E-05x + 0.312007862) was used for the upper position in 2015. Using both these flow models, the estimated number of yearling spring Chinook salmon emigrants was 15,749 (± 2,355, 95% CI). Combining the yearling emigrants with the estimate of parr that emigrated past the trap in the fall of 2014 (20,493 ± 57,648, 95% CI), a total estimated 36,242 (± 57,696, 95% CI) 2013 brood wild spring Chinook migrated from the Methow River basin between 1 October 2014 and 30 June 2015. The majority of the emigrants (51.6%) moved as parr during the month of November 2014 (Figure 9).

One mark/recapture trial was conducted with hatchery spring Chinook smolts at the Twisp trap in the spring of 2015. A significant efficiency discharge relationship existed when adding this data to all other release groups larger than 100 conducted since 2008 ($P < 0.01$, $r^2 = 0.64$; Table 5). The flow model regression ($y = -0.00056877x + 0.529960351$) was used to estimate that 6,298 (± 1,351, 95% CI) smolts emigrated past the Twisp River trap between 26 February and 30 June 2015. There was one redd identified downstream of the Twisp trap in 2013, so an estimated 75 migrants were added to produce a total of 6,373 (± 1,359, 95% CI) yearling emigrants from the Twisp river in 2015. Snow et al. (2015) estimated that 7,293 (± 1,315, 95% CI) 2013 brood spring Chinook salmon parr emigrated from the Twisp river in the fall of 2014, but this number was recalculated using a model containing only 2014 and 2015 release groups instead of old data (Table 8). The updated flow model regression ($y = 0.00090676x + 0.121806521$) was used to estimate that 16,122 (± 2,695, 95% CI) spring Chinook salmon parr emigrated from the Twisp river in the fall of 2014. There were 192 estimated migrants added to this number because of the one redd downstream of the trap in 2013 to total 16,314 (± 2,711, 95% CI) 2013 brood spring Chinook salmon parr that emigrated from the Twisp river between 1 July and 29 November 2014. In addition to the smolt trap estimates, mark/detection trials performed at the Twisp PIT tag array (Table 6) were used to estimate that 3,299 (± 469, 95% CI) spring Chinook emigrated between 30 November 2014 and 25 February 2015 when the smolt trap was not operating. An additional 39 over-winter migrants were estimated from the single redd located downstream of the trap in 2013 to total 3,338 (± 472, 95% CI) over-winter migrants. Adding all emigrant totals, the complete emigration estimate for the 2013 spring Chinook brood was 26,025 (± 3,069, 95% CI) fish. Emigration peaked during November 2014, when 33.3% of the 2013 brood migrated from the Twisp River (Figure 10).

We compared the 2013 brood Chinook estimate calculated as described above to an estimate calculated solely from the PIT tag array. We found that 2013 brood Chinook captured between 1 July 2014 and 30 June 2015 had an existing PIT tag rate of 2.52 percent. We expanded daily PIT detections at the array by the tag rate, and the flow/efficiency regression created for the TWR PIT antennas (y = -0.00174870x + 1.336948968; Table 6) to estimate that 21,452 (± 2,817, 95% CI) 2013 brood spring Chinook migrated past the TWR interrogation site. An additional 255 emigrants were added to account for the one redd located downstream of the TWR site to estimate a total of 21,707 (± 2,834, 95% CI) 2013 brood spring Chinook migrating from the Twisp river between 1 July 2014 and 30 June 2015. This estimate accounted for 83.4 % of the estimate created using the screw trap method. The discrepancy in the estimates is primarily from the high river discharge periods in the spring (Figure 11), and is likely due to the very poor detection efficiency of the PIT antennas at flows that are greater than the upper bounds of the regression model. Similar to smolt trap estimates, the antenna efficiency/discharge model may improve over time if mark/recapture estimates from higher discharge ranges can be included. For consistency, all production tables include the population estimates created from the screw trap estimation method.

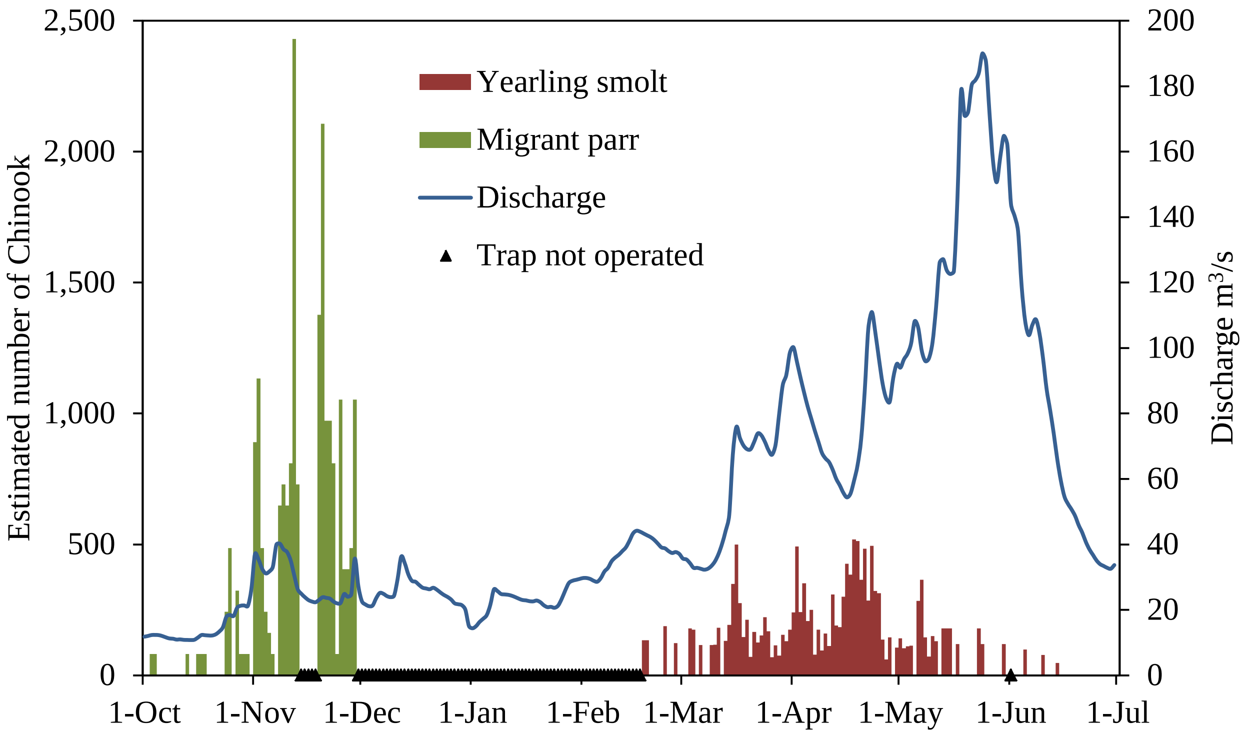

Figure 9. Estimated daily emigration of 2013 brood spring Chinook salmon from the Methow River by life stage.

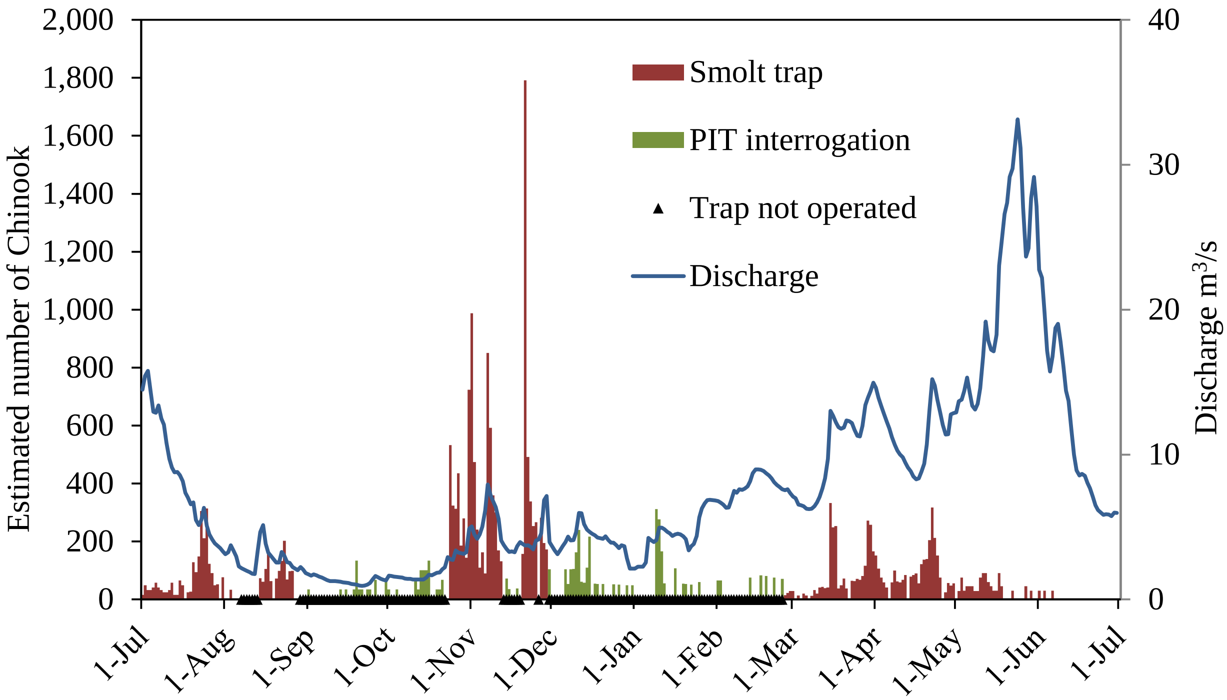

Figure 10. Estimated daily emigration of 2013 brood spring Chinook from the Twisp River by estimation method.

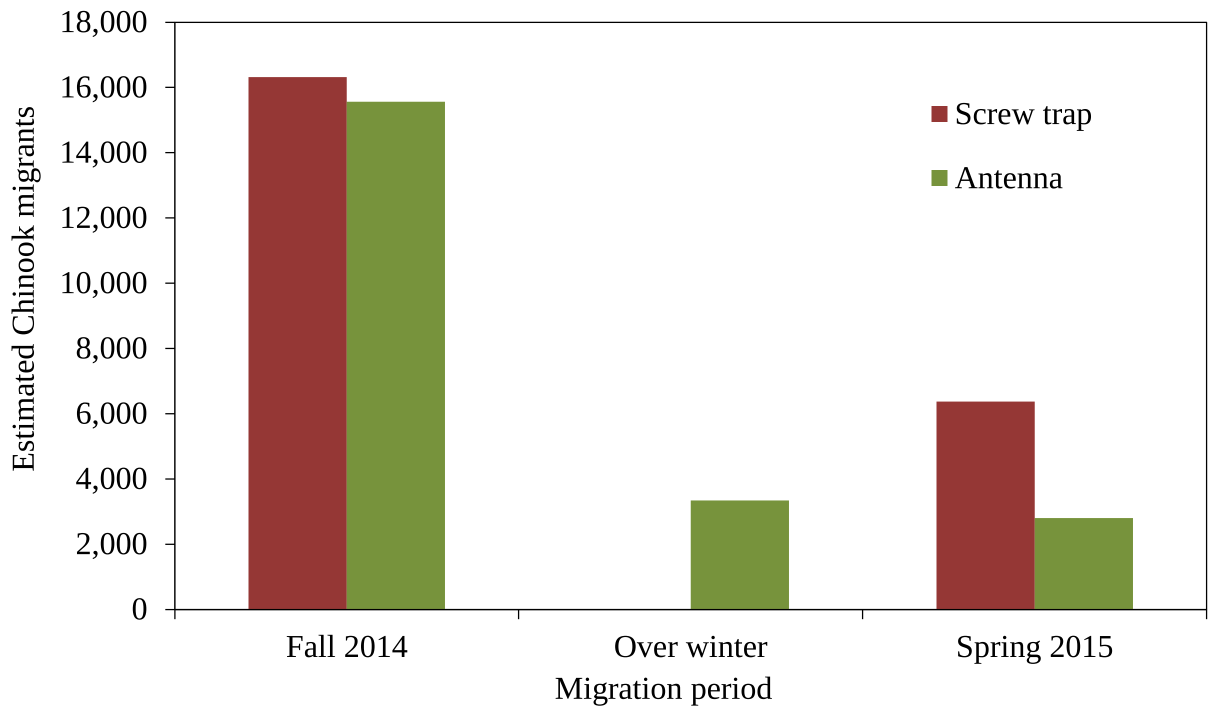

Figure 11. Estimated 2013 brood spring Chinook migration from the Twisp River by migration time and estimation method.

Table 5. Mark/recapture efficiency trials used to estimate emigration of 2013 brood spring Chinook (YCH = yearling Chinook-hatchery origin, and YCW = yearling Chinook-wild origin).

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
			Methow River trap			
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	12-Apr-07	Upper	448	9	2.01	119.0
YCH, YCW	14-Apr-07	Upper	224	2	0.89	105.8
YCH	18-Apr-07	Upper	361	10	2.77	95.1
YCH	20-Apr-07	Upper	305	8	2.62	89.9
YCH	22-Apr-10	Upper	525	7	1.33	119.9
YCH	20-Apr-12	Upper	399	20	5.01	42.9
YCW	05-Apr-13	Upper	234	11	4.70	79.8
YCW	09-Apr-13	Upper	62	2	3.23	70.8
YCW	13-Apr-13	Upper	83	3	3.61	65.2
YCH	15-Apr-13	Upper	353	13	3.68	59.5
YCH	18-Apr-13	Upper	407	28	6.88	51.9
YCW	21-Apr-13	Upper	53	2	3.77	55.7
YCH	25-Apr-13	Upper	392	15	3.83	58.1
YCH	19-Apr-14	Upper	415	23	5.54	51.3
YCW	20-Apr-14	Upper	118	5	4.24	49.8
YCW	23-Apr-14	Upper	98	3	3.06	51.3
YCW	26-Apr-14	Upper	76	6	7.89	45.5
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
	Flow model		5,546	194	3.50	

Table 5. Continued.

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

2014 Brood Chinook Salmon

Sufficient numbers of fish could not be obtained at the Methow trap site to develop a flow regression model for the low position in the fall of 2015, and a pooled efficiency was used to estimate fish passage during this time period (Table 7). With only one recapture in the fall of 2015, mark/recapture trials performed in the fall of 2014 had to be added to the pooled 2015 trials. This helped minimize the effect of the capture of a single marked fish on the production estimate. The two years of pooled mark/recapture data provided a trap efficiency of approximately 0.64%. Using this pooled efficiency, an estimated 34,402 (± 180,061, 95% CI) subyearling spring Chinook migrated past the trap in the fall of 2015.

Five mark/recapture trials conducted at the Twisp trap site in the fall of 2015 along with three trials conducted in the fall of 2014 showed that trap efficiency was significantly related to discharge (Table 8; $P < 0.05$, $r^2 = 0.54$), and the flow model regression ($y = 0.000906764x + 0.121806521$) was used to estimate that 14,317 (± 4,713, 95% CI) 2014 brood spring Chinook salmon parr emigrated past the Twisp trap during active trapping periods between 1 July and 20 November 2015. In addition to the smolt trap estimate, mark/detection trials performed at the Twisp PIT tag array (Table 6) were used to estimate that 3,839 (± 394, 95% CI) spring Chinook emigrated between 18 September and 31 October 2015 while the smolt trap was not operating. Summing all the estimates, the total fall emigration estimate for the 2014 brood was 18,290 (± 4,747, 95% CI), which includes 133 expected emigrants produced from a single redd found downstream of the Twisp trap in 2014.

Table 6. Mark/detection efficiency trials used to estimate emigration of spring Chinook salmon over the Twisp River PIT tag array (TWR) during non-trapping periods.

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

Table 7. Mark/recapture efficiency trials used to estimate emigration of 2014 brood subyearling Chinook salmon (SBC) at the Methow River smolt trap in 2015.

Species	Date	Position	Released	Recaptured	Efficiency (%)	Discharge (m^3/s)
SBC	06-Mar-15	Low	111	4	3.60	32.4
SBC	09-Mar-15	Low	105	1	0.95	34.0
SBC	12-Mar-15	Low	231	8	3.46	41.9
	Pooled		447	13	2.90	
SBC	30-Apr-07	Upper	493	5	1.01	123.0
SBC	26-May-07	Upper	600	5	0.83	171.0
SBC	28-May-07	Upper	600	1	0.17	172.8
SBC	11-Jun-07	Upper	760	7	0.92	132.1
SBC	14-Jun-07	Upper	620	12	1.94	106.8
SBC	18-Jun-07	Upper	1,000	32	3.20	95.2
SBC	25-Jun-07	Upper	1,000	25	2.50	75.7
SBC	28-Jun-07	Upper	833	21	2.52	71.6
SBC	03-Jul-07	Upper	340	12	3.53	64.6
SBC	11-Jun-08	Upper	503	8	1.59	112.9
SBC	23-Jun-08	Upper	170	2	1.18	112.0
SBC	03-Aug-11	Upper	50	2	4.00	59.4
	Flow model		6,969	132	1.89	
SBC	05-Oct-14	Low	2	0	0.00	12.1
SBC	18-Oct-14	Low	4	0	0.00	12.1
SBC	24-Oct-14	Low	3	0	0.00	18.6
SBC	28-Oct-14	Low	11	0	0.00	21.4
SBC	31-Oct-14	Low	2	0	0.00	33.8
SBC	03-Nov-14	Low	31	0	0.00	31.7
SBC	06-Nov-14	Low	6	0	0.00	36.5
SBC	10-Nov-14	Low	25	1	4.00	36.4
SBC	14-Nov-14	Low	48	0	0.00	24.3
SBC	21-Nov-14	Low	55	1	1.82	23.6
SBC	25-Nov-14	Low	35	0	0.00	23.9
SBC	28-Nov-14	Low	16	0	0.00	31.5
SBC	03-Nov-15	Low	76	0	0.00	14.0
SBC	06-Nov-15	Low	18	0	0.00	12.0
SBC	09-Nov-15	Low	9	0	0.00	11.6
SBC	12-Nov-15	Low	3	0	0.00	11.0
SBC	16-Nov-15	Low	28	1	3.57	20.2
SBC	19-Nov-15	Low	67	0	0.00	21.6
SBC	23-Nov-15	Low	28	0	0.00	17.4
	Pooled		467	3	0.64	

Table 8. Mark/recapture efficiency trials used to estimate emigration of 2013 and 2014 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	7.7	4.7
SBC	07-Nov-14	Low	107	12	11.2	7.4
SBC	21-Nov-14	Low	106	3	2.8	3.8
SBC	01-Nov-15	Low	200	7	3.5	4.2
SBC	02-Nov-15	Low	200	16	8.0	3.2
SBC	04-Nov-15	Low	248	8	3.2	2.5
SBC	14-Nov-15	Low	111	13	11.7	6.8
SBC	15-Nov-15	Low	117	10	8.6	5.9
	Flow model		1,206	78	6.5	

<u>*Summer Steelhead*</u>

Several mark/recapture trials were conducted with steelhead in 2015 at the Methow trap, but a significant relationship did not exist between flow and efficiency for these trials. Because no significant regression model exists for steelhead at the Methow River trap, the yearling Chinook flow/efficiency models was used to estimate steelhead production for each position (see Table 5). Combining numbers from both trapping positions, an estimated 19,215 (± 3,980, 95% CI) summer steelhead emigrated past the Methow River trap in 2015. An additional 619 migrants were estimated from redds located downstream of the trap in 2011 through 2014, which provides a total estimated migration of 19,834 (± 4,044, 95% CI) summer steelhead from the Methow River basin in 2015. Most 2015 migrants were age-2 fish (76.4%) from the 2013 brood (Table 9). The entire 2011 brood migration was estimated to be 12,501 (± 3,008, 95% CI) fish, including 453 migrants that were expected from redds (N = 31) located downstream of the Methow trap in 2011.

Numerous mark/recapture trials were conducted with wild summer steelhead at the Twisp site in 2015, but none were conducted with more than 50 fish, and recapture rates were too low for any of these trials to aide in model development (11 recaptures from 239 fish released in 31 separate trials). Therefore, a flow efficiency relationship from previous years' release groups was used to estimate steelhead emigration at the Twisp site in 2015 (Table 10). The flow model regression ($y = -0.00029758x + 0.410040455$; $P < 0.01$, $r^2 = 0.52$) was used to estimate that 5,427 (± 1,486, 95% CI) wild summer steelhead migrated past the Twisp River trap between 26 February and 30 June 2015. An additional 366 migrants were estimated from redds located downstream of the trap in 2011 through 2014, which provides a total estimated migration of 5,793 (± 1,535, 95% CI) summer steelhead from the Twisp River in 2015. Most 2015 migrants were age-2 fish (78.4%) from the 2013 brood (Table 9). Combining numbers from the last four years, the entire 2011 brood migration is estimated to be 6,367 (± 2,016, 95% CI) fish, which includes 135 expected migrants produced from redds (N = 4) that were identified downstream of the Twisp trap in 2011.

Table 9. Estimated number of steelhead emigrants from the Methow River basin in 2015 by age and brood.

Age	Brood	Percent of emigrants	Number
		Methow River trap	
1	2014	5.1	1,008
2	2013	76.4	15,155
3	2012	17.1	3,396
4	2011	1.4	275
Total		100.0	19,834
		Twisp River trap	
1	2014	5.0	288
2	2013	78.4	4,542
3	2012	16.6	963
4	2011	0.0	0
Total		100.0	5,793

Table 10. 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	15.2	4.4
SHR	05-May-08	Low	173	10	5.8	10.6
SHR	22-Apr-09	Low	267	15	5.6	13.0
SHR	25-Apr-09	Low	129	11	8.5	10.9
SHR	18-Apr-10	Low	180	17	9.4	7.5
SHR	02-Apr-11	Low	63	7	11.1	10.6
SHR	06-May-11	Low	58	3	5.2	13.5
SHR	09-May-11	Low	56	3	5.4	15.3
SHR	12-Apr-14	Low	85	8	9.4	7.9
SHR	02-May-14	Low	81	4	4.9	19.8
	Flow model		1,184	92	7.8	

<u>*Summer Chinook*</u>

Three mark/recapture trials were conducted at the Methow trap with subyearling Chinook for the low position in the spring of 2015, but no significant relationship was found between flow and efficiency, so a pooled efficiency of approximately 2.9 percent was used to estimate Chinook emigration during that period. A flow efficiency relationship using data from previous years was used to estimate emigrants during the upper trapping period (Table 7). The flow model regression (y = -0.000028801294x + 0.2504513; $P < 0.01$, $r^2 = 0.79$), was used in addition to the pooled efficiency to estimate that 706,071 (± 578,674, 95% CI) wild summer Chinook migrated past the Methow trap in 2015. There were 29 summer Chinook redds located downstream of the Methow trap in 2014, so an estimated 36,434 (± 131,451, 95% CI) fish migrated from redds located below the trap, thus bringing the total to 742,505 (± 593,417, 95% CI) wild 2014 brood summer Chinook migrants from the Methow river in 2015.

Coho

A total of 25 wild juvenile Coho were captured at the Twisp site and 16 were captured at the Methow site between 1 July 2014 and 30 June 2015. Utilizing the same mark/recapture efficiency trial data used for spring Chinook at each site (Tables 5-8), an estimated 586 (± 201, 95% CI) and 1,336 (± 1,081, 95% CI) wild 2013 brood Coho emigrated from the Twisp and Methow River basins, respectively.

Juvenile Survival

2013 Brood Spring Chinook Salmon

Yearling emigrants accounted for 24.5% of all 2013 brood spring Chinook Salmon migrating from the Twisp River, and 43.5% of the overall emigrants from the Methow River basin (Table 11). The 2013 brood had more emigrants per redd than average for both the Twisp and Methow rivers.

Summer Steelhead

Since juvenile steelhead may emigrate as age-4 fish, completed emigration estimates have only been calculated for broods prior to 2012 (Table 12). The 2011 brood produced an estimated 15 and 34 emigrants from each redd in the Methow and Twisp river basins, respectively.

Table 11. Estimated emigrant-per-redd and egg-to-emigrant survival for Methow Basin spring Chinook. Methow Basin and Twisp River estimates are for redds deposited upstream and downstream of the respective trap sites, and include redds that dewatered. Rows identified with a * include an estimate of over-winter emigration derived from a PIT tag array and added to the total number of emigrants estimated from smolt trapping activities. DNOT = Did not operate trap.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants			Egg to emigrant (%)	Emigrants per redd
				Age-0	Age-1	Total		
Twisp	2003	18	81,395	DNOT	900	900	1.1	50
Twisp	2004	139	510,220	1,219	5,224	6,443	1.3	46
Twisp	2005	55	237,729	3,245	3,329	6,574	2.8	120
Twisp	2006	87	298,074	1,531	16,415	17,946	6	206
Twisp	2007	30	128,182	4,181	5,547	9,728	7.6	324
Twisp	2008	79	268,771	7,139	4,793	11,932	4.4	151
Twisp	2009	24	100,694	3,282	1,842	5,124	5.1	214
Twisp*	2010	145	568,266	4,874	3,917	9,682	1.7	67
Twisp*	2011	63	269,855	6,431	3,617	12,759	4.7	203
Twisp*	2012	139	466,182	3,953	6,043	13,690	2.9	98
Twisp*	2013	85	281,719	16,314	6,373	26,025	9.2	306
Twisp	2014	138	490,824	18,290	--	18,290	--	--
Twisp	Mean	79	291,917	5,217	5,273	10,982	4.3	162
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	--	34,402	--	--
Methow	Mean	716	2,710,375	8,468	24,940	31,996	1.2	46

Table 12. Estimated emigrant-per-redd and egg-to-emigrant survival of Methow Basin summer steelhead. Methow Basin and Twisp River estimates are for redds deposited upstream and downstream of the respective trap sites. Emigrant-per-redd and egg-to-emigrant values were not calculated for incomplete brood years. DNOT = Did not operate trap.

Basin	Brood	Redds	Estimated egg deposition	Number of emigrants					Egg to emigrant (%)	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	--	5,843	--	--
Twisp	2013	140	835,660	183	4,542	--	--	4,725	--	--
Twisp	2014	144	759,456	288	--	--	--	288	--	--
Mean 03-11		329	1,983,714	101	4,338	1,592	141	6,161	0.62	34
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	--	25,625	--	--
Methow	2013	810	4,834,890	1,649	15,155	--	--	16,804	--	--
Methow	2014	878	4,630,572	1,008	--	--	--	1,008	--	--
Mean 03-11		1,202	7,133,587	1,778	11,529	3,061	360	16,729	0.29	17

Smolt to Adult Returns

The Columbia River DART website (http://www.cbr.washington.edu/dart) was used to determine adult PIT tag detections at any Columbia River adult ladder facility for wild Chinook (Table 13) and at Wells Dam for wild steelhead (Table 14). 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 13. 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	--	1	0.23
2012	2014	664	0	--	--	0	0.00
2003-2010 brood mean							0.58
Pooled 2003-2010 brood		6,186	7	35	10	52	0.84
			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	--	2	0.26
2012	2014	883	0	--	--	0	0.00
2003-2010 brood mean							0.73
Pooled 2003-2010 brood		3,133	4	17	2	23	0.73

Table 14. Smolt to adult returns (SAR) from release to Wells Dam by release year for PIT tagged wild steelhead encountered at the Twisp and Methow smolt traps.

Release year	Released	Age at return (*N*) to Wells Dam		Total	SAR %
		1-Salt	2-Salt		
		Twisp trap			
2006	486	0	0	0	0.00
2007	332	2	5	7	2.11
2008	642	7	5	12	1.87
2009	640	3	5	8	1.25
2010	454	2	2	4	0.88
2011	321	1	0	1	0.31
2012	135	1	2	3	2.22
2013	243	2	2	4	1.65
2014	328	1	--	1	0.30
2006-2013 mean					1.29
Pooled 2006-2013	3,253	18	21	39	1.20
		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	--	2	0.34
2006-2013 mean					1.14
Pooled 2006-2013	2,092	7	10	17	0.81

Discussion

River conditions at the Methow site were generally favorable for trapping activities during the 2015 season. River discharge occurred earlier, and was lower than normal, and trapping activities were not suspended as typically happens in most years. Perhaps because of the lower flow, the common algal masses (i.e., didymo) that can negatively impact trap operation were less abundant, making it much easier to keep the trap operating effectively. We were forced to suspend trapping for the days of 20 August and 21 August due to wildfire activity. Overall, there were three nights when the Methow trap was not operating, but these occurred during time periods that experience minimal fish migration.

The Twisp trap was operated every night through the spring run-off event due to lower than average river discharge and minimal debris loading. Conversely, the Twisp site experienced a long period of very low river discharge, and we were unable to operate the trap for 102 days between 22 July and 31 October. During the fall (after about 18 September), the TWR PIT interrogation site indicated that there were Chinook parr migrating past the trap site when the trap was not operating. We used the TWR PIT array to estimate emigration during the days in which the trap did not operate so that production estimates would not be impacted by the non-trapping periods.

The TWR PIT interrogation site was not only used to estimate migration during periods when the Twisp trap was not operating, but it was also used to verify migrant estimates during periods in which the trap was functional. The PIT antennas were used to calculate population estimates using a tag rate determined from screw trap captures. The outcome of these calculations was similar to the screw trap estimates for periods of low river discharge. However, when the flows were higher than the bounds of the tag detection/flow regression model, the antenna estimated much less migration than the screw trap. This phenomenon will likely continue until mark/detection trails can be performed at higher flows to extend the upper bounds of the regression model being used in the PIT antenna estimates.

Higher than average capture of subyearling Chinook at the Twisp trap in November 2015 enabled five mark efficiency trials that contained more than 100 fish per release group. Three groups of over 100 fish were added from mark/efficiency trials conducted in November of 2014. This new model incorporates data outside the independnet variable bounds of the previous model and replaces the regression based on 2006-2009 data that contained release groups with substantially fewer fish overall. River flow patterns at the trapping location have changed over the last decade, and the new model should better represent smolt trapping dynamics at the site. The new model provides more than double the number of estimated emigrants than the old regression for subyearling Chinook migrating from the Twisp river in the fall of 2015. Migration estimates calculated using the TWR interrogation site for the same period are much closer to the totals found using the new regression, strengthening support for the updated regression model.

Production estimates and associated variance estimates for the 2015 trapping season were made using a new methodology described in Murdoch et al. (2012). This new methodology has minimal effect on the production estimate but corrects for the extremely high variances estimated by the former methodology. Once this new 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 2015 to determine the proportion of subyearling fish that were spring Chinook Salmon. Spring Chinook Salmon accounted for 91.0% of the Chinook sampled during the fall trapping period. Emigration estimates were produced for spring Chinook Salmon during the fall trapping period at the Methow River trap site and the proportion of fish identified as summer Chinook Salmon were removed. Emigration estimates are not produced for spring Chinook Salmon that may emigrate before the fall period as subyearling fish. Therefore, spring Chinook production estimates for the Methow Basin, including Twisp River estimates, underestimate production by the portion of spring Chinook Salmon emigrating as subyearling fish in the spring and summer, assuming that those fish do not move back upstream of the trap after initial capture.

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

Year	Trap site	Number of fish released with PIT tags					
		YCW smolts	YCH smolts	SBC parr	SHR migrants	SHH migrants	SHR parr
2005	Twisp	110	0	251	0	0	0
2006	Twisp	818	966	562	466	1,410	689
2007	Twisp	271	1,096	251	324	1,292	126
2008	Twisp	2,502	1,081	511	641	1,594	440
2009	Twisp	627	201	741	637	205	231
2010	Twisp	952	325	291	441	585	450
2011	Twisp	304	211	485	302	752	136
2012	Twisp	599	4	914	127	0	323
2013	Twisp	432	2	325	214	518	392
2014	Twisp	651	205	824	297	410	240
2015	Twisp	431	0	1,099	239	1	383
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

2015 Methow Chinook salmon juvenile assignments

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Summary

In fall 2015, 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 types 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 23% of the spring type originated in the Twisp population.

Methods

We genotyped 100 juvenile Chinook salmon (WDFW collection code 15PE, Table 1) at the 13 standardized GAPS loci as described in Small et al. (2007, 2009, 2010) and compared them to Twisp River spring Chinook salmon, and Methow River spring and summer Chinook salmon genotyped at the same loci.

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

Results and discussion

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

Results from GENECLASS paralleled the STRUCTURE analyses and provided further resolution (Figure 2 and Table 3). We plotted the negative log likelihood assignment values for the juveniles and for the adult spring and summer Chinook salmon collections (Figure 2). The plot shows that the adult spring and summer Chinook salmon assigned well to their respective groups. The distinction indicated high power for distinguishing genetically between run groups. The plot also shows that nine juveniles assigned to the summer collection. Fourteen juveniles assigned with less than 90% likelihood to a spring-run baseline collection. The second most likely assignment for each was the other spring-run collection indicating that the smolts were spring-run, and these were labeled “Spring” in Table 3. For instance, 15PE0022 assigned with 87% likelihood to Methow spring and with 13% likelihood to Twisp spring. It likely originated in the Methow spring-run population but had one or more alleles that were more common in the Twisp spring-run population than in the Methow.

In summary, nine smolts assigned with high likelihood to the Methow summer Chinook salmon collection and 91 smolts assigned to Methow or Twisp spring Chinook salmon collections.

Acknowledgments

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

Figure 2. Graph of negative log likelihood assignment scores from GENECLASS. Methow juveniles (blue diamonds) are abbreviated Juv. Highest likelihood values assigned 91 juveniles to spring and 9 to summer.

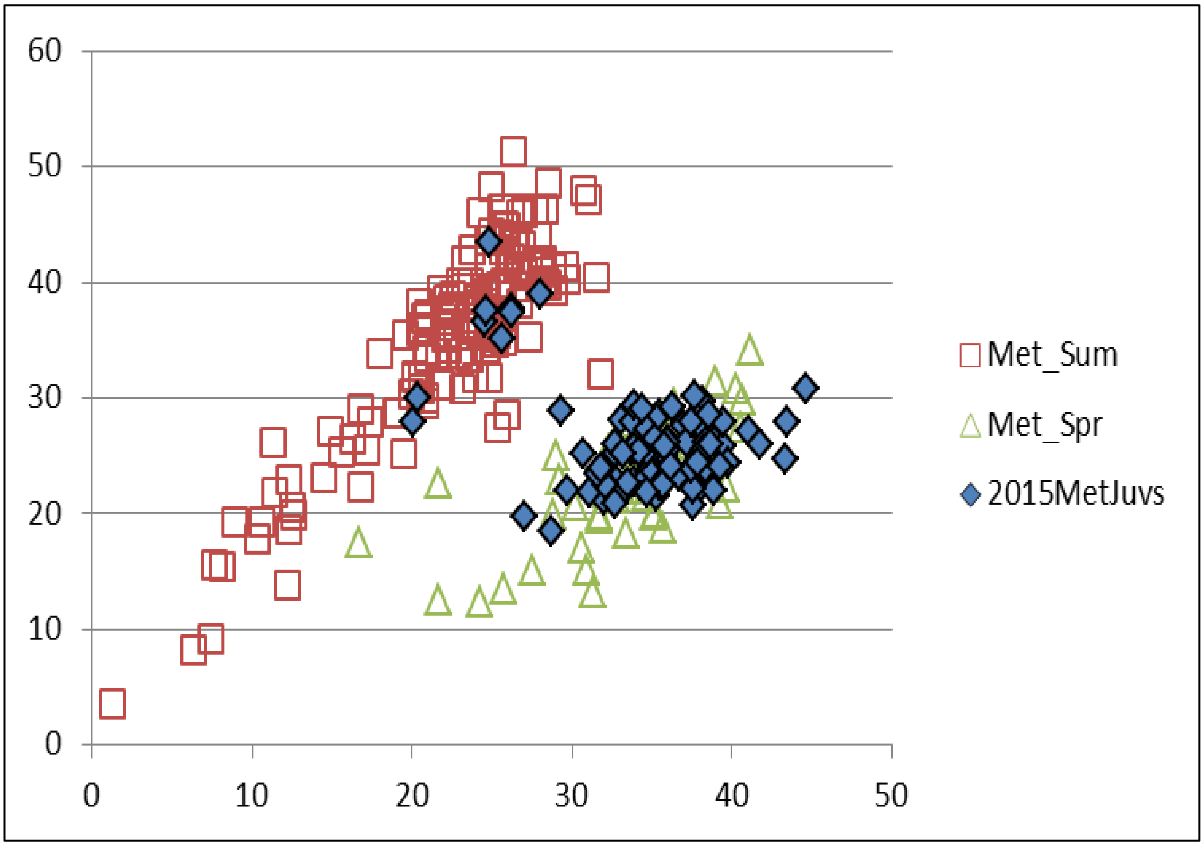

Table 1. List of samples used in the Methow Chinook salmon juvenile assignment tests.

Code	Name	*N*
15PE	Methow juveniles - 2015	100
05HW	Methow spring	42
05HX	Twisp spring	42
93EC	GAPS Methow summer	143

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

	Gene Class		STRUCTURE clusters	
sample	Highest Assign	%	Summer	Spring
15PE0001	MethowSum	100.00	0.979	0.021
15PE0003	TwispSpr	92.39	0.003	0.997
15PE0006	MethowSpr	99.99	0.017	0.983
15PE0008	MethowSum	100.00	0.993	0.007
15PE0010	MethowSpr	99.97	0.005	0.995
15PE0013	TwispSpr	98.69	0.008	0.992
15PE0015	TwispSpr	98.29	0.004	0.996
15PE0017	MethowSum	100.00	0.990	0.010
15PE0020	MethowSpr	99.91	0.005	0.995
15PE0022	Spring	86.73	0.004	0.996
15PE0024	MethowSpr	97.09	0.009	0.991
15PE0027	MethowSpr	97.70	0.025	0.975
15PE0029	TwispSpr	89.24	0.005	0.995
15PE0031	MethowSpr	99.45	0.005	0.995
15PE0034	TwispSpr	100.00	0.004	0.996
15PE0036	Spring	50.91	0.004	0.996
15PE0038	MethowSpr	100.00	0.008	0.992
15PE0041	MethowSpr	89.53	0.004	0.996
15PE0043	MethowSpr	99.99	0.004	0.996
15PE0045	MethowSpr	99.99	0.019	0.981
15PE0048	MethowSpr	98.60	0.005	0.995
15PE0050	Spring	81.91	0.005	0.995
15PE0052	MethowSum	100.00	0.995	0.005
15PE0055	MethowSum	100.00	0.996	0.004
15PE0057	Spring	76.41	0.005	0.995
15PE0059	Spring	79.62	0.004	0.996
15PE0062	MethowSpr	96.81	0.015	0.985
15PE0064	MethowSpr	99.45	0.009	0.991
15PE0066	MethowSpr	97.62	0.029	0.971
15PE0069	Spring	86.86	0.005	0.995
15PE0071	MethowSpr	98.52	0.009	0.991
15PE0073	TwispSpr	99.99	0.009	0.991
15PE0076	MethowSpr	99.47	0.004	0.996
15PE0078	TwispSpr	91.20	0.005	0.995
15PE0080	TwispSpr	95.68	0.016	0.984
15PE0083	MethowSpr	100.00	0.020	0.980
15PE0085	MethowSpr	100.00	0.005	0.995
15PE0087	MethowSpr	100.00	0.018	0.982
15PE0090	MethowSpr	99.93	0.003	0.997
15PE0092	MethowSpr	99.96	0.004	0.996
15PE0094	MethowSpr	99.79	0.017	0.983
15PE0097	TwispSpr	98.43	0.005	0.995
15PE0099	MethowSpr	100.00	0.003	0.997
15PE0104	MethowSpr	99.20	0.005	0.995
15PE0106	TwispSpr	99.98	0.008	0.992
15PE0108	TwispSpr	94.79	0.004	0.996

	Gene Class		STRUCTURE clusters	
sample	Highest Assign	%	Summer	Spring
15PE0111	MethowSpr	100.00	0.004	0.996
15PE0113	MethowSum	100.00	0.995	0.005
15PE0115	MethowSpr	97.56	0.005	0.995
15PE0118	MethowSpr	100.00	0.011	0.989
15PE0120	MethowSpr	99.42	0.005	0.995
15PE0122	MethowSpr	99.93	0.007	0.993
15PE0125	MethowSpr	99.25	0.003	0.997
15PE0127	MethowSpr	100.00	0.018	0.982
15PE0129	Spring	74.87	0.007	0.993
15PE0132	Spring	83.85	0.052	0.948
15PE0134	MethowSum	100.00	0.984	0.016
15PE0136	TwispSpr	94.03	0.003	0.997
15PE0141	TwispSpr	100.00	0.004	0.996
15PE0143	MethowSpr	99.98	0.018	0.982
15PE0146	Spring	77.54	0.047	0.953
15PE0148	MethowSpr	99.85	0.079	0.921
15PE0150	Spring	66.48	0.082	0.918
15PE0153	MethowSum	100.00	0.991	0.009
15PE0157	TwispSpr	92.65	0.004	0.996
15PE0160	TwispSpr	98.54	0.007	0.993
15PE0162	TwispSpr	91.04	0.010	0.990
15PE0164	TwispSpr	90.65	0.004	0.996
15PE0167	MethowSpr	98.18	0.010	0.990
15PE0169	MethowSpr	100.00	0.003	0.997
15PE0171	MethowSpr	98.16	0.012	0.988
15PE0174	TwispSpr	99.17	0.006	0.994
15PE0176	TwispSpr	99.99	0.004	0.996
15PE0178	Spring	87.56	0.005	0.995
15PE0181	MethowSpr	94.79	0.004	0.996
15PE0183	MethowSpr	99.78	0.039	0.961
15PE0185	MethowSpr	99.91	0.005	0.995
15PE0188	MethowSpr	99.87	0.006	0.994
15PE0190	TwispSpr	99.95	0.009	0.991
15PE0192	MethowSpr	100.00	0.191	0.809
15PE0195	Spring	77.25	0.005	0.995
15PE0197	MethowSpr	100.00	0.018	0.982
15PE0199	MethowSpr	100.00	0.006	0.994
15PE0202	MethowSpr	99.91	0.047	0.953
15PE0204	MethowSpr	100.00	0.013	0.987
15PE0206	MethowSpr	99.07	0.005	0.995
15PE0209	MethowSpr	95.30	0.016	0.984
15PE0211	MethowSpr	100.00	0.007	0.993
15PE0213	MethowSpr	99.21	0.005	0.995
15PE0216	MethowSpr	99.12	0.006	0.994
15PE0218	MethowSpr	99.67	0.005	0.995
15PE0220	MethowSpr	100.00	0.029	0.971
15PE0223	Spring	60.72	0.035	0.965
15PE0225	MethowSpr	100.00	0.006	0.994
15PE0227	Spring	56.08	0.319	0.681
15PE0230	TwispSpr	91.34	0.010	0.990
15PE0232	MethowSum	100.00	0.995	0.005
15PE0234	MethowSpr	99.57	0.006	0.994
15PE0237	MethowSpr	99.84	0.004	0.996
15PE0239	MethowSpr	99.40	0.004	0.996

Attachment B. In-stream PIT tagging of juvenile spring Chinook and steelhead in the Methow River basin in 2015.

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19 May, 2016

To: Charlie Snow

From: Matt Young

Subject: 2015 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. In-stream 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 2015, 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 1,500 will be age-1 parr).

Methods

We used a combination of angling and electrofishing to collect spring Chinook Salmon and steelhead parr in 2015. 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. Electrofishing was conducted using a Halltech HT-2000 pulsed DC battery powered backpack electrofisher with a telescoping 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. Sampling efficiency using these techniques varied throughout the sampling period in relation to river flows and staff availability. Start and stop time and 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, electrofishing and angling were conducted at various locations in the Twisp River mainstem (mouth to rkm 40), Little Bridge Creek (mouth to rkm 8), and Buttermilk Creek (mouth to rkm 3; Table 1). Angling effort occurred between June 18 and August18 to target larger sized fish (i.e., age-1 or older steelhead). This time was selected as water temperature and fish activity levels made them relatively susceptible to angling. Angling effort was composed of two passes. In the first pass, the Twisp River mainstem from the Twisp Weir (rkm 11) to the middle of T-7 (rkm 32) and the lower 2.4 km of Little Bridge Creek (LBC-1) were fished completely (i.e., a single angling pass was conducted along the entire length of each reach). Also included in the first pass were randomly selected sites below the Twisp Weir, in Buttermilk Creek, upstream of LBC-1 (rkm 2.4), and upstream from the middle of T-7; angling effort was reduced in these reaches because the likelihood of capturing the progeny of adults sampled at the Twisp Weir declines outside of the primary spawning reaches. After completing this first pass of angling effort, a second pass of angling effort in areas upstream of the weir with the highest redd densities (i.e., T-4–T-7) was conducted at randomly selected sites in order to attain the numeric sampling goal of the relative reproductive success study (1,500 age-1 parr).

Table 1. Stream section, code and approximate length (km) of Twisp River subbasin mainstem and tributary areas where fish collection or salvage occurred in 2015.

Stream section	Code	Length (rkm)	Stream section	Code	Length (rkm)
Twisp River			*Little Bridge Creek*		
South Creek Br. - Poplar Flats C.G.	T-9	3.2	End of Road - Vetch Creek	LBC-4	2.9
Poplar Flats C.G. - Mystery Br.	T-8	3.2	Vetch Creek – upper culvert	LBC-3	3
Mystery Bridge - War Creek Br.	T-7	6.9	Upper culvert - lower culvert	LBC-2	2.4
War Creek Bridge - Buttermilk Br.	T-6	7.4	Lower culvert – conf.	LBC-1	2.4
Buttermilk Br. - Little Bridge Creek	T-5	5.9	*Buttermilk Creek*		
Little Bridge Creek - Twisp Weir	T-4	3.8	Forks - cattle guard	BM-2	2
Twisp Weir - Upper Poorman Br.	T-3	3.6	Cattle guard – conf.	BM-1	2.1
Up. Poorman Br. - Lwr Poorman Br.	T-2	4.9	*War Creek*		
Lower Poorman Bridge – conf.	T-1	2.9	Bridge – conf.	WR-1	0.6
Eagle Creek			*South Creek*		
Trailhead - culvert	EA-2	0.8	Falls – conf.	SO-1	0.6
Culvert – conf.	EA-1	0.5			
Grand total		43.1	Grand total		16

Electrofishing occurred after September 18 when most juvenile Chinook captured would be large enough for PIT tagging (i.e., > 64 mm fork length) and prior to seasonal movments of fish. Individual sampling sites for electrofishing in the Twisp River basin were selected by Douglas 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 selected from within the known distribution of spring Chinook Salmon and steelhead, which was based on redd locations from previous years. Sampling effort was divided into three spatial strata; 29% of sites were downstream of the weir, 44% were upstream of the weir, and 27% were in tributaries. Mainstem sites were 100 m long and tributary sites were 50 m long. Two types of electrofishing sampling methods were used at these sites; three-pass depletion sampling and single-pass sampling. In three-pass depletion samples, each electrofishing pass occurred in an upstream direction and all wetted area within the site that could be accessed was sampled with approximately equal effort per pass. Single-pass sites were conducted in the same manner, but with only a single pass at each site. Electrofishing in other sites targeted the entire length of the stream (SSC-1 – 4), or individual pools or dewatering areas (M-9L – M-14; Table 2).

Table 2. Stream section, code and approximate length (km) of Methow River subbasin mainstem and tributary areas where fish collection or salvage occurred in 2015.

Stream section	Code	Length (rkm)	Stream section	Code	Length (rkm)
Methow River			*Silver Side Channel*		
Lost R. - Gate Creek	M-14	4.8	Channel start - well ring	SSC-4	0.69
Gate Cr. -Early Winters Cr.	M-13	4.2	Well ring – foot br.	SSC-3	0.43
People mover - Hwy 20	M-9L	3	Foot Br. - horse crossing	SSC-2	0.3
			Horse crossing – conf.	SSC-1	0.37
Grand total		12	Grand total		1.8

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 > 64 mm fork length were tagged with PIT tags 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). All hatchery origin fish captured during angling and electrofishing (i.e., fish that failed to emigrate) were euthanized to reduce the proportion of hatchery residuals in natal rearing areas. Sampling locations were geo-referenced using a hand-held GPS device. Fish were allowed to fully recover in a bucket of river water prior to release in a calm part of the river near the sampling location. Tagging data were uploaded to the regional PIT tag database (PTAGIS) maintained by the Pacific States Marine Fisheries Commission (PSMFC) following standard protocols.

During late summer, large portions of the upper Twisp and Methow rivers may become dewatered. When isolated pools containing fish were identified (often by stream surveyors), we attempted to capture and relocate fish to reduce mortality. Stranded fish were captured with dip nets and electrofishing equipment and transported in 19-L plastic buckets filled with aerated river water to a 757- L truck-mounted transport tank. Captured fish were taken to the nearest flowing section of river and released. Due to high water temperature and high fish density in the isolated pools, biological sampling was limited. We enumerated juvenile fish by species, and recorded the hatchery mark (if any) on adult fish. Brook Trout encountered during angling, electrofishing, or salvage operations were euthanized.

Results

In the Twisp River basin we captured a total of 4,793 steelhead, of which 254 were hatchery origin, and 1,267 Chinook salmon parr, of which nine were hatchery origin, during routine angling and electrofishing activities. Angling in the Twisp River basin was conducted between 18 June and 18 August (273 angler hours; Table 3) and electrofishing was conducted between 18 September and 8 November (41.2 hrs; Table 3). Our sampling goals for steelhead parr for the Twisp River reproductive success study were met in 2015 through the combination of angling and electrofishing (Tables 3-4). Electrofishing was the most effective method for collecting target species (Chinook and steelhead), but angling was more effective at collecting larger sized steelhead juveniles (Figure 1). Survival estimates for fish tagged in 2015 would be premature at this time as parr are currently in the process of emigrating and age estimates from scale samples are currently in progress for steelhead.

Table 3. Number of spring Chinook and summer steelhead parr PIT tagged by reach and capture method in the Twisp River basin in 2015. Electrofishing effort was converted from seconds to hours to maintain scale between capture methods.

Section	Angling			Electrofishing		
	Effort (hrs)	Chinook tagged	Steelhead tagged	Effort (hrs)	Chinook tagged	Steelhead tagged
T-9	1	0	0	0.00	0	0
T-8	6	0	19	0.00	0	0
T-7	38	0	302	3.38	98	73
T-6	42	3	116	7.31	172	134
T-5	46	1	164	5.39	223	273
T-4	51	0	245	3.91	123	346
T-3	33	1	183	7.14	128	377
T-2	14	0	147	6.91	267	676
T-1	9	0	34	3.49	85	289
LBC-4	0	0	0	0.10	0	16
LBC-3	0	0	0	0.69	0	102
LBC-2	9	0	32	0.00	0	0
LBC-1	21	0	106	1.43	0	110
BM-2	0	0	0	0.76	0	38
BM-1	2	0	42	0.46	9	20
EA-1	1	0	1	0.00	0	0
EA-2	0	0	0	0.14	0	6
WR-1	0	0	0	0.16	10	2
Total	273	5	1,391	41.27	1,115	2,462

Table 4. Number of spring Chinook Salmon and summer steelhead parr PIT tagged by subbasin and year.

Year	Methow River		Chewuch River		Twisp River	
	Chinook	Steelhead	Chinook	Steelhead	Chinook	Steelhead
2010	26	318	5	508	141	1,496
2011	292	516	517	1,059	1,059	1,861
2012	633	1,029	771	2,034	983	2,366
2013	1,717	1,849	1,610	2,321	1,103	1,988
2014	62	22	3,040	0	924	2,890
2015	51	35	0	0	1,120	3,803

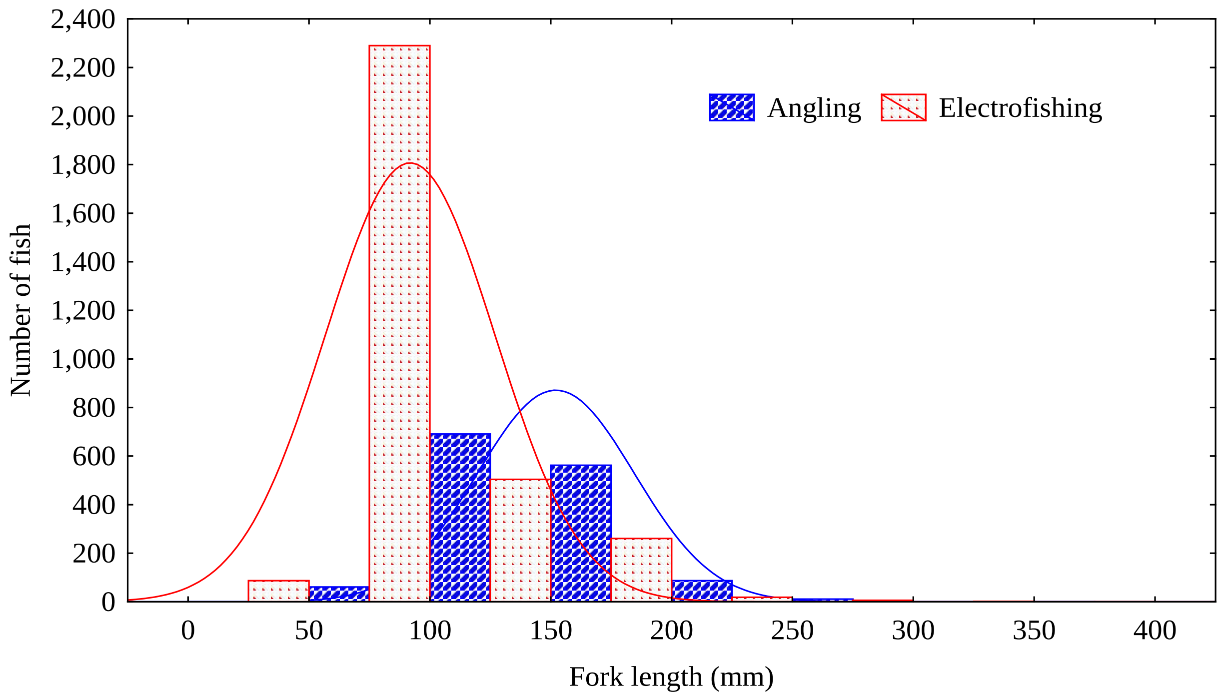

Figure 1. Number of wild steelhead captured and in the Twisp River by capture method. Line represents normal distribution fit.

Between 15 August and 9 October we salvaged stranded fish from isolated pools in the upper Twisp River (sections T-6 and T-8) and in the Methow River (sections M-9, M-13, and M-14). During this time 8,054 stranded fish were captured from isolated pools (Table 5). Chinook and steelhead parr were 68% and 97% of captured fish in the Twisp and Methow rivers, respectively. Bull Trout, Brook Trout, and sculpin were also significant species in the Twisp River, but were not a significant part of the catch in the Methow River.

Table 5. Number and percent of fish captured in 2015 in isolated pools by species and sub-basin. All species except Brook Trout were relocated to nearby flowing water.

Species	Twisp River		Methow River	
	N	%	*N*	%
Bull Trout	247	17.6	8	0.1
Chinook Salmon parr	711	50.6	2,720	40.9
Spring Chinook (adult)	0	0.0	20	0.3
Steelhead parr	243	17.3	3,760	56.6
Coho parr	0	0.0	19	0.29
Sockeye Salmon (adult)	0	0.0	2	< 0.1
Cutthroat Trout	1	0.1	0	0.0
Unknown sculpin	106	7.5	97	1.5
Whitefish	0	0.0	13	0.2
Unknown sucker	0	0.0	1	< 0.1
Longnose Dace	0	0.0	8	0.1
Brook Trout	98	7.0	0	0.0
Total	1,406	100.0	6,648	100.0

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 2015.

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To: Charlie Snow

Date: 16 May 2016

Subject: Results of 2015 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 2015). 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 2015 brood. All ad-clipped adults were assumed to be returns from Winthrop NFH production. There were no documented broods returning to the Okanogan Basin in 2015. 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. The exception to this was for suspected age-3 (i.e., jack) hatchery origin fish which were lethally removed to reduce the escapement of hatchery origin fish on the spawning grounds.

Digital video records of fish passage at Wells Dam between 6 May and 11 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 spawners.

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. Most spring Chinook salmon released from Methow Basin hatcheries in recent years have been tagged with a CWT but not been 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 designate hatchery origin. Snouts were sent to the WDFW CWT Lab for tag extraction and decoding. Scales were sent to the WDFW Scale 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 2015 MH broodstock (WDFW, unpublished data). Female carcasses with intact abdominal cavities, a large number of eggs, and no external signs of spawning (i.e., eroded caudal fin) were categorized as pre-spawn mortalities. Estimated egg deposition was calculated using mean fecundities from MH broodstock (i.e., MetComp stock for Methow and Chewuch subbasins, Twisp stock for Twisp subbasin) and adjusted for mean egg-retention rates.

Natural Replacement Rate

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

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

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 2015, 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 2015 spring Chinook salmon migration to Wells Dam was monitored between 4 May and 16 June. Overall, wild fish migrated to Wells Dam two days earlier than hatchery fish (Table 1). Based on PIT tag detections at Wells Dam fish ladders, an estimated 6 fish were double counted and 183 fish fell below Wells Dam after being counted and did not re-ascend; excluding these totals, the estimated spring Chinook salmon return to Wells Dam (including broodstock) was 9,992 fish. The run was composed primarily of hatchery fish (92.0%), 55% of which were adipose fin-clipped. After correcting for sex determination errors and accounting for fish retained for broodstock (*N* = 608), removed as surplus (*N* = 132) or distributed to local tribes (*N* = 6,333) the estimated run escapement to the Methow River was 2,919 fish. After accounting for these adjustments, sex composition estimated from trapping data suggested there would be 1.38 fish for each redd constructed.

Table 1. Mean migration date of hatchery (H) and wild (W) spring Chinook to Wells Dam of the overall return for the 2006-2015 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

Table 1. Continued.

Year	Origin	Percentile					Mean	*N*
		10	25	50	75	90		
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	1,462

Redd Distribution and Spawn Timing

Spawning ground surveys were performed on foot between 25 July and 30 September. A total of 979 spring Chinook redds were constructed in the Methow basin in 2015 (Tables 2-4); the majority of redds were found in the Methow River subbasin (66.8%; *N* = 654; Table 2). The greatest number of redds within that subbasin were found in the 9 km reach downstream of Weeman Bridge (*N* = 294). Hatchery fish outnumbered wild fish on the spawning grounds in the vast majority of the reaches in the Methow Basin (Tables 2-4). On average, wild fish spawned one day earlier than hatchery fish in all three subbasins (Tables 5-7).

Spawner Composition, Demographics, and Egg Deposition

Based on expanded redd counts, there were an estimated 1,353 spawners in the Methow River basin in 2015, of which 398 (29.4%) were estimated to be wild (NOR) fish (see Tables 2-4). Estimated spawning escapement does not include hatchery or wild fish collected for broodstock. Wild fish comprised 67.1%, 46.9%, 17.1% of the estimated spawning escapement in the Twisp, Chewuch, and Methow subbasins, respectively (see Tables 2-4).

A total of 837 spring Chinook salmon carcasses were sampled during the 2015 spawning period (Tables 2-4). Of these, 597 Methow Hatchery and wild fish carcasses were sampled for which age, origin, gender, and length were measurable (Table 8). Comparisons of hatchery and wild fish show similar mean lengths within age groups for both MetComp and Twisp stocks (Table 8).

A total of 538 female carcasses were examined during surveys. Of these, egg retention was estimated on 455 fish. 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 3,867,031 eggs were deposited in the Methow River basin in 2015 (Table 9).

Table 2. 2015 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					
M15	1	0.2	1	0	2	2	0[b]	1[b]
M14	6	0.9	8	19	11	32[a]	5[b]	3[b]
M13	2	0.3	3	0	2	2	0	3
M12	13	2.0	18	3	5	8	7	11
M11	10	1.5	14	1	0	1	14	0
M10	84	12.8	116	42	8	51[a]	97	19
M9	294	45.0	407	177	38	218[a]	337	70
M8	14	2.1	19	18	1	19		
M7	68	10.4	94	67	3	70	132	7
M6	19	2.9	26	36	2	38		
M5,4	13	2.0	18	7	0	7	18	0
Total	524	80.1	724	370	72	448[a]	610	114
			Lost River					
L2	29	4.4	40	6	5	11	24[b]	17[b]
L1	1	0.2	1	0	0	0		
Total	30	4.6	41	6	5	11	24	17
			Early Winters Creek					
EW5,4	0	0.0	0	0	0	0	0	0
EW3	9	1.3	12	8	5	13	7	5
EW2,1	1	0.2	1	0	1	1	0	1
Total	10	1.5	13	8	6	14	7	6
			Methow River tributaries					
HA2	0	0.0	0	0	0	0	0	0
HA1	4	0.6	6	3	1	4	5	1
MH1	19	2.9	26	13	1	15[a]	24	2
Lsusp1	0	0.0	0	0	0	0	0	0
Susp1	25	3.8	35	7	2	10[a]	27	8
W3	0	0.0	0	0	0	0	0	0
W2	0	0.0	0	0	0	0	0	0
W1	3	0.5	4	2	1	3	3	1
WN1	39	6.0	54	18	2	21[a]	49	5
Total	90	13.8	125	44	7	54[a]	108	17
Grand total	654	100.0	903	427	90	526[a]	749	154

[a] Includes carcasses of unknown origin.
[b] Expanded count from combined recoveries in M15, M14 and L2.

Table 3. 2015 spring Chinook salmon redd distribution, estimated spawning escapement, and carcass recoveries in the Chewuch River subbasin.

Reach	Redds		Estimated	Carcasses				
				Recoveries			Expanded count	
	Count	Subbasin Prop. (%)	spawning escapement	H	W	Total	H	W
			Chewuch River mainstem					
C13	2	1.0	3	0	1	1	0	3
C12	12	6.0	17	6	6	12	8	9
C11	1	0.5	1	1	0	2[a]	1	0
C10	6	3.0	8	3	4	7	3	5
C9	0	0.0	0	0	0	0	0	0
C8	10	5.0	14	3	4	7	12	25
C7	17	8.3	23	8	18	27[a]		
C6	33	16.0	46	9	14	24[a]	18	28
C5	21	10.2	29	9	12	21	12	17
C4	36	17.5	51	12	9	22[a]	29	22
C3	0	0.0	0	1	1	2		
C2	61	29.6	84	51	22	73	59	25
C1	7	3.4	10	8	0	8	10	0
Total	206	100.0	286	111	91	206[a]	152	134

[a] Includes carcasses of unknown origin.
[b] Expanded count estimated from carcass recoveries in C12 and C11.

Table 4. 2015 spring Chinook salmon redd distribution, estimated spawning escapement, and carcass recoveries in the Twisp River subbasin.

Reach	Redds		Estimated	Carcasses				
				Recoveries			Expanded count	
	Count	Subbasin Prop. (%)	spawning escapement	H	W	Total	H	W
T10	0	0.0	0	0	0	0	0	0
T9	0	0.0	0	0	0	0	0	0
T8	5	4.2	7	1	2	3	2	5
T7	17	14.3	23	2	16	18	3	20
T6	56	47.1	77	8	34	44[a]	15	62
T5	30	25.2	41	18	12	30	25	16
T4	4	3.4	6	3	1	4	5	1
T3	5	4.2	7	3	2	5	4	3
T2	2	1.7	3	0	1	1	0	3
T1	0	0.0	0	0	0	0	0	0
Total	119	100.0	164	35	68	105[a]	54	110

[a] Includes carcasses of unknown origin.

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

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
Mean	H	104	11	45	251	6
Mean	W	113	13	31	250	6

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

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
Mean	H	94	10	127	251	7
Mean	W	106	11	34	249	7

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

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
Mean	H	88	5	16	249	7
Mean	W	92	6	13	247	8

Table 8. Mean POH length (*N*; SD) by age and sex of spring Chinook salmon carcasses recovered during Methow Basin spawning ground surveys in 2015. These data include all measureable and aged Methow Hatchery fish regardless of their recovery location.

Stock	Origin	Mean length (POH; cm) of adult returns (*N*; SD)					
		Male			Female		
		Age-3 (2012 BY)	Age-4 (2011 BY)	Age-5 (2010 BY)	Age-3 (2012 BY)	Age-4 (2011 BY)	Age-5 (2010 BY)
MetComp	H	42 (3; 7)	60 (76; 4)	72 (5; 3)	- -	60 (231; 3)	70 (14; 3)
Methow / Chewuch	W	40 (7; 3)	59 (63; 5)	76 (4; 4)	55 (1; - -)	60 (81; 3)	70 (21; 3)
Twisp	H	- -	56 (4; 2)	- -	- -	59 (16; 3)	72 (3; 3)
Twisp	W	34 (1; - -)	57 (24; 4)	73 (4; 9)	- -	61 (31; 3)	71 (8; 5)

Table 9. Estimated egg deposition for spring Chinook salmon in the Methow Basin in 2015. 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		
						2013	2014	2015
Chewuch	109	4,020	1.1	206	21.0	609,061	907,636	819,011
Methow	288	3,882	0.6	654	66.8	1,185,499	2,813,070	2,523,595
Twisp	58	4,438	0.7	119	12.2	281,719	490,824	524,425
Total	455			979		2,076,279	4,211,530	3,867,031

Natural Replacement Rate

Natural replacement rates (NRR) for the latest complete brood (2009) were less than 1.0 in all subbasins (Chewuch = 0.14; Methow = 0.08; Twisp = 0.27; Appendices A-C). HRR values from the 2009 brood were much greater than corresponding NRR values all subbasins (Appendices A-C).

Stray Rates by Brood Year

Based on total expanded CWT recoveries, an estimated 33.1% of the 2009 brood Chewuch spring Chinook salmon was recovered on spawning grounds of other recipient spawning areas (Appendix D). Excluding broods with no usable spawning ground recovery information (1992, 1994-1995, 1998, 2000), the recovery rate of Chewuch River fish in stray areas (mean = 32.3%) was greater than the 5% target. Based on total expanded CWT recoveries, an estimated 2.0% of the 2009 brood Methow spring Chinook salmon was recovered on spawning grounds of other recipient spawning areas (Appendix E). Excluding broods with no usable spawning ground recovery information (1992, 1994, 1998, 2000), the recovery rate of Methow River fish in stray areas (mean = 3.1%) was less than the 5% target. Based on total expanded CWT recoveries, an estimated 42.7% of the 2009 brood Twisp spring Chinook salmon carcasses were recovered on spawning grounds of non-target areas (Appendix F). Excluding broods with no spawning ground recoveries (1992, 1994-1995), the recovery rate of Twisp River fish in stray areas (mean = 22.2%) was greater than the 5% target.

Stray Rates within the Methow Basin

A total of 482 coded wire tags (CWTs) were successfully decoded from the adult spring Chinook salmon collected during spawning ground surveys in the Methow River basin in 2015. These fish were expanded by tag-specific retention rates and stream-specific sample rates to account for 815 fish (Appendix G). As a percent of the spawning escapement, the Methow subbasin had the highest recovery rates of within-basin strays (Table 10-12; 11.2% Chewuch and 0.2% Twisp releases).

Stray Rates outside the Methow Basin

A total of 74 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, 55 fish strayed into other spring Chinook salmon populations (e.g., Chiwawa and Entiat Rivers; Table 13). Stray Methow Hatchery fish have comprised less than 5.0% of the overall estimated spawning escapement to the Entiat River (Table 13).

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

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

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

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

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

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	- -
2000	Similkameen River	630130	Methow	3	- -	- -
2001	Similkameen River	630614	Chewuch	5	- -	- -
2001	Similkameen River	631024	MetComp	5	- -	- -
2002	Similkameen River	631024	MetComp	5	- -	- -
2003	Similkameen River	631024	MetComp	1	- -	- -

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

Discussion

Ongoing collaborative efforts to reduce surplus hatchery-origin spring Chinook salmon in the Methow Basin had greatest impacts in 2015. Joint efforts of USFWS, WDFW, and multiple tribal entities removed a total of 6,465 fish, many of which would have otherwise ended up on spawning grounds in the Methow Basin. With lower than average streamflow limiting available spawning habitat, adult management activities reducing surplus hatchery-origin fish escapement likely reduced competition for spawning sites and redd superimposition. However, even though nearly 70% of the hatchery fish above Wells Dam were removed from the population destined to spawn in the Methow Basin, the remaining hatchery fish still outnumbered wild fish three to one. In 2015, the Twisp weir was not operated for spring Chinook brood collection as all wild fish needed for broodstock quotas were collected at Wells Dam. Redd-based escapement estimates from spawning ground surveys found few hatchery fish returning to the Twisp subbasin. Removing surplus hatchery fish at the Twisp weir would have decreased pHOS in the Twisp River, but overall run-at-large pHOS in the Methow Basin would have remained above 0.70. Since spawn escapement estimates in the Chewuch and Methow subbasins combined show that hatchery spawners outnumber wild spawners three to one, reducing hatchery fish in these areas should be the focus of adult management moving forward.

References

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Appendix A. Natural Replacement Rates (NRR) in the Chewuch subbasin for brood years 1992 to 2009 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age 1.1	Return age 1.2	Return age 1.3	Total expanded recruits (NOR)	NRR	HRR
1992	421.75	0	25	14	41.25	0.10	1.50
1993	184.34	2	69	21	95.53	0.52	1.01
1994	62.85	0	15	3	18.95	0.30	0.17
1995	6.09	1	12	19	33.69	5.54	- -
1996	8.00	0	13	86	102.02	12.75	0.39
1997	123.30	1	662	55	921.30	7.47	4.34
1998	7.00	11	23	19	62.69	8.96	12.71
1999	21.08	0	2	0	2.14	0.10	- -
2000	82.84	6	47	13	69.97	0.84	3.34
2001	2,493.22	0	205	49	264.51	0.11	4.50
2002	665.75	2	91	60	168.76	0.25	4.14
2003	489.60	0	15	33	53.04	0.11	0.65
2004	334.62	4	63	11	92.24	0.28	1.18
2005	507.78	5	282	8	312.76	0.62	1.81
2006	513.24	25	191	224	574.58	1.12	4.84
2007	276.50	8	183	33	287.00	1.04	8.28
2008	252.00	22	76	16	141.53	0.56	7.92
2009	770.77	3	89	6	106.60	0.14	4.25

Appendix B. Natural Replacement Rates (NRR) in the Methow subbasin for brood years 1992 to 2009 with corresponding hatchery replacement rates (HRR). NOR = natural origin recruits.

Parent brood	Est. spawning escapement	Return age			Total expanded recruits (NOR)	NRR	HRR
		1.1	1.2	1.3			
1992	924.26	0	44	43	92.38	0.10	- -
1993	759.56	5	79	32	119.66	0.16	1.94
1994	172.27	0	23	7	30.46	0.18	0.50
1995	27.39	1	54	18	77.30	2.82	8.71
1996	15.00	1	30	230	268.34	17.89	3.33
1997	152.45	21	348	50	537.66	3.53	3.09
1998	23.00	16	34	2	60.75	2.64	12.71
1999	70.27	3	2	0	4.32	0.06	0.80
2000	639.39	5	197	39	256.60	0.40	3.34
2001	7,587.84	3	183	36	230.62	0.03	3.76
2002	1,729.65	0	96	93	208.89	0.12	5.45
2003	604.80	0	59	27	95.12	0.16	1.21
2004	820.82	13	163	35	248.46	0.30	3.90
2005	746.76	11	239	3	268.70	0.36	2.69
2006	1,069.72	33	363	198	773.90	0.72	9.42
2007	696.50	9	268	27	390.25	0.56	5.72
2008	583.80	16	57	19	118.97	0.20	8.80
2009	1,740.97	0	103	18	131.34	0.08	4.25

Appendix C. Natural Replacement Rates (NRR) in the Twisp subbasin for brood years 1992 to 2009 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	316.61	0	54	37	96.00	0.30	0.84
1993	426.42	5	27	17	50.48	0.12	0.60
1994	74.49	0	13	9	22.94	0.31	1.00
1995	12.17	0	26	12	39.30	3.23	- -
1996	8.00	0	11	56	69.10	8.64	5.39
1997	71.74	0	460	109	729.31	10.17	3.60
1998	11.00	24	72	21	138.15	12.56	2.00
1999	24.60	0	7	0	7.36	0.30	1.53
2000	256.27	37	264	17	339.31	1.32	2.70
2001	889.58	27	77	20	128.96	0.14	1.22
2002	241.09	0	47	35	90.85	0.38	8.00
2003	43.20	0	1	0	1.11	0.03	1.36
2004	340.55	8	48	9	75.82	0.22	2.42
2005	121.00	4	28	5	39.16	0.32	1.92
2006	165.00	19	179	61	337.90	2.05	8.93
2007	105.00	5	105	8	150.63	1.43	0.93
2008	165.90	10	56	4	90.67	0.55	10.37
2009	129.36	5	25	3	35.28	0.27	3.00

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

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

Appendix E. Methow River spring Chinook expanded CWT recoveries.

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

Appendix F. Twisp River spring Chinook expanded CWT recoveries.

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

Appendix G. Expanded coded wire tag (CWT) recoveries in 2015 by recovery location. Recoveries were expanded by tag-specific mark rates and stream sample rates.

Recovery location	BY	CWT	Release river	Stray status	Estimated escapement
Chewuch River	2010	635687	Methow	Within-Basin	3
Chewuch River	2010	635584	Twisp	Within-Basin	1
Chewuch River	2010	636068	Methow	Within-Basin	1
Chewuch River	2010	635197	Chewuch	Homed	1
Chewuch River	2011	635664	Chewuch	Homed	88
Chewuch River	2011	636409	Methow	Within-Basin	10
Chewuch River	2011	054789	Methow	Winthrop	6
Chewuch River	2011	055582	Methow	Winthrop	4
Chewuch River	2011	051599	Methow	Winthrop	2
Chewuch River	2011	053178	Methow	Winthrop	1
Chewuch River	2011	636414	Methow	Within-Basin	1
Chewuch River	2011	636415	Methow	Within-Basin	1
Chewuch River	2011	636411	Methow	Within-Basin	1
Chewuch River	2011	054967	White River	Out-of-Basin	1
Chewuch River	2011	190328	Jack Creek	Out-of-Basin	1
Chewuch River	2012	100251	Sawtooth NFH	Out-of-Basin	18
Chewuch River	2012	636577	Chiwawa River	Out-of-Basin	1
Chewuch River	2012	636485	Chiwawa River	Out-of-Basin	1
Early Winters Creek	2011	636410	Methow - MVP	Homed	3
Early Winters Creek	2011	635664	Chewuch	Within-Basin	2
Early Winters Creek	2011	051599	Methow	Winthrop	1
Early Winters Creek	2011	636409	Methow	Homed	1
Early Winters Creek	2011	055582	Methow	Winthrop	1
Hancock Creek	2011	636409	Methow	Homed	2
Hancock Creek	2011	636412	Methow - MVP	Homed	2
Hancock Creek	2011	635664	Chewuch	Within-Basin	2
Lost River	2011	636409	Methow	Homed	8
Lost River	2011	054789	Methow	Winthrop	8
Lost River	2011	635664	Chewuch	Within-Basin	4
Lost River	2011	055582	Methow	Winthrop	4
Methow Hatchery Outfall	2010	054792	Methow	Winthrop	2
Methow Hatchery Outfall	2011	054789	Methow	Winthrop	4
Methow Hatchery Outfall	2011	635664	Chewuch	Within-Basin	4
Methow Hatchery Outfall	2011	051599	Methow	Winthrop	2
Methow Hatchery Outfall	2011	636409	Methow	Homed	2
Methow Hatchery Outfall	2012	636284	Methow - MVP	Homed	2
Methow River	2010	635687	Methow	Homed	15
Methow River	2010	055361	Methow	Winthrop	6
Methow River	2010	636067	Methow	Homed	5

Appendix G. Continued.

Recovery location	BY	CWT	Release river	Stray status	Estimated escapement
Methow River	2010	636065	Methow	Homed	3
Methow River	2010	636064	Methow	Homed	3
Methow River	2010	054832	Methow	Winthrop	2
Methow River	2010	055240	Methow	Winthrop	2
Methow River	2011	636409	Methow	Homed	140
Methow River	2011	635664	Chewuch	Within-Basin	79
Methow River	2011	054789	Methow	Winthrop	52
Methow River	2011	636413	Methow	Homed	34
Methow River	2011	636412	Methow - MVP	Homed	25
Methow River	2011	051599	Methow	Winthrop	25
Methow River	2011	636411	Methow	Homed	23
Methow River	2011	636410	Methow - MVP	Homed	17
Methow River	2011	636415	Methow	Homed	15
Methow River	2011	055582	Methow	Winthrop	15
Methow River	2011	636414	Methow	Homed	12
Methow River	2011	054754	Methow	Winthrop	9
Methow River	2011	053178	Methow	Winthrop	7
Methow River	2011	636094	Chiwawa	Out-of-Basin	2
Methow River	2012	636485	Chiwawa	Out-of-Basin	3
Methow River	2012	636284	Methow - MVP	Homed	3
Methow River	2012	054671	Methow	Winthrop	3
Methow River	2012	100246	Clear Creek	Out-of-Basin	2
Methow River	2012	055653	Methow	Winthrop	2
Methow River	2012	636464	Twisp	Within-Basin	2
Methow River	2012	055659	Methow	Winthrop	2
Suspension Creek	2011	636409	Methow	Homed	7
Suspension Creek	2011	635664	Chewuch	Within-Basin	7
Suspension Creek	2011	636413	Methow	Homed	4
Suspension Creek	2011	636411	Methow	Homed	4
Twisp River	2010	635584	Twisp	Homed	3
Twisp River	2011	636179	Twisp	Homed	32
Twisp River	2011	636409	Methow	Within-Basin	5
Twisp River	2011	055582	Methow	Winthrop	3
Twisp River	2011	636415	Methow	Within-Basin	2
Twisp River	2011	636412	Methow - MVP	Within-Basin	2
Twisp River	2011	635664	Chewuch	Within-Basin	2
WNFH outfall	2010	053177	Methow	Winthrop	2
WNFH outfall	2011	054789	Methow	Winthrop	13
WNFH outfall	2011	051599	Methow	Winthrop	8
WNFH outfall	2011	053178	Methow	Winthrop	5

Appendix G. Continued.

Recovery location	BY	CWT	Release river	Stray status	Estimated escapement
WNFH outfall	2011	635664	Chewuch	Within-Basin	5
WNFH outfall	2011	55582	Methow	Winthrop	5
Wolf Creek	2011	54789	Methow	Winthrop	1
Wolf Creek	2011	636412	Methow - MVP	Homed	1

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

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

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

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

Year	HOR spawners (proportion)															HOR Total	NOR spawners (proportion)			NOR Total	Adult spawner PNOB	PNI
	MC-Che			MC-Met			Twisp			Winthrop NFH			Out-of-basin									
	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5		3	4	5			
2003	0.069	0.000	0.878	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.007	0.000	465	0.167	0.083	0.750	25	0.568	0.374
2004	0.063	0.870	0.015	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.000	0.000	0.000	0.000	289	0.000	1.000	0.000	46	0.039	0.043
2005	0.007	0.749	0.071	0.014	0.050	0.000	0.000	0.007	0.000	0.000	0.035	0.000	0.053	0.014	0.000	289	0.010	0.933	0.057	219	0.339	0.373
2006	0.000	0.510	0.096	0.000	0.067	0.000	0.000	0.025	0.000	0.013	0.088	0.017	0.109	0.071	0.004	378	0.000	0.648	0.352	135	0.040	0.052
2007	0.063	0.056	0.273	0.091	0.000	0.000	0.000	0.000	0.000	0.098	0.000	0.042	0.091	0.286	0.000	203	0.059	0.176	0.765	74	0.002	0.003
2008	0.014	0.438	0.014	0.014	0.062	0.000	0.000	0.000	0.000	0.090	0.146	0.042	0.000	0.062	0.118	166	0.051	0.590	0.359	86	0.003	0.005
2009	0.258	0.247	0.009	0.150	0.015	0.000	0.026	0.000	0.000	0.176	0.075	0.018	0.026	0.000	0.000	500	0.065	0.919	0.016	271	0.017	0.025
2010	0.006	0.612	0.000	0.006	0.099	0.000	0.000	0.006	0.000	0.000	0.233	0.000	0.000	0.038	0.000	341	0.045	0.910	0.045	155	0.026	0.036
2011	0.134	0.437	0.042	0.049	0.014	0.000	0.000	0.000	0.000	0.021	0.076	0.023	0.070	0.134	0.000	499	0.052	0.390	0.558	370	0.102	0.151
2012	0.009	0.670	0.118	0.009	0.041	0.000	0.009	0.027	0.000	0.000	0.036	0.000	0.000	0.081	0.000	261	0.036	0.696	0.268	81	0.205	0.212
2013	0.020	0.702	0.096	0.041	0.041	0.000	0.020	0.020	0.000	0.030	0.020	0.000	0.000	0.010	0.000	226	0.024	0.833	0.143	89	0.369	0.339
2014	0.046	0.472	0.000	0.056	0.253	0.000	0.000	0.000	0.028	0.019	0.126	0.000	0.000	0.000	0.000	267	0.059	0.912	0.029	166	0.428	0.410
2015	0.000	0.620	0.007	0.000	0.092	0.028	0.000	0.000	0.007	0.000	0.092	0.000	0.140	0.014	0.000	152	0.000	0.859	0.141	134	0.251	0.321

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

Year	HOR spawners (proportion) MC-Che			MC-Met			Twisp			Winthrop NFH			Out-of-basin			HOR Total	NOR spawners (proportion)			NOR Total	Adult spawner PNOB	PNI
	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5		3	4	5			
2003	0.000	0.000	0.000	0.008	0.060	0.541	0.004	0.042	0.004	0.004	0.010	0.319	0.000	0.008	0.000	597	0.600	0.200	0.200	8	0.393	0.285
2004	0.056	0.000	0.000	0.059	0.544	0.011	0.000	0.065	0.000	0.056	0.203	0.006	0.000	0.000	0.000	622	0.015	0.985	0.000	199	0.061	0.074
2005	0.025	0.474	0.000	0.025	0.225	0.019	0.019	0.006	0.000	0.027	0.139	0.012	0.000	0.019	0.010	526	0.000	0.824	0.176	221	0.296	0.296
2006	0.000	0.290	0.004	0.000	0.321	0.013	0.003	0.058	0.000	0.007	0.274	0.012	0.000	0.013	0.005	942	0.000	0.730	0.270	128	0.009	0.010
2007	0.067	0.040	0.076	0.040	0.011	0.022	0.058	0.033	0.009	0.200	0.204	0.100	0.000	0.140	0.000	545	0.080	0.360	0.560	152	0.058	0.069
2008	0.087	0.092	0.009	0.061	0.164	0.000	0.000	0.004	0.000	0.109	0.433	0.000	0.000	0.041	0.000	412	0.060	0.800	0.140	172	0.006	0.008
2009	0.060	0.073	0.002	0.248	0.086	0.001	0.022	0.006	0.002	0.273	0.160	0.024	0.009	0.034	0.000	1,480	0.097	0.790	0.113	261	0.017	0.019
2010	0.018	0.120	0.002	0.019	0.439	0.000	0.001	0.010	0.000	0.009	0.374	0.000	0.000	0.006	0.002	1,331	0.024	0.968	0.008	290	0.024	0.028
2011	0.130	0.204	0.007	0.123	0.122	0.017	0.041	0.004	0.002	0.080	0.170	0.038	0.006	0.056	0.000	1,391	0.030	0.536	0.434	432	0.112	0.128
2012	0.012	0.297	0.014	0.054	0.403	0.011	0.005	0.089	0.000	0.006	0.077	0.006	0.000	0.015	0.011	691	0.000	0.703	0.297	63	0.220	0.194
2013	0.052	0.211	0.011	0.125	0.392	0.007	0.078	0.029	0.007	0.043	0.016	0.015	0.007	0.007	0.000	505	0.114	0.743	0.143	113	0.399	0.328
2014	0.012	0.073	0.005	0.097	0.550	0.002	0.005	0.018	0.000	0.040	0.185	0.002	0.000	0.011	0.000	1,131	0.029	0.905	0.067	250	0.377	0.315
2015	0.000	0.165	0.000	0.008	0.480	0.041	0.003	0.000	0.000	0.011	0.256	0.025	0.008	0.003	0.000	749	0.089	0.767	0.144	154	0.235	0.221

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

Year	HOR spawners (proportion)															HOR Total	NOR spawners (proportion)			NOR Total	Adult spawner PNOB	PNI
	MC-Che			MC-Met			Twisp			Winthrop NFH			Out-of-basin									
	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5		3	4	5			
2003	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.667	0.000	0.000	0.000	0.000	0.000	0.000	0.000	18	0.333	0.167	0.500	25	0.374	0.472
2004	0.000	0.045	0.000	0.000	0.000	0.000	0.045	0.708	0.000	0.000	0.045	0.000	0.045	0.112	0.000	98	0.098	0.902	0.000	243	0.112	0.280
2005	0.000	0.136	0.000	0.000	0.000	0.000	0.000	0.864	0.000	0.000	0.000	0.000	0.000	0.000	0.000	34	0.000	0.828	0.172	87	0.547	0.660
2006	0.000	0.000	0.000	0.000	0.048	0.000	0.000	0.936	0.000	0.000	0.016	0.000	0.000	0.000	0.000	100	0.000	0.692	0.308	65	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.304	0.566	0.130	0.000	0.000	0.000	0.000	0.000	0.000	65	0.167	0.000	0.833	40	0.509	0.451
2008	0.018	0.018	0.000	0.000	0.000	0.000	0.064	0.827	0.018	0.000	0.000	0.000	0.018	0.037	0.000	126	0.105	0.895	0.000	40	0.589	0.437
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.619	0.165	0.114	0.051	0.000	0.000	0.051	0.000	0.000	97	0.250	0.500	0.250	32	0.163	0.178
2010	0.000	0.045	0.000	0.000	0.090	0.000	0.000	0.820	0.045	0.000	0.000	0.000	0.000	0.000	0.000	96	0.024	0.952	0.024	156	0.029	0.070
2011	0.047	0.000	0.000	0.000	0.000	0.000	0.236	0.095	0.000	0.000	0.000	0.000	0.575	0.047	0.000	85	0.036	0.607	0.357	159	0.070	0.167
2012	0.000	0.036	0.000	0.000	0.015	0.000	0.029	0.890	0.000	0.000	0.015	0.000	0.000	0.015	0.000	146	0.083	0.792	0.125	56	0.214	0.228
2013	0.000	0.031	0.000	0.000	0.061	0.000	0.346	0.500	0.031	0.000	0.000	0.000	0.031	0.000	0.000	117	0.438	0.500	0.063	39	0.534	0.416
2014	0.000	0.030	0.000	0.016	0.045	0.000	0.061	0.818	0.015	0.000	0.015	0.000	0.000	0.000	0.000	157	0.100	0.875	0.025	92	0.621	0.496
2015	0.000	0.041	0.000	0.000	0.184	0.000	0.000	0.653	0.061	0.000	0.061	0.000	0.000	0.000	0.000	54	0.015	0.809	0.176	110	0.633	0.658

Attachment D. Summary of summer steelhead spawning ground surveys and escapement estimates conducted in the Methow River basin in 2015.

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From: Charles Frady

To: Charlie Snow

Date: 8 April 2016

Subject: Results of 2015 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 (Miller et al. 2016) unless specifically relevant to Methow Basin activities.

Methods

Run Composition

Broodstock were collected at Wells Dam from a composite of both the Methow and Okanogan populations. Adult fish were trapped a maximum of three days per week and were retained for broodstock as necessary to achieve collection goals for HOR and NOR fish (Tonseth 2015). 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 2015, trapping was only conducted on 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 were considered fallbacks; fish were not considered fallbacks if downstream detection (e.g., Rocky Reach juvenile bypass [RRJ]) was consistent with likely kelt migration timing. Total fallback was calculated by expanding the estimated fallback proportion of HOR and NOR fish to the run-at-large HOR and NOR totals at Wells Dam.

Steelhead passing Wells Dam were subjected to local selective fisheries, and creel surveys were used to estimate the number of steelhead removed from the Methow, Columbia, Okanogan, and Similkameen river basins (Maitland et al. 2015). Estimates of tribal fisheries conducted by the CCT at Chief Joseph Dam, the mouth of the Okanogan River, and in the Okanogan Basin were provided by CCT staff (Mike Rayton, personal communication). Run escapement estimates were calculated for the Methow and Okanogan rivers by applying the proportion of fish that migrated to each basin based on results of local radio-telemetry studies (English et al. 2001, 2003) to the estimated number of HOR and NOR steelhead passing Wells Dam. Basin-specific fishery removal and indirect mortality (5%) estimates, along with local broodstock collections were subtracted from the estimated escapement to each basin to determine the number of steelhead available for natural spawning. No estimates were made of pre-spawn mortality or illegal removal (i.e., poaching).

Spawn Timing and Redd Distribution

An evaluation of spawn timing and redd distribution in the natural environment was conducted in the Twisp River (Goodman et al. 2016). Adult steelhead on their upstream spawning migration were trapped at the Twisp weir and sampled for hatchery marks, sex, and origin. All NOR fish were sampled, tagged and released upstream from the weir except for fish retained for broodstock. HOR fish were also sampled, tagged, and released upstream of the weir consistent with escapement goals and objectives of an on-going steelhead relative reproductive success study (RRS) in the Twisp River. These objectives targeted a spawning population upstream of the Twisp River weir comprised of equal populations of NOR and HOR fish. All excess HOR steelhead were lethally removed from the spawning population. All steelhead released upstream of the weir received uniquely colored anchor tags that represented their origin and sex (red = NOR male, blue = HOR male, green = HOR female, pink = NOR female). The assignment of colored anchor tags rotates each year to avoid any spawning success bias that could be associated with the presence of anchor tags. Visual observation of these tags was used to assess the spawn timing and location of HOR and NOR fish. Observations of anchor tagged fish on redds were used for spawn timing analyses and to determine redd distribution.

Historically, the Methow River basin was divided into four geographic subbasins; the upper Methow, lower Methow, Chewuch, and Twisp, and index areas of annual spawning activity were established within each subbasin and index areas were surveyed weekly. In 2015, 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. 2016). 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 2015; therefore, redd totals in lower Methow River reaches should be considered minimum values. The reach below the lower Chewuch River PIT array (CRW-1), and both hatchery outfall channels were surveyed weekly. Winthrop NFH outfall survey data was provided by USFWS. Steelhead redds were individually flagged with date, redd number, and location recorded on each flag. Each redd was also recorded with hand-held global positioning system (GPS) devices for subsequent mapping.

Natural Replacement Rate (NRR) and Stray Rates

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

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

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

Recently, PIT tag antenna arrays have also been deployed at or near the mouth of many spawning tributaries on the upper Columbia River. This technology allows the escapement of Wells Hatchery steelhead to tributaries downstream of Wells Dam to be estimated. Stray rates to the Wenatchee and Entiat populations can be estimated using PIT tag rates from run-at-large sampling at Priest Rapids Dam. Since all returning Wells Hatchery steelhead were from a single stock (MEOK), evaluating within-basin straying is not relevant from a genetic risk perspective. Homing fidelity was assessed via PIT tags that were inserted into a portion of the 2011 and 2012 brood fish and the release location of tagged fish was recorded during release monitoring.

None of the 2011 or 2012 brood releases from the Wenatchee Basin were given unique external marks to distinguish them from Wells Hatchery, Methow Hatchery, or WNFH releases. Only fish released from Ringold Hatchery were identified as strays. The number of stray HOR steelhead reported should be considered a minimum value. Unmarked HOR fish (identified through scale analysis) were apportioned to local or stray populations based on proportions of externally-marked fish in the weekly collections. Since stray HOR fish are largely no longer distinguishable from local HOR fish, all comparisons of HOR and NOR fish include all hatchery-origin fish.

Results

<u>*Run Composition*</u>

Stock assessment and collection of the 2015 brood Wells Hatchery steelhead broodstock occurred at Wells Dam between 28 July and 11 November 2014. During that time, a total of 7,347 steelhead passed Wells Dam. Of those fish, 421 (5.7%) were sampled for hatchery marks or were scale sampled to determine origin. Of the sampled fish, 191 HOR steelhead were retained for broodstock purposes. All remaining steelhead were released into the west ladder 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 2015 brood was 7,022 fish (Table 1). Analysis of scale samples and observations of hatchery marks indicate that NOR fish comprised 31.5% of the steelhead run to Wells Dam (68.5% HOR). Based on biological sampling of steelhead during broodstock collection at Wells Hatchery, only 5.3% of total escapement was composed of out-of-basin stray hatchery fish, presumably from Ringold Hatchery. The abundance and relative proportion of NOR steelhead in the 2015 brood return was great enough to allow a selective sport fishery in the Methow, Okanogan, and Similkameen rivers, as well as the mainstem Columbia River. Creel censuses conducted during these fisheries estimated 1,213 adipose fin-clipped steelhead were retained (total HOR fish mortality = 1,248; Table 2; Maitland et al. 2015, with unpublished corrections). Indirect mortality of steelhead captured and released during the fisheries was assumed to be 5% and resulted in estimated mortality of 55 NOR steelhead (Table 2). Remaining steelhead were assigned to the Okanogan and Methow Basins based on results of radio-telemetry studies (see Table 1; English et al. 2001, 2003). An estimated 366 and 1,236 wild fish were available for natural spawning in the Okanogan and Methow River basins, respectively (see Table 1). Historic steelhead passage, mortality, and escapement data are presented in Appendix A.

Based on radio-telemetry data (English et al. 2001, 2003), an estimated 58.0% of the hatchery fish passing Wells Dam were destined for the Methow Basin. After broodstock and fishery removal, an estimated 1,693 HOR and 1,236 NOR steelhead were available for natural spawning in the Methow River basin (see Table 1), resulting in a basin pHOS estimate of 0.58.

Table 1. Escapement and disposition of the 2015 brood summer steelhead passing Wells Dam. HOR (*N* = 191) fish removed for broodstock at Wells Dam are not included in the escapement estimate above Wells Dam. Methow and Okanogan River escapements are based on radio-telemetry data (English et al. 2001, 2003), which account for 90.4% and 91.6% of the hatchery and wild escapement, respectively. Dam count includes passage from 15 June 2014 through 14 June 2015.

Area	Description (Variable)		Number
Wells Dam	Wells Dam fish count (DCPUD raw data)	(A)	7,957
	Wells Dam HOR total (based on trapping)	(A_{HOR})	5,454
	Wells Dam NOR total (based on trapping)	(A_{NOR})	2,503
	Estimated double counted fish (HOR)	(B)	118
	Estimated double counted fish (NOR)	(C)	109
	Estimated fallback fish (HOR)	(D)	315
	Estimated fallback fish (NOR)	(E)	393
	Adjusted Wells Dam HOR total	($F = A_{HOR}-B-D$)	5,021
	Adjusted Wells Dam NOR total	($G = A_{NOR}-C-E$)	2,001
Above Wells Dam	Local HOR fish	(H)	4,648
	Stray HOR fish	(I)	373
	Hatchery fish removed in WDFW fishery	(J)	392
	HOR fish removed in CCT fisheries	(J_{CCT})	175
	Above Wells HOR run estimate	($K = (H+I)-J-J_{CCT}$)	4,454
	NOR fish	(L)	2,001
	NOR fish removed in WDFW fishery	(M)	12
	NOR fish removed in CCT fisheries	(M_{CCT})	98
	Above Wells NOR run estimate	($N = L-M-M_{CCT}$)	1,891
Okanogan Basin	HOR run escapement estimate	(O = K * 0.324)	1,443
	HOR fish removed in WDFW fishery	(P)	255
	HOR fish collected for broodstock	(Q)	42
	NOR run escapement estimate	(R = N * 0.208)	393
	NOR fish removed in WDFW fishery	(S)	11
	NOR fish collected for broodstock	(T)	16
	Maximum spawning escapement estimate	(O-P-Q+R-S-T)	1,512
Methow Basin	HOR run escapement estimate	(U = K * 0.580)	2,583
	HOR fish removed in WDFW fishery	(V)	601
	HOR fish collected for broodstock	(W)	168
	HOR fish removed as excess	(Wexcess)	121
	NOR run escapement estimate	(X = N * 0.708)	1,339
	NOR fish removed in WDFW fishery	(Y)	32
	NOR fish collected for broodstock	(Z)	71
	Maximum spawning escapement estimate	(U-V-W+X-Y-Z)	2,929

Table 2. Estimated number of steelhead caught, retained, released, and mortalities from expanded creel census above Wells Dam during the 2014-2015 fishery.

Origin/disposition	Columbia	Methow	Okanogan	Similkameen	Total
Est. total steelhead caught	785	1,591	220	424	3,020
Est. HOR steelhead retained (ad -)	384	582	74	173	1,213
Est. HOR steelhead released (ad -)	11	38	25	30	104
Est. HOR steelhead released (ad +)	137	339	42	78	596
Est. NOR steelhead released	253	632	78	143	1,106
Est. HOR steelhead hook mortality	8	19	3	5	35
Est. NOR steelhead hook mortality	12	32	4	7	55

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

Tagged steelhead were detected between 10 February and 26 May as they ascended the Twisp River to spawn. Based on recaptures of PIT-tagged fish above the Twisp River array, detection efficiency for adult steelhead was 100.0%. Eighteen NOR steelhead were retained for broodstock. Though no PIT tags were detected in scanned redds, observations of anchor-tagged females on redds suggested that NOR females on average spawned further upstream than HOR females (Goodman et al. 2016). Based on observations of anchor-tagged females, there were no differences in spawn timing between NOR and HOR females (Goodman et al. 2016).

Redd surveys in the Twisp River basin were conducted from 2 March to 5 June. Redd surveys in the Mainstem Methow River from the MRW array upstream of Winthrop downstream to Pateros were conducted from 5 March to 8 June. Based on PIT-based escapement estimates (Truscott et al. 2016), removal of fishery harvest, and comprehensive Twisp River redd counts (Goodman et al. 2016), an estimated 991 steelhead redds were created in the Methow River basin in 2015 (Tables 3-5). Historic redd counts for each of the subbasins are listed in Appendices B1-B4.

Based on biological sampling during 2015 run evaluation at Wells Dam, the age distribution of HOR steelhead was skewed towards 2-salt fish (72.8%); NOR steelhead were also skewed towards 2-salt fish (80.9%). Based on scale analysis, 28.3% (N = 64) of the steelhead sampled at the Twisp River weir were NOR (Table 6). Using expanded redd counts by tributary, and the mean fecundity from Wells Hatchery broodstock by salt age and origin, an estimated 5,776,539 were deposited in the Methow Basin (Table 7). This estimate may be biased towards hatchery (ad-clipped) fish and not representative of actual spawners since the majority of fish used to calculate means were from Wells Hatchery broodstock.

Table 3. Twisp River mainstem and tributary census redd counts by section number and survey year. Ns = not surveyed. Data from Goodman et al. 2016.

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

[1] Methow Salmon Recovery Foundation pond outfall.

Table 4. Lower Methow River redd counts and estimated escapement by reach(es). Redd totals in Methow River mainstem reaches (MRW8-1) are direct counts only; escapement for this area is derived from PIT-based escapement estimates (Truscott et al. 2016) using 1.47 fish per redd. Ns = not surveyed.

Stream (description)	Code	Redds	Estimated escapement	
			HOR	NOR
Methow River (MRW PIT array – Red Barn)	MRW8	12	656	101
Methow River (Red Barn – Halderman Hole)	MRW7	10		
Methow River (Halderman Hole – Braids)	MRW6	10		
Methow River (Braids – Carlton Bridge)	MRW5	6		
Methow River (Carlton Bridge – WDFW Access)	MRW4	5		
Methow River (WDFW Access – Upper Burma Br.)	MRW3	0		
Methow River (Upper Burma Br. – Lower Burma Br.)	MRW2	1		
Methow River (Lower Burma Bridge – Pateros)	MRW1	1		
Chewuch River (CRW PIT array to – Confluence)	CRW1	0	--	--
Methow Hatchery outfall	MH1	17	--	--
Winthrop NFH outfall	WN1	56	--	--
Beaver Creek (above PIT antenna)	Beaver	102	47 (23-94)	103 (59-153)
Beaver Creek (below PIT antenna)	BV1	Ns	--	--
Libby Creek (above PIT antenna)	Libby	23	21 (6-52)	13 (3-42)
Gold Creek (above PIT array)	Gold	115	68 (29-163)	101 (50-278)
Total		358	--	--

Table 5. Estimated escapement of HOR and NOR fish and the proportion of hatchery origin spawners (pHOS) based on redd counts and surveyor efficiency model (Lower Methow) or expanded PIT tag array data (other subbasins) with 95% confidence intervals. Estimated redd totals in the Upper Methow and Chewuch Rivers are back-calculated from escapement totals (Truscott et al. 2016) using 1.47 fish per redd.

Location	Redds	Spawners			
		HOR	NOR	Total	pHOS
Upper Methow River	268	241 (176-390)	153 (99-216)	394 (275-606)	0.61
Chewuch River	204	73 (42-138)	227 (145-281)	300 (187-419)	0.24
Twisp River	161[a]	393 (318-504)	236 (170-305)	629 (488-809)	0.62
Lower Methow River	358	--	--	--	--
Total	991	--	--	--	--

[a] From Table 3.

Table 6. Summary of adult steelhead sampled at the Twisp weir in 2015, 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	11	36	6	0	53	39
	M	None	3	7	1	0	11	7
	Total NOR		14	43	7	0	64	46
HOR	F	Ad+CWT	0	1	0	0	1	0
		HFN	2	0	0	0	2	0
		CWTO	17	47	9	0	73	26
	Total F		19	48	9	0	76	26
	M	Ad-only	1	0	0	0	1	0
		HFN	1	6	0	0	7	1
		CWTO	27	45	6	0	78	20
	Total M		29	51	6	0	86	21
	Total HOR		48	99	15	0	162	47
Grand total			62	142	22	0	226	93

Table 7. Estimated 2015 steelhead redd totals from PIT-based expansions and surveyor efficiency model and estimated egg deposition in the Methow Basin. Fecundities are from Wells MEOK HOR females and Twisp/Omak NOR females and proportions are estimated from PIT-based escapement (mean; %): HOR 1-salt (4,481; 6.5), HOR 2-salt (6,104; 55.1), NOR 1-salt (3,986; 5.5), NOR 2-salt (5,941; 32.9). Twisp redd total is from Goodman et al. 2016.

Area	Redds	% of redds	Estimated egg deposition				
			2011	2012	2013	2014	2015
U. Methow	268	27.0	2,394,516	1,548,633	1,647,444	1,086,444	1,562,172
Chewuch	204	20.6	693,972	184,224	1,211,707	1,075,896	1,189,116
Twisp	161	16.2	1,187,880	759,924	835,660	759,456	938,469
L. Methow	358	36.2	1,062,840	909,606	1,140,079	1,708,776	2,086,782
Total	991	100.0	5,339,208	3,402,387	4,834,890	4,630,572	5,776,539

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

A total of 421 steelhead were trapped and sampled at Wells Dam, of which 116 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* = 2,001) 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 1,417 NOR steelhead returning to the Methow Basin prior to broodstock collection, estimated fallback, and Columbia River fishery-related mortality (Table 8). The NRR of the Methow Basin steelhead population was below replacement (i.e., < 1.0) in each of the fourteen brood years examined (Table 9). A plot of NRR verses run escapement suggests that high spawner escapement reduces overall productivity rates in the Methow Basin (Figure 1).

Table 8. NOR steelhead sampling at Wells Hatchery and expanded age composition by brood year of Methow Basin recruits (70.8% of NOR returns to Wells Dam). Brood year totals exclude the estimated number of double counted fish from 2009 through 2015.

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	
2015	2,001	116	0.0580	29	260	9	202	14	1,417
2014	2,231	147	0.0659	12	839	6	61	0	1,580
2013	1,210	70	0.0579	46	337	3	153	0	857
2012	1,643	94	0.0572	15	471	6	15	0	1,163
2011	2,045	120	0.0587	13	642	7	76	0	1,448
2010	2,070	115	0.0556	59	762	6	44	0	1,466
2009	1,217	127	0.1044	72	471	2	36	0	862
2008	1,283	132	0.1029	15	679	1	22	0	908
2007	631	52	0.0824	0	214	2	29	0	447
2006	765	124	0.1621	6	159	3	45	0	542
2005	861	104	0.1208	10	276	3	0	0	610
2004	1,161	116	0.0999	14	642	1	7	0	822
2003	821	27	0.0329	0	0	5	70	0	581
2002	900	18	0.0200	35	212	3	71	0	637
2001	553	26	0.0470	15	302	7	0	0	392
2000	435	41	0.0943	24	166	1	16	0	308
1999	242	29	0.1198	7	55	1	0	0	171

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

Parent brood	Methow run escapement	Brood at age					Adults produced	NRR
		1.1	1.2, 2.1	1.3, 3.1, 2.2	2.3, 3.2, 4.1	4.2		
1996	429	1999	2000	2001	2002	2003	319	0.7436
1997	1,972	2000	2001	2002	2003	2004	715	0.3626
1998	2,341	2001	2002	2003	2004	2005	745	0.3182
1999	1,636	2002	2003	2004	2005	2006	194	0.1186
2000	2,085	2003	2004	2005	2006	2007	1,011	0.4849
2001	3,758	2004	2005	2006	2007	2008	651	0.1732
2002	10,974	2005	2006	2007	2008	2009	395	0.0360
2003	5,064	2006	2007	2008	2009	2010	448	0.0885
2004	5,472	2007	2008	2009	2010	2011	1,006	0.1838
2005	4,779	2008	2009	2010	2011	2012	1,163	0.2434
2006	3,462	2009	2010	2011	2012	2013	1,565	0.4521
2007	3,748	2010	2011	2012	2013	2014	1,524	0.4045
2008	3,670	2011	2012	2013	2014	2015	880	0.2398
2009	4,475	2012	2013	2014	2015	2016	1,222	0.2731

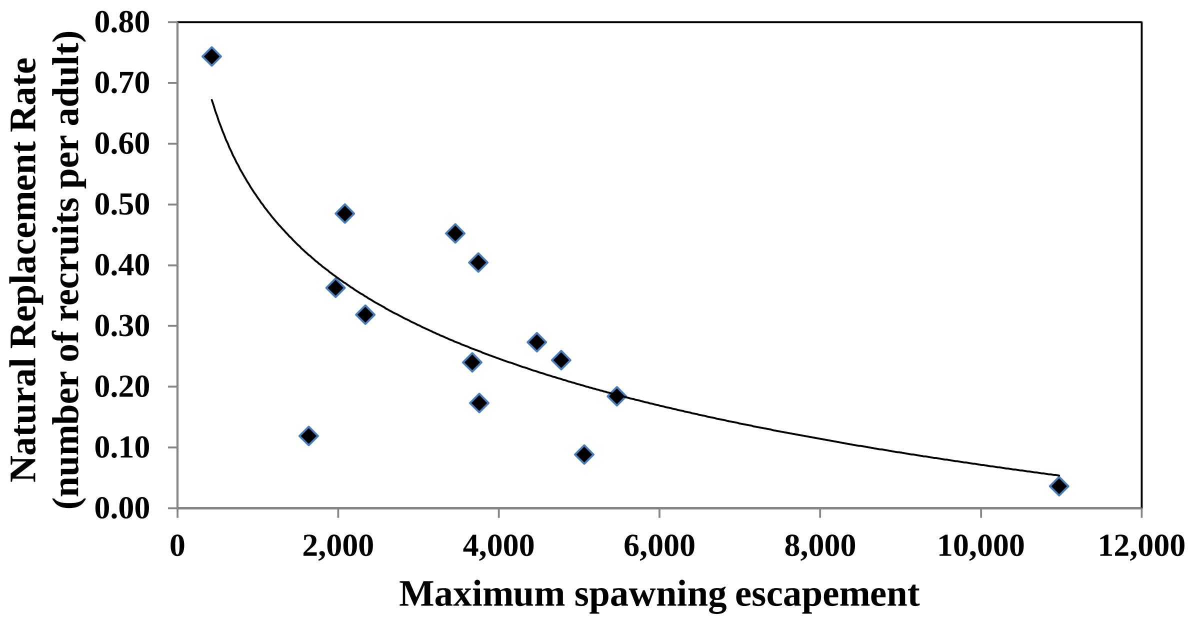

Figure 1. Methow Basin steelhead run escapement (HOR + NOR; x-axis) verses natural replacement rate (NRR; y-axis) for parent brood years 1996-2009.

Straying rates of Wells Hatchery Steelhead

Detections at PIT tag arrays were used to evaluate overall spawning escapement above the PIT tag array site and to estimate the contribution of Wells Hatchery steelhead releases to tributary-specific spawning escapement estimates. Based on completed adult return data from the 2011 brood, stray rates for Methow Basin steelhead releases averaged 24.6% across two release locations (Table 10).

Table 10. Detection of adult HOR summer steelhead released from Wells Hatchery into Methow Basin tributaries. Detections of 2012 brood releases are considered incomplete because they include only 1-salt returns. Detections in the Lower Methow mainstem are not considered strays for any of the release groups. HOR steelhead were not released in the Chewuch River after the 2010 brood.

Brood	Release river (donor pop.)	Recipient river, river area, or tributary						Total	% stray
		Upper Methow	Twisp	Chewuch	Lower Methow tribs	Lower Methow mainstem	Okanogan		
2011	Methow	16	0	0	2	10	1	29	10.3
2011	Twisp	0	10	0	1	1	6	18	38.9
2012	Methow	1	0	0	0	0	1	2	--
2012	Twisp	0	12	0	0	0	1	13	--

Discussion

Ongoing monitoring of PIT-tagged adult steelhead shows that pHOS is often lower in areas where hatchery steelhead are not released. In 2015, pHOS values in Beaver Creek, Gold Creek, and the Chewuch River were all below 0.40. Conversely, in both areas where steelhead are released (Upper Methow River, Twisp River), pHOS values were > 0.60 in both cases. While pHOS above the Twisp River weir is manipulated to achieve a 0.50 rate as part of the relative reproductive success study, adult management opportunities in the Upper Methow River are limited to hatchery outfall traps. Historically, trapping of adult steelhead has been largely ineffective at Winthrop NFH. Only recently have adult steelhead released from Methow Hatchery been returning to the site, but recent data suggest this location may be effective in removing excess hatchery adult returns. Concurrent recreational fisheries should continue to be the principal avenue by which to reduce adipose-fin-clipped hatchery steelhead from the spawning population, but maintaining the recreational fishery for a long enough period for effective reduction has been challenging given the limited allowable impacts to wild fish. Currently, a steelhead radio-telemetry study designed to compare present distribution of hatchery and wild fish with historic data, validate ongoing PIT-based escapement, and estimate pre-spawn mortality, is on-going and should provide local managers necessary information to monitor and assess steelhead populations in the Upper Columbia.

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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. For brood years 2007-2015, proportion of hatchery and wild fish at Wells Dam was estimated through run-at-large sampling; in previous years, proportions were calculated from broodstock trapping records. Estimated double counts and fallback were based on expanded PIT tag interrogation data. Estimated fishery mortality in the Columbia River for brood years 2003-2005 includes fishery-related mortality in the Wells Dam tailrace; all other fishery mortality in the Columbia River occurred in the section between Wells Dam and Chief Joseph Dam. Estimated fishery mortality for hatchery fish in the Methow Basin includes hatchery fish removed as excess. For brood years 2001 and 2002, WDFW fishery mortality (Columbia) was estimated from catch record cards. CCT fishery data were provided by Mike Rayton (unpublished data).

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

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

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

Appendix 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.