Salmonid Abundance in Mill Creek between the Mill Creek Diversion Dam and the Mill Creek Division Dam

Report to the US Army Corps of Engineers

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Abstract

Fish movement in the Mill Creek flood control channel may be restricted when flow drops to summer base flow levels. As a result, construction of a low flow channel is being considered to improve fish passage in Mill Creek. Salmonid abundance was estimated for the U.S. Army Corps of Engineers to evaluate the cost/benefit of constructing the low flow channel. To estimate salmonid abundance, the U.S. Fish and Wildlife Service with assistance from the Washington Department of Fish and Wildlife and the U.S. Army Corps of Engineers designed and conducted simple random sampling surveys using snorkeling in the flood control channel of Mill Creek during June, July and August of 2009. We attempted to quantify the detection probability of the snorkel surveys through multiple pass, depletion electrofishing, but were unsuccessful with this method. As a result, survey estimates represent minimum abundance estimates for the study area. The estimated minimum salmonid abundance was 410, 538 and 407 fish during June, July and August, respectively. Although detection probabilities could not be estimated, qualitative observations suggest there may have been considerably more salmonids present during June when the abundance estimate was 410 fish. Detection probability was likely lower during the June survey due to limited visibility resulting from higher streamflows. Detection probabilities during July and August were likely higher because streamflows were lower and visibility was not limited. The decrease in estimated salmonid abundance from July (538 fish) to August (407 fish) may have been due to mortality associated with the near lethal water temperatures prior to the August survey, continued exposure to predation and angling, and/or emigration.

Acknowledgments

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Background

A flood control channel approximately 100’ wide was constructed by the U.S. Army Corps of Engineers (COE) between Mill Creek Diversion Dam (aka Bennington Diversion Dam, hereafter referred to as the Diversion Dam) and Mill Creek Division Dam (hereafter referred to as the Division Dam) to help contain high streamflows through the City of Walla Walla. There are 80 concrete stabilization weirs spaced approximately 18 m apart in the one-mile section of Mill Creek between the two dams (Figure 1). Pools have been scoured out downstream from each of the concrete weirs. As streamflow drops to summer base flow levels, movement of fish residing in these pools may be restricted. Restricted movement may cause fish to remain in areas where temperatures may become lethal. In addition, the relatively wide, shallow flood channel has little cover, which likely increases salmonid exposure to predation and vulnerability to angler harvest.

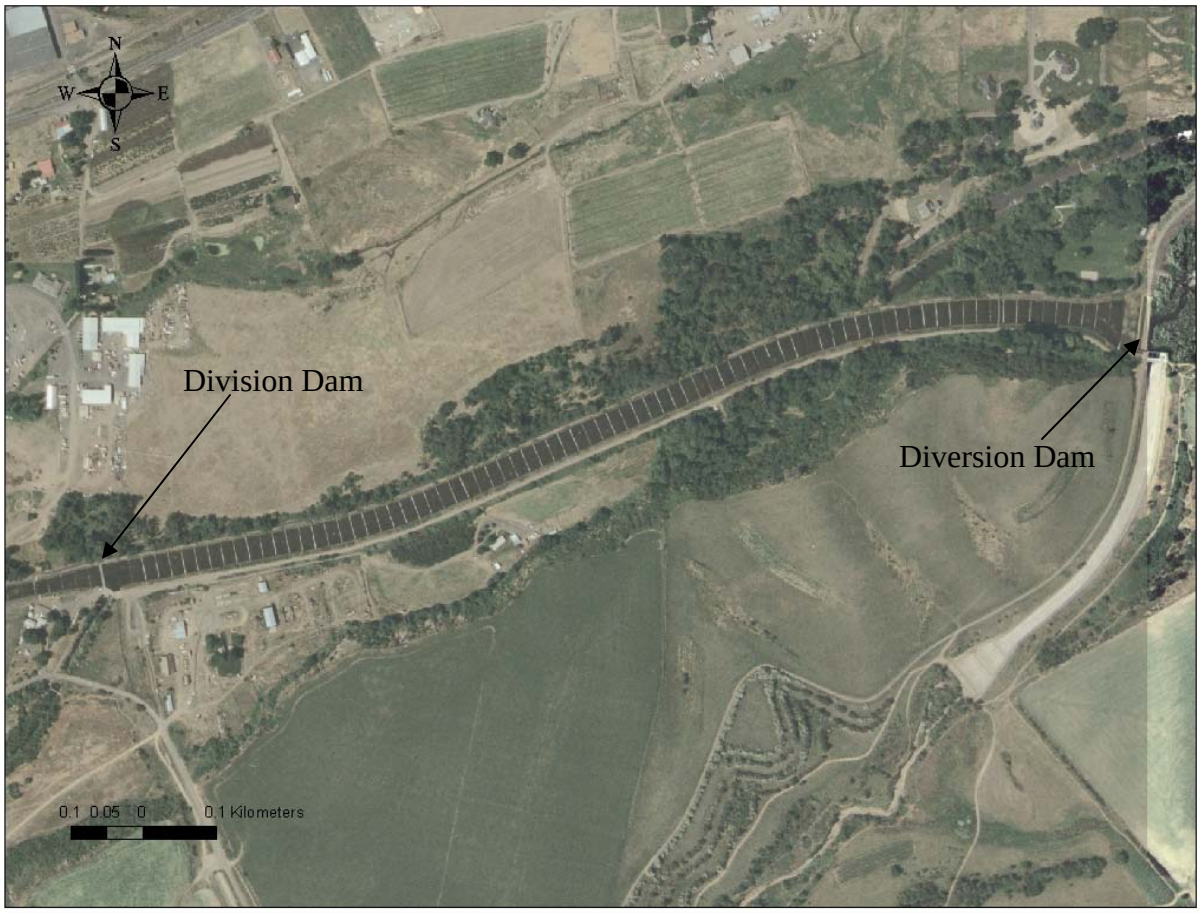

Figure 1. Mill Creek between the Diversion Dam and the Division Dam showing the concrete stabilization weirs.

The COE is studying the feasibility of constructing a low-flow channel between the Diversion Dam and the Division Dam. A low-flow channel could improve fish passage, connectivity, and migration conditions through this section of Mill Creek when summer base flows and water

temperatures are marginal for salmonids. This action is required by reasonable and prudent measure 3.a from the October 23, 2007 USFWS Biological Opinion for the Mill Creek Flood Control Project and its effects on ESA-listed bull trout. The target date for completion is 2012. The COE expressed interest in characterizing the benefits of this project to salmonids. To accomplish this, and to describe salmonid usage of this area from late spring (June) through the summer (July, August), studies were conducted to estimate salmonid abundance and distribution.

Methods

Snorkel Surveys

Snorkel surveys were conducted to estimate salmonid abundance using a simple random sampling study design between the Division Dam and the Diversion Dam. The surveys were conducted on June 4, July 14 and August 12, 2009. Eighty pools were identified in the study area and numbered from 1 to 80 beginning with pool 1 directly upstream of the Division Dam and ending with pool 80 directly downstream of the Diversion Dam. Four of the 80 pools were eliminated from those randomly selected for sampling. We eliminated pools 1 and 2 directly above the Division Dam because they were backwatered by the dam and pools 79 and 80 directly below the Diversion Dam because they were structurally different due to the hydraulics created by water passing the dam via the spillway, low flow outlet and ladder under various flows and the resulting sediment deposition and scouring. The remaining 76 pools were not backwatered by the Division Dam and were similar in structure. During each survey 20 of the 76 pools were randomly selected and snorkeled and the total number of salmonids observed in each pool was enumerated. Snorkel surveys within the study area were conducted from downstream to upstream.

Two snorkelers systematically surveyed each pool with the goal of obtaining a complete visual count of all salmonids, while one person recorded data. A GPS location was recorded for each pool sampled. Date, time and water temperature were recorded at each pool sampled. Salmonid data collected included the following species and life stage:

- Bull trout adult
- Bull trout subadult
- Steelhead adult
- Rainbow trout adult
- Rainbow/Steelhead juvenile/smolt
- Chinook adult
- Chinook juvenile/smolt
- Mountain whitefish adult
- Mountain whitefish juvenile

The presence of non-salmonids was also recorded by species for each pool sampled.

Detection Probabilities

We attempted to estimate detection probability (i.e., snorkeling efficiency) by multiple pass, depletion electrofishing as described in Schneider (2000). A subset of five pools was randomly selected for electrofishing from the 20 pools selected for snorkeling. We electrofished when water temperatures were <18°C. Electrofishing was conducted after the snorkel survey was complete. Two personnel, each outfitted with a Smith Root backpack electrofisher model LR-24A systematically sampled each pool. Electrofishing within pools and within the study area was conducted from downstream to upstream. A similar amount of electrofishing time was expended for each pass. All salmonids collected were measured and released. All non-salmonid fish collected were identified to species and released.

Abundance Estimation

As mentioned previously, we randomly selected and snorkeled 20 of the 76 pools within the study area for each survey. Prior to calculating the abundance estimates, we first evaluated whether there were differences in mean abundance between the upper section (pools 41-78) and lower section (pools 3-40) of Mill Creek to determine if abundance should be estimated from stratified samples. Mean abundance ($\bar{y}$) was calculated as $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$, where y_i is the number of salmonids observed in the i^{th} pool and n is the number of pools sampled. Mean abundance was calculated for each section (upper, lower) and month (June, July, August). Within each survey month, we conducted a two sample t-test to determine if there were significant differences in mean salmonid abundance between the upper and lower sections.

There were a total of 38 pools in each section, therefore the estimated total abundance ($\hat{\tau}$) for each section and month was $\hat{\tau} = 38 \cdot \bar{y}$. The estimated total abundance for the entire study area for each month was the sum of the section-specific abundance estimates. For reasons explained below, we were unable to estimate detection probabilities for the surveys; thus, the estimated numbers of salmonids are not corrected for snorkeling efficiency. Because the detection probabilities are likely less than 100%, the abundance estimates reported represent minimum abundances. We used bootstrapping methods to estimate 95% confidence limits on the section-specific abundance estimates and the total abundance estimates, by month.

Results and Discussion

Snorkel Surveys

Snorkel surveys were conducted on June 4, July 14 and August 12, 2009. The June 4 survey was conducted prior to the onset of base streamflows (Figure 2). The July 14 and August 12 surveys were conducted at base streamflow.

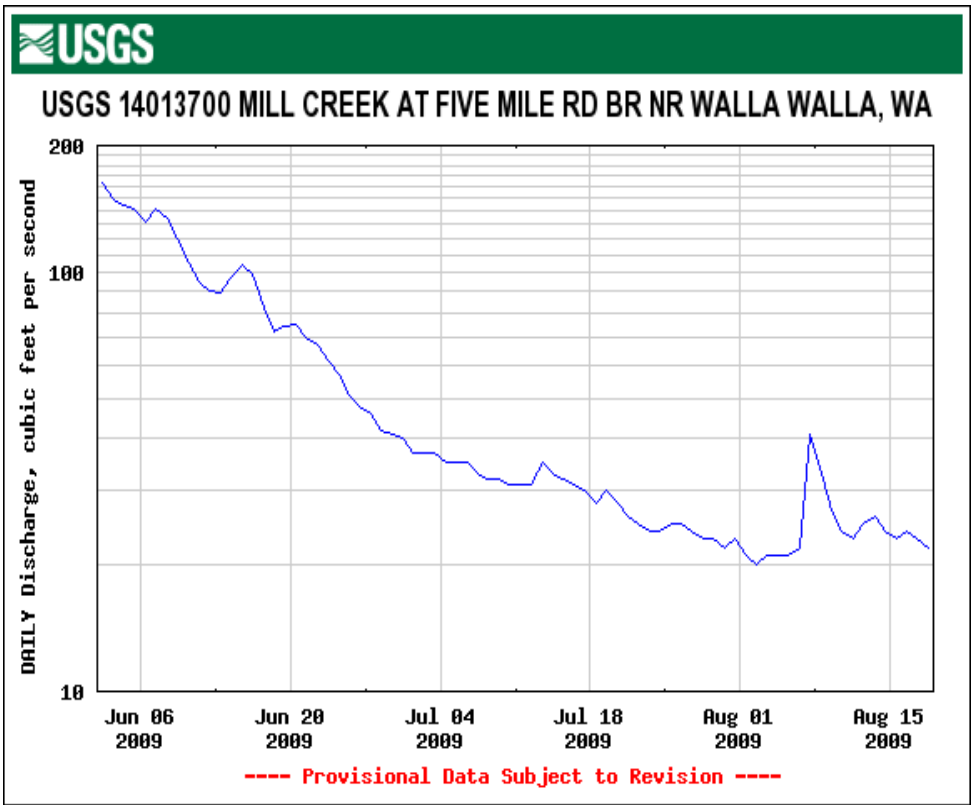

Figure 2. Daily average streamflow at Five Mile Road Bridge on Mill Creek, near Walla Walla, Washington.

Average daily water temperature at the Diversion Dam on June 4, July 14 and August 12 was 13.8, 17.7 and 19.0 ºC, respectively. Temperatures were suitable for rearing salmonids during the the first survey. Temperatures increased between the June 4 and July 14 surveys and had peaked prior to the August 12 survey (Figure 3).

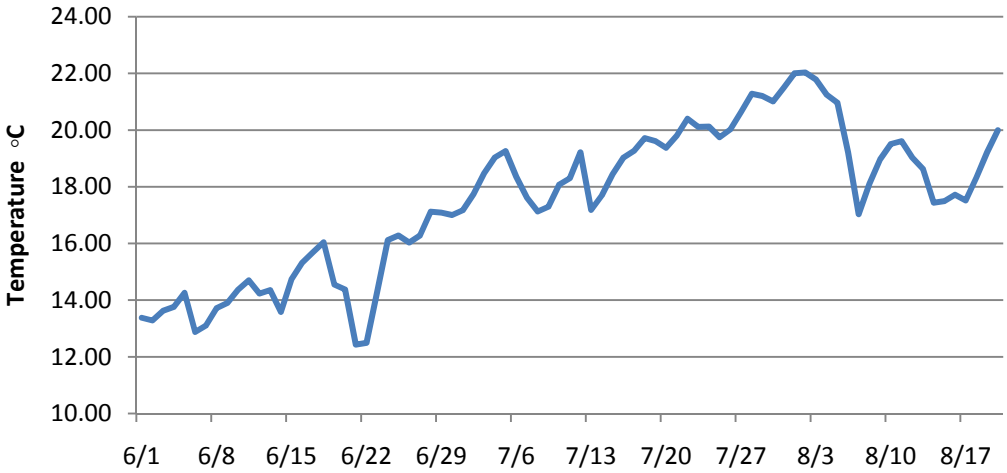

Figure 3. Average daily water temperature at Bennington Diversion Dam on Mill Creek, near Walla Walla, Washington.

The number of bull trout, *O. mykiss* and Chinook salmon observed in each pool sampled are summarized in Table 1. A total of 351 salmonids were observed during the three surveys. Of those, 95% were *O. mykiss* observed during June (103), July (129) and August (100). During the July survey, two subadult bull trout were observed. No adult bull trout or adult steelhead were observed during any of the surveys in the randomly selected sample pools. Adult resident *O. mykiss* were observed during all three surveys.

Although no adult steelhead were observed in randomly selected pools, it is worth noting that adult steelhead were present in the study area during June. We observed adult salmonids below the Diversion Dam in pool 80 from the access road that runs parallel to Mill Creek. We snorkeled the pool and observed 2 steelhead, which were likely kelts, along with several Chinook adults. Fish observed in Pool 80 were not used when estimating salmonid abundance for the study area. We only mention the observations to note that adult steelhead were present even though they were not observed while snorkeling the randomly selected pools.

Table 1. Number of subadult (or juvenile) and adult (in parentheses) bull trout, *O. mykiss*, and Chinook salmon (CHK) observed in each pool sampled during snorkel surveys in Mill Creek, Washington during 2009.

June				July				August			
Pool #	Bull Trout	*O. mykiss*	CHK	Pool #	Bull Trout	*O. mykiss*	CHK	Pool #	Bull Trout	*O. mykiss*	CHK
5	0	9	0	11	0	2	0	8	0	0	0
9	0	7	0	13	0	1	0	9	0	0	0
10	0	11	0	22	0	3 (3)	6	10	0	3	0
21	0	8	0	24	0	0	0	16	0	0	0
23	0	0 (1)	0	28	1	10 (3)	0	23	0	1	0
32	0	6	0	32	0	2	3	24	0	3	0
37	0	9	0	36	0	12	0	25	0	4	0
39	0	0	0	38	0	7	0	31	0	0	0
40	0	5	0	42	0	9	2	33	0	0	0
41	0	1	0	47	0	7 (1)	0	36	0	5	0
43	0	6	0	48	0	1	0	37	0	3	0
46	0	2	0	49	0	3 (3)	0	47	0	16	0
51	0	5	0	52	0	4	0	54	0	0	0 (1)
52	0	0	0	55	0	5 (1)	0	58	0	2	0
55	0	3	0	56	0	2 (1)	0	59	0	13 (2)	0
60	0	2	0	57	0	8 (1)	0	63	0	3	0
61	0	9 (2)	0	69	0	4	0	65	0	8	0
66	0	4	0 (3)	74	0	16	0	70	0	3	0
70	0	8	0	76	0	8	0	71	0	25 (1)	0
74	0	5	0	77	1	12	2	75	0	8	0
Total	**0**	**100 (3)**	**0 (3)**		**2**	**116 (13)**	**13**		**0**	**97 (3)**	**0(1)**

Observations of non-salmonids observed during snorkel surveys are summarized in Table 2. Redside shiner, dace *spp.*, sucker spp., and sculpin *spp.* were observed during all three surveys. Brook lamprey were only observed during the June survey when they were presumably spawning.

Table 2. Observations of non-salmonids in each pool sampled while conducting snorkel surveys in Mill Creek, Washington during 2009. Species codes are as follows: RS = redside shiner, DA = dace *spp.*, BL = brook lamprey, SU = sucker *spp.*, and SC = sculpin *spp.*

June		July		August	
Pool #	Species present	Pool #	Species present	Pool #	Species present
5	RS, SU,	11	RS, DA, SU, SC	8	RS, DA,
9	RS, DA,	13	RS, DA, SU, SC	9	RS, DA, SC
10	RS, DA, SU,	22	RS, DA, SU, SC	10	RS, DA, SC
21	RS, DA, BL,	24	RS, DA, SU, SC	16	DA, SC
23	BL, SU,	28	RS, DA, SU, SC	23	DA, SC
32	DA, SC	32	RS, DA, SU, SC	24	DA, SC
37	DA,	36	RS, DA, SU, SC	25	SC
39		38	RS, DA, SU, SC	31	RS, DA, SC
40	DA,	42	RS, DA, SU, SC	33	DA, SC
41	BL,	47	RS, DA, SU, SC	36	RS, DA, SU, SC
43	RS,	48	RS, DA, SU, SC	37	RS, SC
46	DA,	49	RS, DA, SU, SC	47	RS, DA, SC
51	BL,	52	RS, DA, SU, SC	54	DA, SC
52	RS, DA, SC	55	RS, DA, SU, SC	58	RS, SC
55	RS, DA,	56	RS, DA, SC	59	RS, DA, SU, SC
60	RS, DA,	57	RS, DA, SU, SC	63	SU,
61	DA, BL,	69	RS, DA, SU, SC	65	RS, DA, SU, SC
66	BL,	74	RS, DA, SU, SC	70	RS, DA, SC
70	BL,	76	RS, DA, SU, SC	71	RS, DA, SU, SC
74	DA, BL,	77	RS, DA, SU, SC	75	RS, DA, SC

Detection Probabilities

During the June survey, we attempted to estimate detection probabilities by multiple pass depletion electrofishing. Depletion electrofishing proved ineffective in the study area. As a result the total salmonid population within the study area could not be corrected for detection probability. In order to calculate a depletion rate, each successive electrofishing pass must show a decrease in the number of salmonids captured. In our sampling, the number of salmonids captured remained the same or increased during the second pass in 3 of 5 pools sampled (Table 3).

Table 3. Number of salmonids captured while conducting multiple pass electrofishing surveys between the Division Dam and the Diversion Dam in Mill Creek, WA.

	Number of Salmonids	
Pool	pass 1	pass 2
23	1	1
32	3	2
43	1	1
55	2	1
70	1	5

Electrofishing was ineffective in the study area primarily because of pool area and depth. Although two people with electrofishers systematically sampled the pool, it was possible for fish to swim around the electrical field as the samplers proceeded through the pool. In addition, pool depth immediately downstream of the concrete sills often exceeded wading depth of personnel operating the electrofisher which limited the area that could effectively be sampled. As a result, we did not conduct electrofishing surveys during the July and August snorkel surveys.

Although detection probabilities were not calculated, qualitative observations suggest that the detection probabilities were lower on June 4 in comparison to the July 14 and August 12 surveys. Streamflow during the June, July and August surveys was 144 cfs, 33 cfs and 25 cfs respectively. Higher streamflows in June reduced visibility which likely reduced detection probability during that month. Streamflow conditions were similar during July and August and the detection probability was likely higher than the June survey and similar between July and August.

Abundance Estimation

Mean salmonid abundance (Table 4) did not differ significantly between lower and upper section pools in June (P = 0.30) or July (P = 0.68). During August, however, the mean number of salmonids in upper section and lower section pools was statistically different (P = .01), with low mean abundance in the lower section pools. On average, 9.1 salmonids were observed in upper section pools, whereas only 1.7 salmonids were observed in lower section pools in August.

Table 4. Average number of salmonids observed during snorkel surveys between the Division Dam and the Diversion Dam in Mill Creek, WA, with results of a two sample t-test.

Month	Lower Section Pools	Upper Section Pools	P-value
June	6.2	4.6	0.30
July	6.6	7.6	0.68
August	1.7	9.1	0.01

One possible explanation for the difference in distribution during August is water temperature. Average daily water temperatures were cooler at the Diversion Dam than at the Division Dam.

(Figure 1). Temperatures peaked at 25 ºC at the Division Dam, and 22 ºC at the Diversion Dam on August 2, just 10 days prior to the last survey (Figure 4). As a result of exposure to near lethal temperatures, salmonids may have moved from the lower section into the cooler water available in the upper section of the study area for refuge. Flows increased from 22 cfs on August 9 to 41 cfs on August 10 (Figure 2) which may have allowed fish movement prior to the August 12 survey. The observation of increased mean abundance in the upper section between July and August may have been the result of the higher flows and resulting passage conditions. Future sampling designs may need to maintain the stratification of upper and lower pools following peak summer temperatures to account for differences in fish distribution.

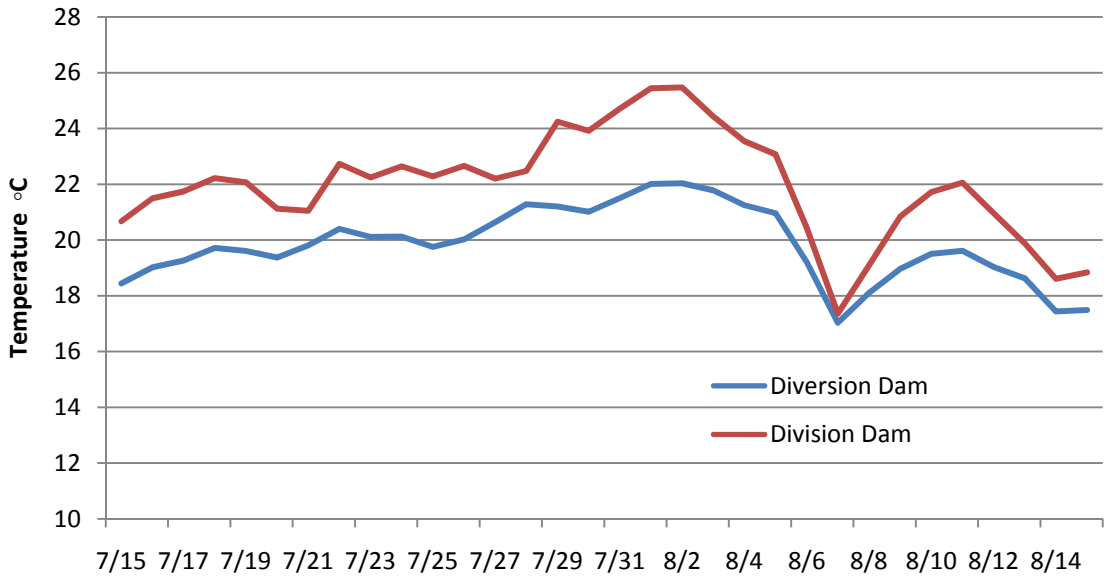

Figure 4. Average daily water temperature in 2009 at the Division Dam and the Diversion Dam in Mill Creek, near Walla Walla, Washington.

The total number of salmonids observed while snorkeling during June, July and August 2009, was 106, 144 and 101 respectively (Table 5). The pools snorkeled (20) in each month represented 26% of the pools available (76) within the study area. Expanding the monthly counts according to this figure yielded total abundance estimates during June, July and August of 410, 538, and 407 salmonids, respectively (Table 5). Within the upper section, estimated abundance was 173, 288, and 342 during June, July, and August (Table 5). Within the lower section, estimated abundance was 236, 252, and 66 during June, July, and August (Table 5). As previously discussed, higher streamflow likely reduced the detection probability during June, thus there may have been considerably more salmonids than was estimated during June. The decrease in the estimated number of salmonids from July (538) to August (407) was primarily due to the lower estimated abundance in the lower section during August. The mean abundance in the lower section was significantly lower in August compared to July (t-test, $P = 0.041$), while the upper section showed a slight increase between July and August. The decrease in total abundance between July and August may have been due to mortality associated with the near

lethal water temperatures prior to the August survey, continued exposure to predation and angling, and/or emigration.

Table 5. Monthly number of salmonids observed, estimates of abundance by section, and estimates of total abundance between the Division Dam and the Diversion Dam in Mill Creek, WA. The 95% confidence limits are given in parentheses.

Month	Observed	Lower	Upper	Total
June	106	236 (144, 317)	173 (104, 249)	410 (297, 520)
July	144	252 (119, 385)	288 (200, 386)	538 (374, 706)
August	101	66 (24, 107)	342 (165, 557)	407 (227, 626)

References

Schneider, James C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.