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LITTLE SHEEP CREEK SMOLT TRAP FOR STEELHEAD GENETICS

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Abstract

This primary purpose of this project is to collect tissue samples for genetic analysis by NOAA Fisheries Service to determine parental origin of juvenile steelhead (*Oncorhynchus mykiss*) migrants from Little Sheep Creek in the Imnaha River Subbasin in northeast Oregon. We also determined migration timing, age structure and abundance of juvenile steelhead migrating from Little Sheep Creek. In 2015, we collected tissue samples from 250 juvenile, 300 smolt, and 94 resident steelhead for genetic analysis. We estimated 10,194 juvenile steelhead migrated from Little Sheep Creek in migratory year 2015, and that 41% of the migrants left during the period July – December. The age-2 smolt was the predominant migrant during the 2015 migratory year.

Introduction

Initiated in 1989, this study (Bonneville Power Administration Project 1989-096-00) monitors genetic changes associated with hatchery propagation in multiple Snake River sub-basins for Chinook salmon and steelhead. Oregon Department of Fish and Wildlife (ODFW) contracted with NOAA Fisheries Service (August 2004–February 2012) to collect tissue samples from migrating steelhead from Little Sheep Creek, Oregon for determination of parental origin. ODFW contracted with BPA in February 2012 to continue the sample collection.

ODFW has been releasing hatchery-reared steelhead *Oncorhynchus mykiss* smolts in Little Sheep Creek since 1983 to supplement steelhead production as part of the Lower Snake River Compensation Plan. One of the goals of the supplementation program is to increase the natural production of steelhead in Little Sheep Creek by allowing hatchery-produced steelhead spawners released into Little Sheep Creek to spawn naturally each year (range 46–1,198 hatchery and wild spawners for 1987–2013 brood years). However, the number of naturally-produced adults returning to the Little Sheep Creek facility has been small. Naturally spawning steelhead in Little Sheep Creek have produced an average of 0.62 adults returning to Little Sheep Creek (range 0.1–2.2 progeny/parent for 1987–2004 brood years). At this time, we do not know the reasons for the low productivity of steelhead from Little Sheep Creek. Possible reasons for the low productivity can be divided into two categories: poor survival and productivity from the adult to migrant life stages in Little Sheep Creek, or low survival of steelhead from migrant to returning adult after leaving Little Sheep Creek. This project estimates the number of migrant steelhead leaving Little Sheep Creek and collects tissue samples for determination of the parentage (hatchery or wild) of the migrants through genetic pedigree analysis by NOAA Fisheries Service staff. Location of the study area and rotary screw trap is shown in Figures 1 and 2.

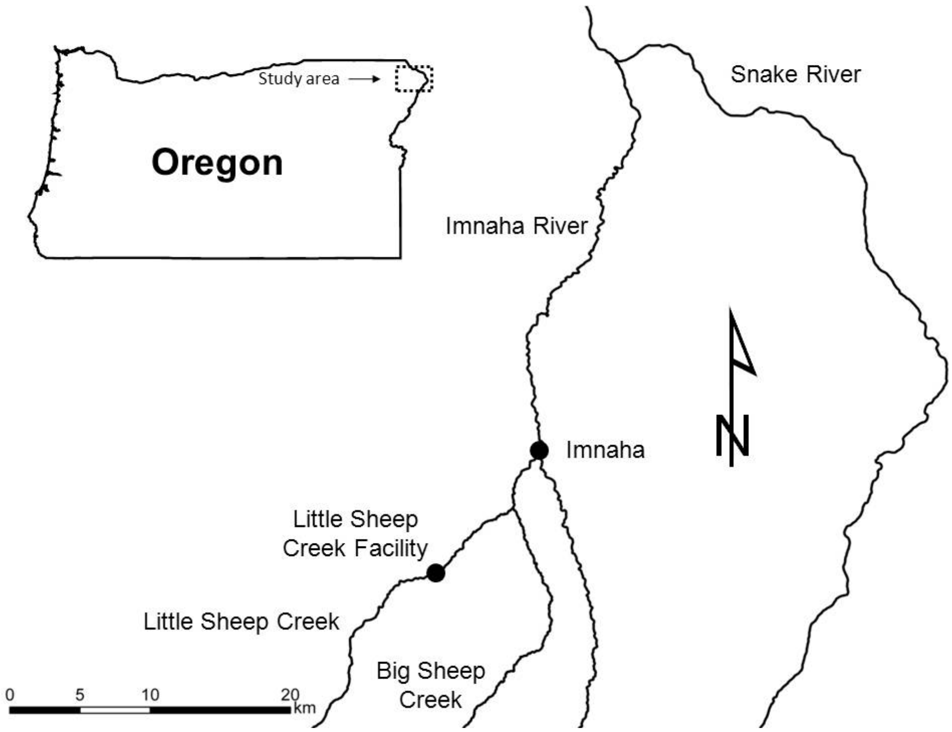

Figure 1. Study area map of Little Sheep Creek. The rotary screw trap was located at Little Sheep Creek Facility.

Figure 2. Location of rotary screw trap in relation to Little Sheep Creek Steelhead Facility. The trap is located on Little Sheep Creek (rkm 8.4), 11 km southwest of the town of Imnaha, Oregon

Methods

Steelhead outmigration estimates are necessary to separate the freshwater and ocean portions of salmonid natural production.

We operated a rotary screw trap to capture downstream migrant steelhead at our Little Sheep Creek Facility located on Little Sheep Creek (rkm 8.4), 11 km southwest of the town of Imnaha, Oregon (Figures 1 and 2). The trap was originally installed and began fishing on February 3, 2005. Although the intent was to operate the trap continuously through the year, there were times when the trap was not operated due to low flows, high water temperatures, or freezing conditions. Usually, these times that the trap was not operated occurred during periods of very low trap catch. No attempt was made to adjust abundance estimates for periods when the trap was not operating.

The rotary screw trap was equipped with a live-box that safely held hundreds of juvenile steelhead trapped over 24–72 h periods. The trap was generally checked daily, but was checked as infrequently as every third day when few fish were captured per day and environmental conditions were not severe. All juvenile steelhead captured in traps were removed for enumeration. Fork lengths (FL, mm) were measured from most juvenile steelhead captured, and weights were taken from up to 50 fish per day. Fry (< 50 mm FL) captured in the trap were able to escape without detection, so they were not included in migrant abundance estimates. Prior to sampling, juvenile steelhead were anesthetized with buffered MS-222 (40–60 mg/L). Fish were allowed to recover fully from anesthesia before release into the stream. Stream height was recorded daily from a staff gage. Water temperature was recorded daily at the trap location using a hand held thermometer.

We use the term "migratory year" to refer to the earliest year that juvenile salmonids are expected to migrate to the ocean. The migratory year for juvenile steelhead in northeast Oregon, based on extensive trapping and marking in the Grande Ronde River and Imnaha River subbasins, overlaps two calendar years and begins on July 1 and ends on June 30 of the subsequent year. For example, the 2015 migratory year begins on July 1, 2014 and ends on June 30, 2015. The majority of steelhead migrants captured in our rotary screw trap as they leave Little Sheep Creek during migratory year 2015 will migrate to the ocean by summer of 2015.

We estimated the abundance of migrants for two migration periods each migratory year. The "early" migrants were captured in our rotary screw trap during July–December, and the "late" migrants were captured during January–June. Migrant abundance was estimated by conducting weekly trap efficiency tests throughout the migratory year at the trap site. Trap efficiency was determined for steelhead smaller than 120 mm fork length, and for steelhead larger than or equal to 120 mm fork length. Trap efficiency was determined by releasing a known number of fin clipped (marked) fish above the trap and enumerating recaptures. Trap efficiency was estimated by

$$\hat{E}_j = R_j / M_j \,, \tag{1}$$

where $\hat{E}_j$ is the estimated trap efficiency for period *j*, R_j is the number of marked fish recaptured during period *j,* and M_j is the number of marked fish released upstream during period *j*.

The abundance of migrants that passed the trap site during each period was estimated by

$$\hat{N}_j = U_j \Big/ \hat{E}_j \ , \qquad (2)$$

where $\hat{N}_j$ is the estimated number of fish migrating past the trap for period *j*, U_j is the total number of unmarked fish captured that period, and $\hat{E}_j$ is the estimated trap efficiency for period *j*. Total migrant abundance for early and late migrants was estimated as the sum of the abundance estimates for each period.

Variance of each period $\hat{N}$ was estimated by the one-sample bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations. The trap efficiency estimate was used in the bootstrap procedure to estimate variance of the population estimate for each period. Each bootstrap iteration calculated $\hat{N}_j^{\,*}$ from equations (1 and 2) drawing $R_j^{\,*}$ and $U_j^{\,*}$ from the binomial distribution, where asterisks denote bootstrap values. Variance of $\hat{N}_j^{\,*}$ was calculated from the 1,000 iterations. The period variance estimates were summed to obtain an estimated variance for the total migrant abundance. Confidence intervals for total migrant abundance were calculated by

$$95\%\,CI = 1.96\sqrt{V} \ , \qquad (3)$$

where *V* is the estimated total variance determined from the bootstrap.

Scale samples were taken from a subsample of steelhead (10 - 15 fish/10 mm FL group) during both migration periods. Scales were examined to determine age and an age–length key (DeVries and Frie 1996) was developed for each migration period. The age–length key and the length distribution of fish captured in the rotary screw trap were used to describe age structure of early and late migrants.

We collected tissue samples from steelhead captured in the rotary screw trap and provided them to NOAA Fisheries Service for pedigree analysis to determine parentage of individual fish. The tissue was taken from the caudal fin and stored in individually labeled vials containing 95% ethanol. Our goal was to collect tissue samples from 300 steelhead smolts during the period March–June, 200 randomly selected (without regard to age or size) juvenile steelhead during July–February, and every resident rainbow trout captured in the screw trap. Smolts were identified based on the criteria of silvery appearance or faint parr marks during the period March–June. Resident rainbow trout were identified as sexually mature fish, fish with a fork length of 180 mm or greater, or hatchery steelhead that had been released from the Little Sheep Creek Facility at least 3 months prior to being captured in the rotary screw trap.

Results

We saw patterns of diminished trap catch during the winter months of December to March, and so we present estimates of steelhead migrants for a given migratory year as “early” and “late” migrants, with early migrants during the period of July 1 to December 31 and late migrants during the period of January 1 to June 30. Our estimates of migrants for the periods from July 2014 through June 2015 are presented in Table 1. During the 2015 migratory year the early migrants constituted 41% of the total migrants, which falls below the range of observed percentages of early migrants in previous years (44–71%). We estimated in total there were 10,194 steelhead migrants leaving Little Sheep Creek in migratory year 2015. The early migrants had several peaks from mid-September to mid-November, and the number of late migrants peaked in early May (Figure 3).

The predominant age of migrants from Little Sheep Creek is the age-2 smolt, similar to that typically observed in Grande Ronde subbasin streams (Jonasson et al. 2015). The age-2 smolts may leave the rearing areas of Little Sheep Creek in the fall (early migrant) at age-1 to overwinter in downstream areas before migrating to the ocean the following spring at age-2 (Table 2). We typically observe early steelhead migrants of ages 0, 1, 2 and rarely age-3, and late migrants of ages 1, 2, 3, and rarely age-4.

We collected tissue samples from fish in the three categories: smolt, juvenile, and resident (Table 4) and provided them to NOAA Fisheries Service for genetic analysis.

Table 1. Abundance estimates of steelhead migrants leaving Little Sheep Creek during migratory year 2015. Early migrants left during July–December and late migrants left January–June. MY = migratory year (July 1 to June 30).

	Size	Early migrants		Late migrants		Total migrants	
MY	(mm)	Abundance	95% CI	Abundance	95% CI	Abundance	95% CI
2015	< 120	1,412	499	1,660	374	3,072	624
	≥ 120	*2,721*	*339*	*4,401*	*823*	*7,122*	*890*
	all	**4,133**	**604**	**6,061**	**904**	**10,194**	**1,087**

Table 2. Age structure of early and late steelhead migrants leaving Little Sheep Creek during migratory year 2015. The same four cohorts were represented in each migration period but ages increased by one year from early migrants to late migrants (e.g., age-0 early migrants were the same cohort as age-1 late migrants). Age structure was based on the frequency distribution of sampled lengths and allocated using an age–length key.

	Percentage				
Migration period	Age-0	Age-1	Age-2	Age-3	Age-4
Early	10.1	78.4	11.4	0.1	0.0
Late	0.2	23.6	50.5	24.5	1.3

Table 3. Length of steelhead migrants captured in the rotary screw trap on Little Sheep Creek by age group, migratory year 2015.

	Age-0			Age-1			Age-2			Age-3		
Period	mean	SE	*N*	mean	SE	*N*	mean	SE	*N*	mean	SE	*N*
Early	65.8	0.94	148	131.9	0.46	1146	154.6	1.60	166	214.0	--	1

	Age-1			Age-2			Age-3			Age-4		
Period	mean	SE	*N*	mean	SE	*N*	mean	SE	*N*	mean	SE	*N*
Late	100.9	0.81	362	137.1	0.87	776	166.4	0.88	376	173.0	3.51	20

Table 4. Summary of steelhead genetic samples collected at the Little Sheep Creek rotary screw trap in 2015.

	Number of samples		
Year	juvenile	resident	smolt
2015	250	94	300

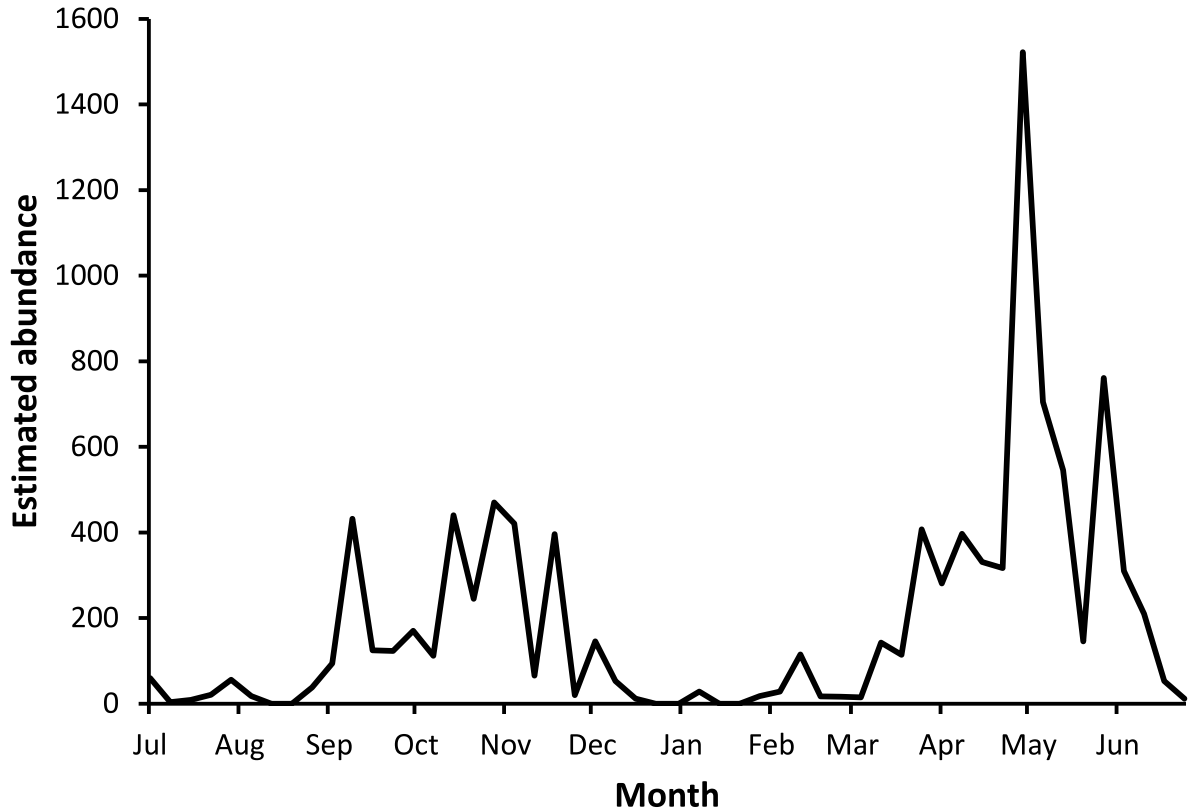

Figure 3. Estimated migration timing and abundance of juvenile steelhead migrants captured by a rotary screw trap on Little Sheep Creek during migratory year 2015.

Synthesis of Findings: Discussion/Conclusions

As the juvenile abundance information from this study is integrated with the spawner abundance and spawner origin (hatchery or natural) and the relative reproductive success results obtained from the steelhead migrants at the rotary screw trap, we should gain a better understanding of the efficacy of the steelhead supplementation in Little Sheep Creek.

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Appendix A: Use of Data & Products

The data collected through this contract are shared with NOAA Fisheries staff and Lower Snake River Compensation Plan – Oregon Evaluation Studies staff. Tissue samples collected through this contract are provided to NOAA Fisheries staff for genetic analysis.

Appendix B: Detailed Results

Appendix Table B-1. Abundance estimates of steelhead migrants leaving Little Sheep Creek during migratory years 2005–2015. Early migrants left during July–December and late migrants left January–June. MY = Migratory year (July 1 to June 30).

	Size	Early migrants		Late migrants		Total migrants	
MY	(mm)	Abundance	95% CI	Abundance	95% CI	Abundance	95% CI
2005	< 120		--	2,799	1,508	--	--
	≥ 120		--	8,820	5,166	--	--
	all		--	**11,619**	**5,382**	--	--
2006	< 120	1,633	727	2,411	1,515	4,044	1,680
	≥ 120	6,076	2,103	2,978	1,186	9,054	2,415
	all	**7,709**	**2,225**	**5,389**	**1,924**	**13,089**	**2,942**
2007	< 120	2,232	1,009	2,467	1,326	4,699	1,666
	≥ 120	4,972	709	5,145	1,567	10,117	1,720
	all	**7,204**	**1,233**	**7,612**	**2,053**	**14,816**	**2,395**
2008	< 120	1,623	565	1,051	471	2,674	736
	≥ 120	5,757	1,442	5,232	1,528	10,989	2,101
	all	**7,380**	**1,549**	**6,283**	**1,599**	**13,663**	**2,226**
2009	< 120	490	247	751	286	1,241	377
	≥ 120	11,080	4,955	3,952	692	15,032	5,003
	all	**11,570**	**4,961**	**4,703**	**748**	**16,273**	**5,018**
2010	< 120	3,102	555	4,402	1,316	7,504	1,428
	≥ 120	3,288	1,745	3,685	817	6,973	1,927
	all	**6,390**	**1,831**	**8,087**	**1,549**	**14,477**	**2,398**
2011	< 120	2,323	744	177	102	2,500	751
	≥ 120	12,079	1,611	6,368	3,030	18,447	3,431
	all	**14,402**	**1,775**	**6,545**	**3,031**	**20,947**	**3,513**
2012	< 120	1,168	200	2,300	672	3,468	701
	≥ 120	3,525	890	3,335	1,797	6,860	2,005
	all	**4,693**	**912**	**5,635**	**1,918**	**10,328**	**2,124**
2013	< 120	4,166	576	2,759	1,618	6,925	1,717
	≥ 120	7,491	1,427	2,536	909	10,027	1,692
	all	**11,657**	**1,539**	**5,295**	**1,856**	**16,952**	**2,411**
2014	< 120	4,320	1,094	2,536	477	6,856	1,193
	≥ 120	7,023	1,679	6,353	999	13,377	1,954
	all	**11,343**	**2,004**	**8,889**	**1,107**	**20,233**	**2,289**

Appendix Table B-1. Continued.

MY	Size (mm)	Early migrants		Late migrants		Total migrants	
		Abundance	95% CI	Abundance	95% CI	Abundance	95% CI
2015	< 120	1,412	499	1,660	374	3,072	624
	≥ 120	2,721	339	4,401	823	7,122	890
	all	**4,133**	604	**6,061**	**904**	**10,194**	**1,087**

Appendix Table B-2. Age structure of early and late steelhead migrants leaving Little Sheep Creek during migratory years 2005–2015. The same four cohorts were represented in each migration period but ages increased by one year from early migrants to late migrants (e.g., age-0 early migrants were same cohort as age-1 late migrants). Age structure was based on the frequency distribution of sampled lengths and allocated using an age–length key.

	Percent				
Migration period and migratory year	Age-0	Age-1	Age-2	Age-3	Age-4
Early					
MY 2006	15.0	82.7	2.3	0.1	0.0
MY 2007	12.3	80.8	6.7	0.2	0.0
MY 2008	9.0	85.3	5.6	0.0	0.0
MY 2009	1.9	68.5	29.6	0.0	0.0
MY 2010	45.1	49.7	5.2	0.0	0.0
MY 2011	1.6	90.9	7.5	0.0	0.0
MY 2012	21.8	58.5	19.7	0.0	0.0
MY 2013	23.6	73.3	3.0	0.1	0.0
MY 2014	28.7	62.1	9.0	0.2	0.0
MY 2015	10.1	78.4	11.4	0.1	0.0
Mean	**16.9**	**73.0**	**10.0**	**0.1**	**0.0**
Late					
MY 2005	0.0	24.3	69.0	6.7	0.0
MY 2006	0.0	39.8	57.7	2.5	0.0
MY 2007	0.0	24.1	67.1	8.7	0.0
MY 2008	0.0	14.5	74.9	10.6	0.0
MY 2009	0.0	17.7	79.9	2.4	0.0
MY 2010	0.0	60.2	38.6	1.2	0.0
MY 2011	0.0	9.5	88.5	1.9	0.0
MY 2012	0.0	48.8	48.0	3.2	0.0
MY2013	0.0	66.4	30.3	3.2	0.0
MY 2014	0.0	25.1	55.4	19.4	0.1
MY 2015	0.2	23.6	50.5	24.5	1.3
Mean	**0.0**	**32.2**	**60.0**	**7.7**	**0.1**

Appendix Table B-3. Length of steelhead migrants captured in the rotary screw trap on Little Sheep Creek, migratory years 2005–2015.

		Age-0			Age-1			Age-2			Age-3		
MY	Period	mean	SE	*N*	mean	SE	*N*	mean	SE	*N*	mean	SE	*N*
2005	Late	--		0	104.7	0.76	291	152.5	1.32	482	199.2	4.18	45
2006	Early	73.3	1.00	217	139.3	0.49	1062	217.9	4.56	29	314.5	--	1
	Late	--		0	99.2	1.10	194	158.4	1.13	385	218.0	6.91	17
2007	Early	69.6	0.53	252	131.3	0.33	1923	151.4	1.55	167	216.5	13.56	5
	Late	--		0	98.8	1.31	153	157.7	0.65	856	176.0	1.34	122
2008	Early	74.7	0.82	171	133.5	0.45	1374	165.2	3.76	88	--		
	Late	--		0	112.5	1.36	166	160.1	0.76	928	184.6	1.08	132
2009	Early	74.8	1.15	63	141.4	0.70	868	150.7	0.95	361	--		
	Late	--		0	94.4	1.21	224	170.3	0.52	864	187.7	4.03	25
2010	Early	73.0	0.32	991	138.4	0.98	638	175.0	3.21	55	--		
	Late	--		0	104.0	0.44	1382	164.6	0.61	1031	206.9	3.46	33
2011	Early	71.4	0.83	61	137.6	0.28	3911	140.9	1.12	324	--		
	Late	--		0	119.6	2.46	92	162.2	0.76	504	191.8	3.04	11
2012	Early	73.7	0.39	494	140.9	0.48	1093	166.7	0.84	363	--		
	Late	--		0	101.8	0.57	650	159.7	1.02	288	190.3	2.71	12
2013	Early	72.1	0.36	842	135.1	0.35	2476	180.6	1.59	98	244.5	12.25	3
	Late	--		0	106.2	0.62	577	158.7	1.13	224	180.3	2.67	24
2014	Early	67.2	0.32	941	128.0	0.39	2039	154.5	1.08	294	190.2	8.77	7
	Late	--		0	97.9	0.56	611	151.8	0.46	1348	172.2	0.56	472
2015	Early	65.8	0.94	140	131.9	0.46	1146	154.6	1.60	166	214.0	--	1
	Late[a]	54.5	--	3	100.9	0.81	362	137.1	0.87	776	166.4	0.88	376

[a] Also age 4: mean = 173.0, SE = 3.51, N = 20

Appendix Table B-4. Summary of steelhead genetic samples collected at the Little Sheep Creek rotary screw trap, 2005–2014.

Year	Number of samples		
	juvenile	resident	smolt
2005	200	124	297
2006	298	99	292
2007	218	115	300
2008	300	71	300
2009	200	67	300
2010	198	155	300
2011	200	216	300
2012	201	201	300
2013	205	171	300
2014	250	83	251
2015	250	94	300

Appendix C: List of Metrics and Indicators

Category	Subcategory	Subcategory Focus 1	Subcategory Focus 2	Specific Metric Title
Fish	Abundance of Fish	Fish Life Stage: Juvenile - Migrant	Fish Origin: Natural	Abundance of emigrating steelhead
Fish	Age Structure: Fish	Fish Life Stage: Juvenile - Migrant		Age composition of emigrating steelhead
Fish	Timing of Life Stage: Fish	Fish Life Stage: Juvenile - Migrant		Steelhead emigration timing