APPENDIX A

Abundance and Total Numbers of Chinook Salmon and Trout in the Chiwawa River Basin, Washington, 2006.

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TO: HCP Hatchery Committee

FROM: Tracy Hillman

Subject: *DRAFT* Abundance and Total Numbers of Chinook Salmon and Trout in the Chiwawa River Basin, Washington, 2006

The Chelan County Public Utility District (PUD) hatchery program is operated through a habitat conservation program (HCP) that was incorporated into the PUD's license in 2004. The HCP directed the signatories to develop a monitoring and evaluation plan within one year of the effective date. This study will help the HCP Hatchery Committee determine if it is meeting Objective 7 in the monitoring and evaluation plan (Murdoch and Peven 2005).

Objective 7: *Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of juveniles per redd) of supplemented streams when compared to non-supplemented streams.*

We estimated densities and total numbers of age-0 spring Chinook salmon *Oncorhynchus tshawytscha,* trout *Oncorhynchus* sp., and char *Salvelinus* sp. in the Chiwawa River basin, Washington, in August 2006. This was the 14th year of an ongoing study to assess the freshwater productivity (juveniles/redd) of Chinook salmon in the Chiwawa Basin. We used landscape classification to stratify streams in the basin that supported juvenile Chinook salmon (Hillman and Miller 2004). Classification "explained" most of the variability in fish numbers caused by geology, land type, valley bottom type, stream state condition, and habitat type. We identified ten reaches on the lower 31 miles (50 km) of the Chiwawa River and one reach in each of Phelps, Rock, Chikamin, Big Meadow, Alder, Brush, Y, and Peven[1] creeks (Figure 1). Each reach consisted of several combinations of state-type and habitat-type strata. We used classification to find reference areas for reaches in the Chiwawa River. We matched Reach 3 and Reach 8 of the Chiwawa River with a moderately-confined section of Nason Creek (RM 0.62-1.70) and an unconfined area of the Little Wenatchee River (RM 4.39-8.55), respectively (Hillman and Miller 2004). Following methods described in Hillman and Miller (2004), we used

[1]Unnamed tributary that drains the eastside of Chiwawa Ridge. Its confluence with the Chiwawa River is about 1 mile (1.6 km) downstream from the mouth of Phelps Creek.

underwater observations to estimate numbers of fish in 196 randomly selected sites.

During sampling in August 2006, discharge in the Chiwawa River averaged 177 cubic feet per second (cfs) and ranged from 120 to 271 cfs (Figure 2). Stream temperatures for the study period ranged from 9.0 to 16.0^{o}C. Fish species observed in the Chiwawa Basin and reference areas during the 1992-2006 survey period[2] included: spring Chinook salmon, coho salmon *O. kisutch*, sockeye salmon *O. nerka* (in the Little Wenatchee River reference area), steelhead/rainbow trout *O. mykiss* (hatchery rainbow were present only in 1992 and 1993), cutthroat trout *O. clarki lewisi*, bull trout *S. confluentus*, brook trout *S. fontinalis*, mountain whitefish *Prosopium williamsoni*, dace *Rhinichthys* sp., suckers *Catostomus* sp., and sculpin *Cottus* sp. The age-0 spring Chinook that we observed in the Chiwawa Basin during the 2006 survey were produced from 362 redds counted in the fall of 2005 (Mosey and Schoolcraft 2006). Assuming a mean fecundity of 4,231 eggs per female Chinook (from females collected for broodstock), and that no female produced more than one redd, we estimated that the Chiwawa River basin was seeded with 1,531,622 eggs in 2005.

The amount of different types of habitat within the Chiwawa Basin varied annually. In 2006, riffles made up the largest fraction of habitat types in reaches of the Chiwawa Basin (47% of the total stream surface area) (Table 1). Pools (16%), glides (8%), and multiple channels (29%) constituted the remaining 53% of the stream surface area. We consistently found woody debris associated with multiple-channel habitat.

Chinook Salmon Abundance

Chinook salmon were the most abundant salmonid in the Chiwawa Basin. We estimated, based on surface area, that age-0 Chinook salmon numbered 79,902 (±17.9% of the estimated total) in the Chiwawa River Basin in August 2006 (Table 2). Extrapolating based on volume of habitat types, we estimated 77,229 (±17.6%) age-0 Chinook in the Chiwawa Basin. About 8% of the juvenile Chinook were in tributaries to the Chiwawa River. During the 1992-2006 survey period, numbers of age-0 Chinook ranged from 5,815 to 134,872 in the Chiwawa Basin (Figure 3). Most of the difference in juvenile numbers among years resulted from different seeding levels (Figure 4). Numbers of Chinook redds in the Chiwawa Basin during 1992-2006 ranged from 13 to 1,046, resulting in seeding levels of 59,800 to 4,958,800 eggs (Appendix A).

As in most years, age-0 Chinook in 2006 were distributed contagiously among reaches in the Chiwawa River (Table 2, Appendix B). Densities of age-0 Chinook were highest in the upper reaches (Reaches 7-10; Table 2); although we found the highest density in Brush Creek (24,494 fish/ha). Age-0 Chinook were most abundant in multiple channels and least abundant in glides. We found the majority of the Chinook associated with woody debris in multiple channels. These sites (multiple channels) made up 29% of the total area of the Chiwawa Basin, but they provided habitat for 54% of all the age-0 Chinook in the basin in 2006 (Appendix C). In contrast, riffles made up 47% of the total area, but provided habitat for only 12% of all age-0 Chinook in the Chiwawa Basin. Pools made up 16% of the total area and provided habitat for 31% of all age-0 Chinook in the basin. Virtually no Chinook used glides that lacked woody debris.

[2] The study period 1992-2006 includes only 14 years of sampling because there was no sampling in 2000.

We assumed that the Chiwawa River was seeded with 1,531,622 Chinook eggs (362 redds times 4,231 eggs/female) in fall, 2005, and that at least 79,902 of those survived to August 2006. Thus, we estimated a mean egg-to-parr survival of at least 5.2% (95% confidence bound 4.3-6.2%). During 1992-2006, egg-to-parr survival averaged 6.4% (range 2.7-22.1%) in the Chiwawa Basin (Appendix A). This survival rate comports with those from other streams. For example, Mullan et al. (1992) estimated an egg-to-parr survival rate of 9.8% for spring Chinook salmon in Icicle Creek, a tributary of the Wenatchee River. Using a Beverton and Holt model, Hubble (1993) estimated that egg-to-parr survival of Chinook in the Chewack River, a tributary to the Methow River, ranged between 13% and 32%, depending on percent seeding level in the basin. Kiefer and Forster (1991) estimated a mean egg-to-parr survival rate of 5.5% (range 5.1-6.7%) for naturally-spawning spring Chinook salmon in the entire upper Salmon River. They also noted that egg-to-parr survival of natural spawners and adult outplants in the headwater streams of the upper Salmon River averaged 24.4% (range 16.1-32.0%). Petrosky (1990) reported an egg-to-parr survival range of 1.2-29.0% for Chinook in the upper Salmon River, Idaho. Konopacky et al. (1986) estimated egg-to-parr survival of Chinook in Bear Valley Creek, Idaho, as 8.1-9.4%. Work by Richards and Cernera (1987) in Bear Valley Creek indicated an egg-to-parr survival of 2.1%.

Mean densities of age-0 Chinook salmon in two reaches of the Chiwawa River were less than those in corresponding reference areas (Figure 5). Within both the Chiwawa River and its reference areas, pools and multiple channels consistently had the highest densities of age-0 Chinook.

We estimated a total of 388 (±29.9% of the estimated total) age-1+ Chinook salmon in the Chiwawa Basin in August 2006 (Table 3). In August 1992-2006, numbers of age-1+ Chinook ranged from 5 to 563 in the Chiwawa River basin (Figure 3). These fish most often occurred downstream from Reach 10 (Appendix B). We found relatively few age-1+ Chinook in tributaries. Age-1+ Chinook were most abundant in multiple channels and pools.

Steelhead/Rainbow Abundance

Based on stream surface area, we estimated a total of 16,245 (±12.7% of the estimated total) age-0 steelhead/rainbow (<4 in) in reaches of the Chiwawa Basin in 2006 (Table 4). During the 1992-2006 survey period, numbers of age-0 steelhead/rainbow ranged from 1,410 to 45,727 in the Chiwawa River basin (Figure 6). In 1992-2006, numbers of age-0 steelhead/rainbow varied among reaches, but were typically highest in the lower reaches (Appendix B). In all years they most often used riffle and multiple channel habitats in the Chiwawa River, although we also found them associated with woody debris in pool and glide habitat. In tributaries they were generally most abundant in small pools. Those that we observed in riffles selected stations in quiet water behind small and large boulders or occupied stations in quiet water along the stream margin. In pool and multiple-channel habitats, we found age-0 steelhead/rainbow using the same kinds of habitat as age-0 Chinook salmon.

We estimated that 10,533 (±10.7% of the estimated total) age-1+ steelhead/rainbow (4-8 in) lived in reaches of the Chiwawa Basin in August 2006 (Table 5). During the survey period 1992-2006, numbers of age-1+ steelhead/rainbow ranged from 2,533 to 22,128 (Figure 6). In all years

we found these fish in nearly all reaches, but they were typically most numerous in Reaches 1 and 7 (Appendix B). We observed age-1+ steelhead/rainbow mostly in pool, riffle, and multiple-channel habitats. Those that we observed in pools were usually in deeper water than age-0 steelhead/rainbow and Chinook. Like age-0 steelhead/rainbow, age-1+ steelhead/rainbow selected stations in quiet water behind boulders in riffles, but we did not find the two age groups together. Age-1+ steelhead/rainbow appeared to use deeper and faster water than did age-0 steelhead/rainbow.

We estimated that steelhead/rainbow larger than 8 inches numbered 50 (±24.0% of the estimated total) in the Chiwawa River in August 2006 (Table 6). During the period 1992-2006, steelhead/rainbow numbers ranged from 8 to 1,869 (Appendix B). Steelhead/rainbow larger than 8 inches were most abundant in Reaches 1 and 7; however, in 1992 and 1993, they were most abundant near campgrounds in Reaches 8, 9, and 10 (Appendix B). We found very few in tributary survey reaches. Most of the steelhead/rainbow larger than 8 inches used deep pools (>5 feet), and occupied stations near the bottom at the upstream end of pools.

Bull Trout Abundance

We estimated based on surface area that at least 238 (±36.1% of the estimated total) juvenile (2-8 in) bull trout lived in reaches of the Chiwawa River Basin in 2006 (Table 7). We found most of these fish in the upper-most reaches and in tributaries of the Chiwawa River. During 1992-2006, numbers of juvenile bull trout ranged from 79 to 505 (Figure 7). These estimates and those for adult bull trout are incomplete, because we did not sample the entire range of bull trout in all tributaries. Also, we did not extend our survey into the headwaters of the Chiwawa River, because there were no juvenile Chinook there. Areas beyond the distribution of juvenile Chinook salmon are known to support bull trout and cutthroat trout (USFS 1993). In addition, our estimates of bull trout abundance were based on daytime snorkel surveys, which may underestimate the actual abundance of bull trout. Several studies (e.g., Goetz 1994; Thurow and Schill 1996; Hillman and Chapman 1996; Bonar et al. 1997) have found bull trout population estimates based on nighttime snorkeling to be in some cases more accurate than daytime snorkeling, especially for juvenile bull trout. Our estimates of adult bull trout numbers may be more accurate than those for juveniles.

In all years we found most juvenile bull trout in the upstream reaches of the Chiwawa River. Of the reaches we surveyed, they were most numerous in Reaches 7-10 on the Chiwawa River (Appendix B). We found the majority of these fish in multiple channels, pools, and riffles, and few in glides. They consistently occupied stations close to the stream bottom over rubble and small boulder substrate or near woody debris. This is similar to the observation of Pratt (1984) in the upper Flathead River Basin in Montana. She found that juvenile bull trout lay close to instream cover and that they tended to conceal themselves. As a result, she found it difficult to accurately estimate their numbers. Although this implies that we underestimated numbers of juvenile bull trout in the Chiwawa River, the relative distribution of juvenile bull trout is valid if we assume that we saw the same fraction of juveniles in all reaches.

We estimated a total of 686 (±18.2% of the estimated total) adult (>8 in) bull trout in reaches of the Chiwawa Basin in 2006 (Table 8). In previous years, numbers ranged from 76 to 900 (Figure

7). As with juvenile bull trout, we found most of the adult bull trout upstream from Reach 6 (Appendix B). We found relatively few adult bull trout in tributaries of the Chiwawa River. Adult bull trout primarily used pools and multiple channel habitat, although most of the smaller adults (<10 in) used riffles. In all years we found few adult bull trout near campgrounds. There also appeared to be an inverse relationship between numbers of adult bull trout and numbers of age-0 Chinook salmon in pools in Reaches 7-10. That is, where we found large bull trout we generally observed few juvenile Chinook salmon.

Abundance of Other Salmonids

In 2006 we counted 160 brook trout, an exotic species closely related to the bull trout, in the Chiwawa River, Chikamin Creek, Big Meadow Creek, Minnow Creek, and in the Little Wenatchee River. Brook trout occurred throughout most of the Chiwawa River. In both the Chiwawa and Little Wenatchee rivers, brook trout usually used multiple channels. Few appeared to be bull trout/brook trout hybrids. In Chikamin, Minnow, and Big Meadow creeks, brook trout were most abundant in pools. Brook trout ranged from 2-8 inches.

We counted a total of 69 westslope cutthroat trout in the Chiwawa River, Phelps Creek, and the Little Wenatchee River. These fish most often occurred in pools and multiple channel habitats. They ranged in size from 2-12 inches. We found no juvenile coho salmon in the Chiwawa River, but did see them in Nason Creek.

We observed both juvenile and adult mountain whitefish in the Chiwawa River, Nason Creek, and the Little Wenatchee River. In sum, we counted 3,895 adult and 1,985 juvenile whitefish in these streams. We found few whitefish in tributaries to the Chiwawa River.

Conclusion

This was the 14th year of a study to monitor trends in juvenile spring Chinook production in the Chiwawa River Basin. As shown in Figure 3, numbers of juvenile Chinook salmon in the Chiwawa Basin have fluctuated widely over the 14-year period. Numbers of juveniles in 2001 and 2002 were some of the highest recorded, while numbers in the mid-1990s were some of the lowest. Interestingly, the highest spawning escapements (highest redd numbers) resulted in the lowest egg-parr survival rates (Appendix A). Indeed, there is a significant negative relationship between parr per redd and numbers of redds in the Chiwawa Basin (Appendix D1), suggesting a density-dependent relationship between seeding levels and juvenile production. Although data at high seeding levels are lacking, the relationship appears to limit the production of juvenile Chinook salmon to less than about 170,000 parr in the basin (upper 95% CI in Appendix D2). This is an important observation because Objectives 1, 3, 4, and 7 and their associated hypotheses in the monitoring and evaluation plan (Murdoch and Peven 2005) are only valid when the supplemented population is below its carrying capacity.

The presence of density-dependence in the early life stages of spring Chinook is not surprising. Rarely does density dependence appear in numbers of adult spring Chinook or on their spawning grounds. The Chiwawa Basin has plenty of spawning habitat, as indicated by the large numbers of spawners and redds widely distributed throughout the basin during 2001 and 2002. However, those large spawning escapements did not translate into large numbers of juveniles or smolts.

Thus, density-dependent regulation occurs sometime during the early life stages of the fish. Our observations indicate that it is unlikely that physical habitat (space) currently limits parr production in the basin. Low nutrient levels and its effects on food (macroinvertebrates) production may be the primary limiting factor in the basin. If spawning escapements remain relatively high, marine-derived nutrients should increase in the basin, resulting in more food for juvenile Chinook salmon.

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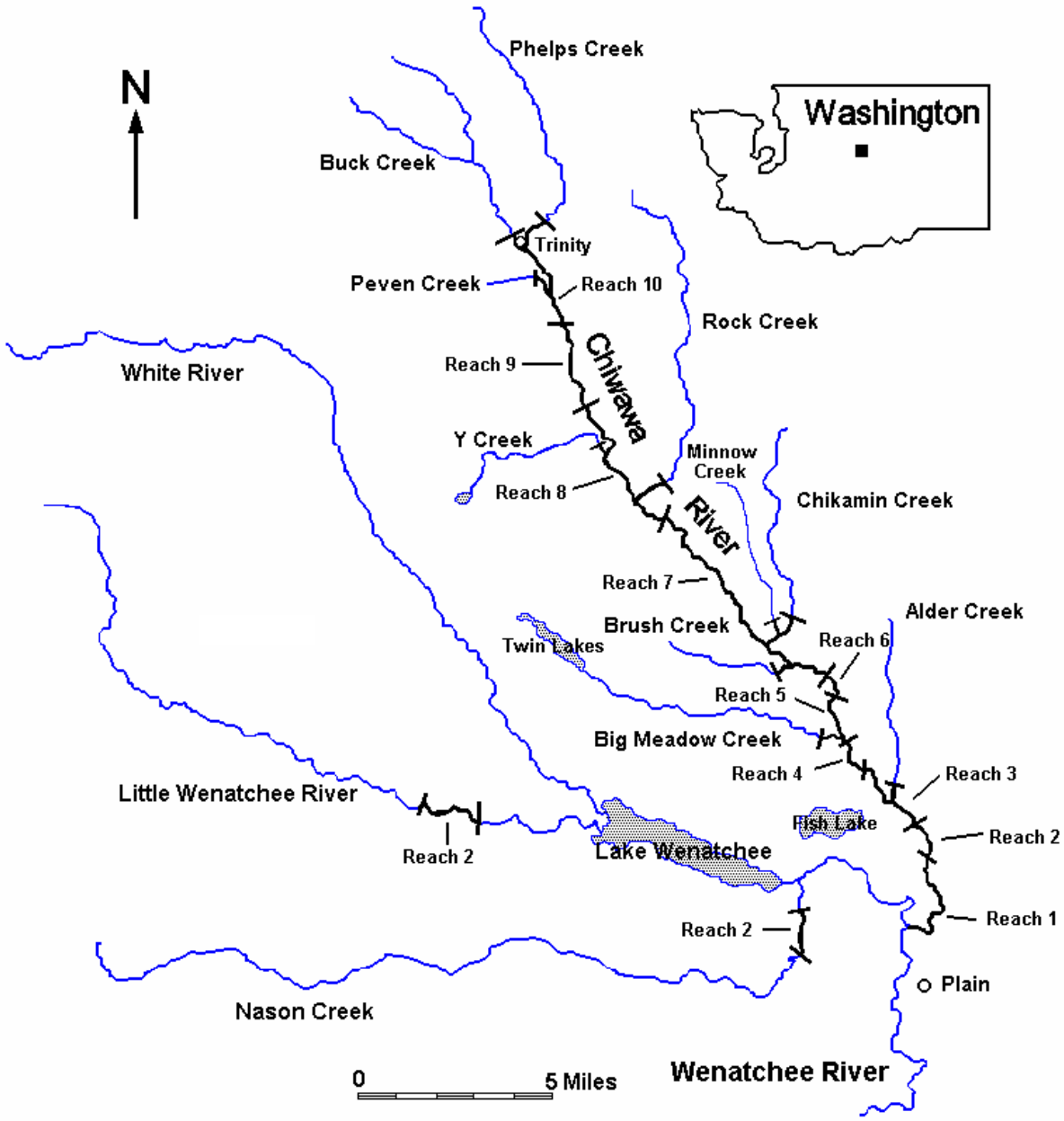


Figure 1. Location of study reaches on the Chiwawa River, and Chikamin, Rock, Big Meadow, Peven, Alder, Brush and Phelps creeks, Chelan County, Washington. Reach 2 on Nason Creek and Reach 2 on the Little Wenatchee River were matched with Reaches 3 and 8 on the Chiwawa River, respectively.

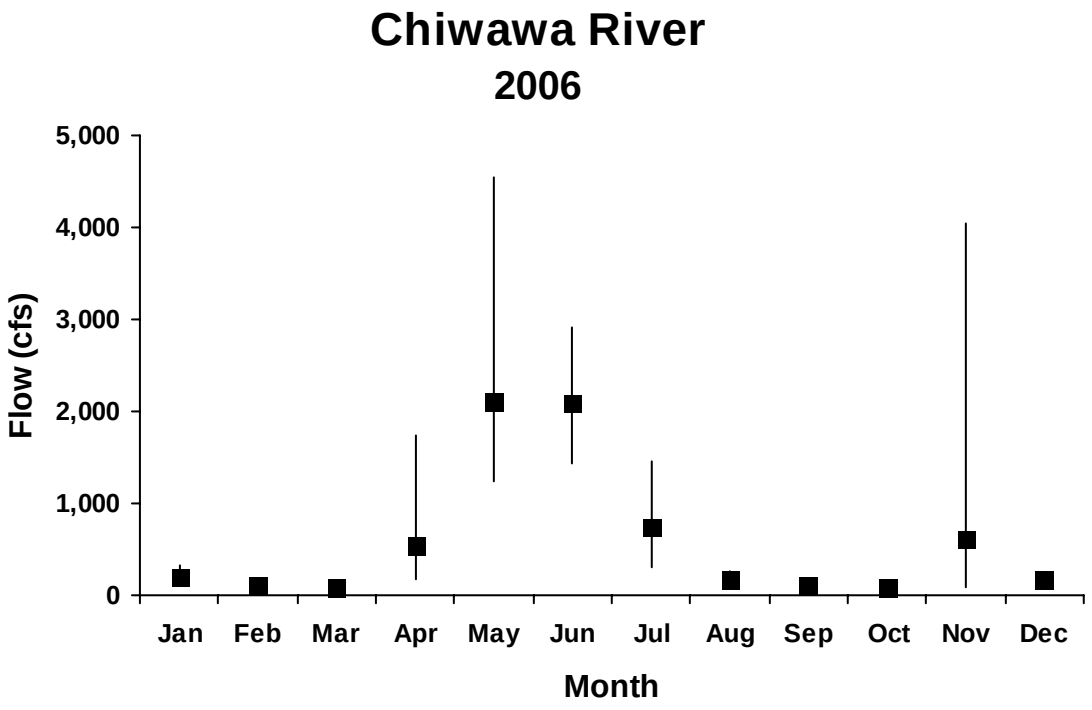


Figure 2. Mean, minimum, and maximum monthly flows in the Chiwawa River for 2006.

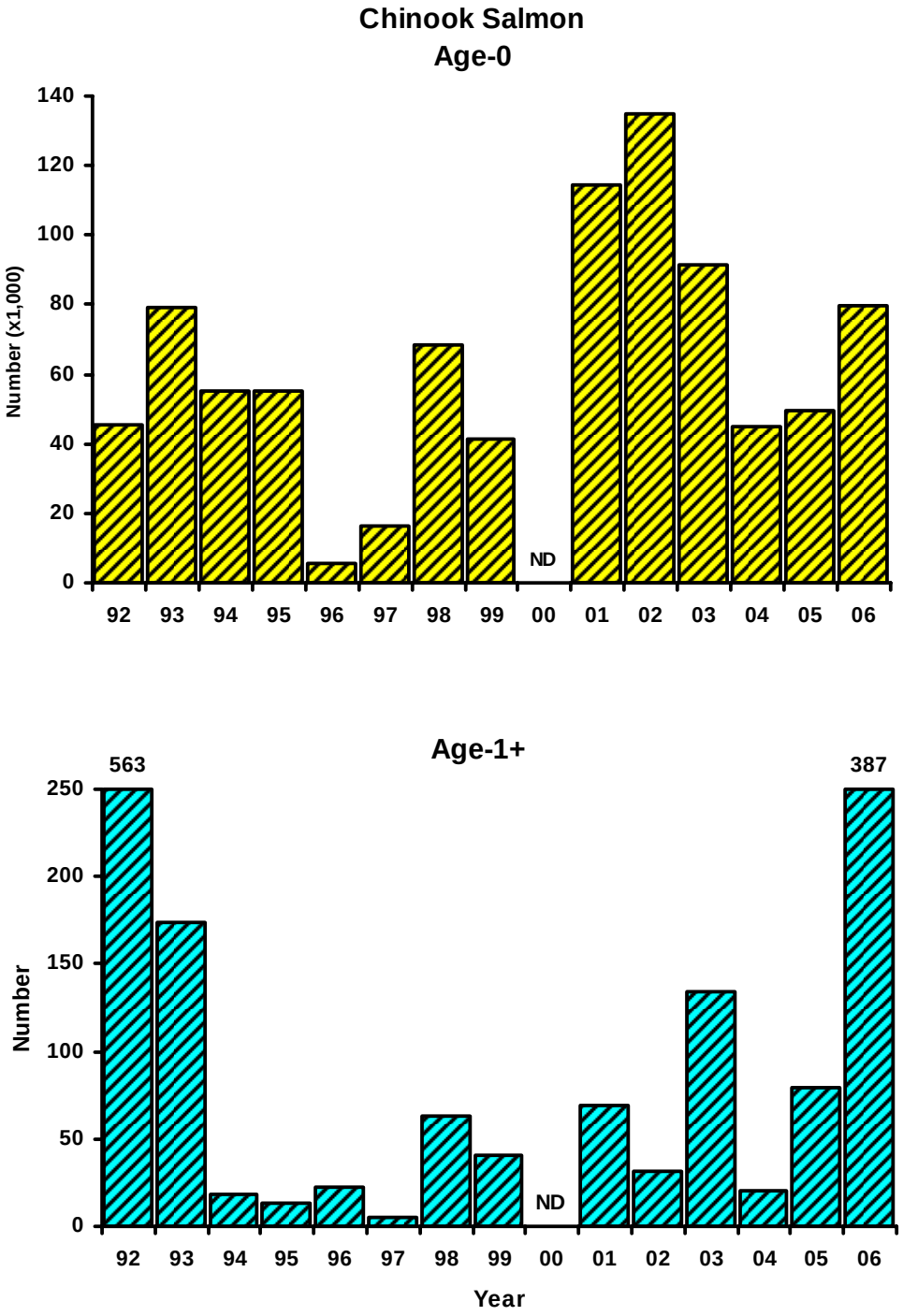


Figure 3. Numbers of age-0 and age-1+ Chinook salmon within the Chiwawa River Basin in August 1992-2006; ND = no data.

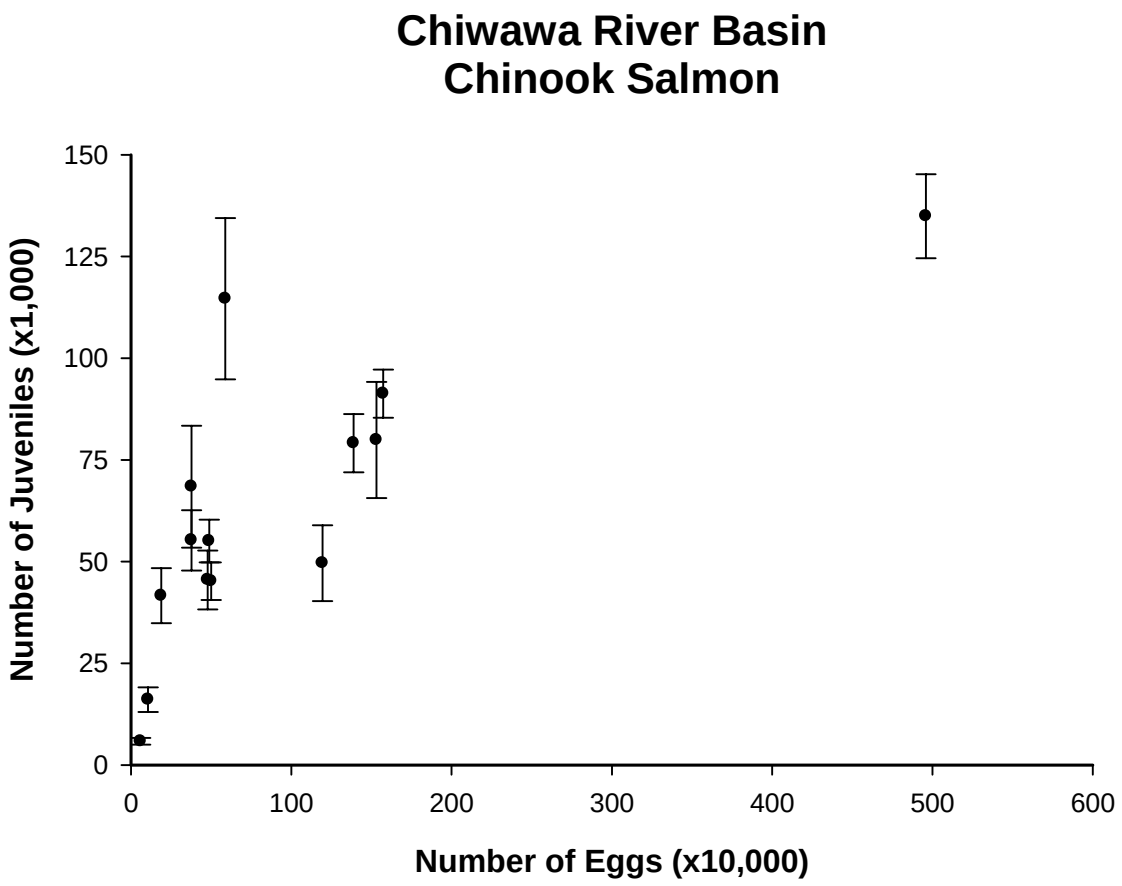


Figure 4. Relationship between total numbers of age-0 Chinook salmon (based on fish/ha) and numbers of eggs in the Chiwawa River Basin. Vertical bars indicate 95% confidence bounds.

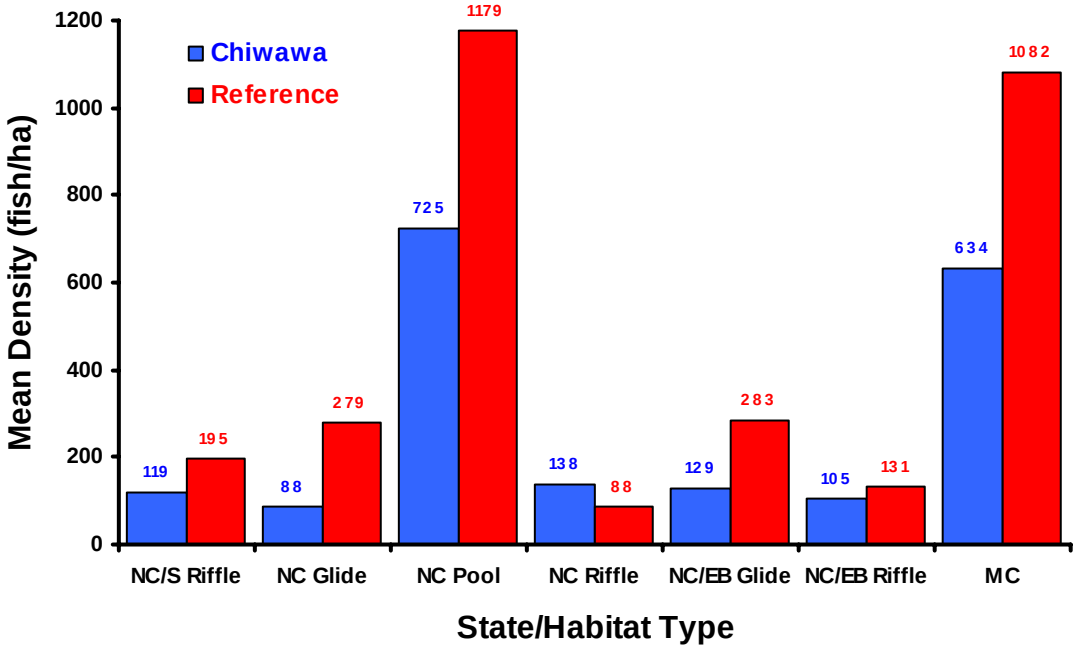


Figure 5. Comparison of the thirteen-year means of age-0 Chinook salmon densities within state/habitat types in reaches 3 and 8 of the Chiwawa River and their matched reference areas on Nason Creek and the Little Wenatchee River.

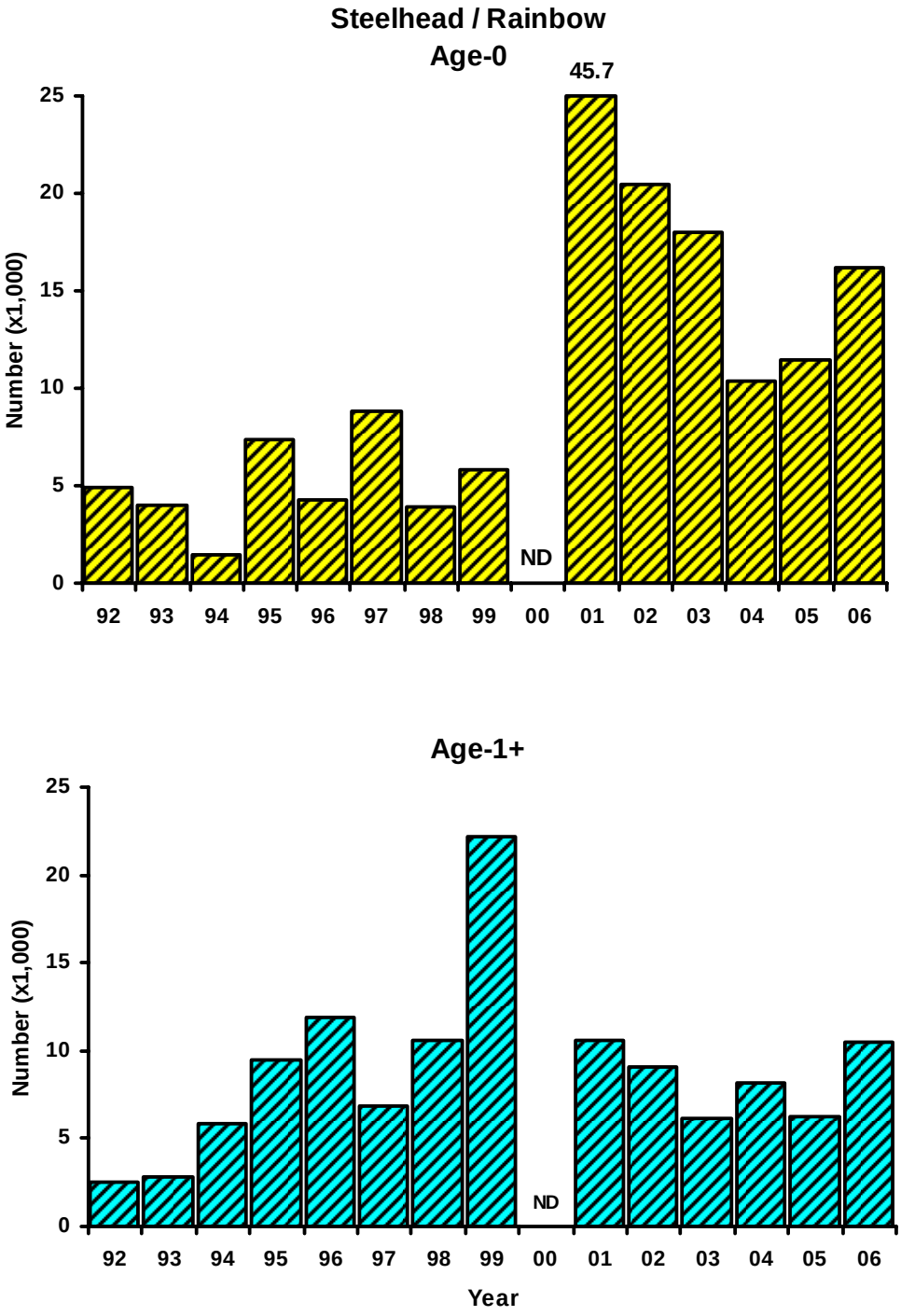


Figure 6. Numbers of age-0 (<4 in) and age-1+ (4-8 in) steelhead/rainbow within the Chiwawa River Basin in August 1992-2006; ND = no data.

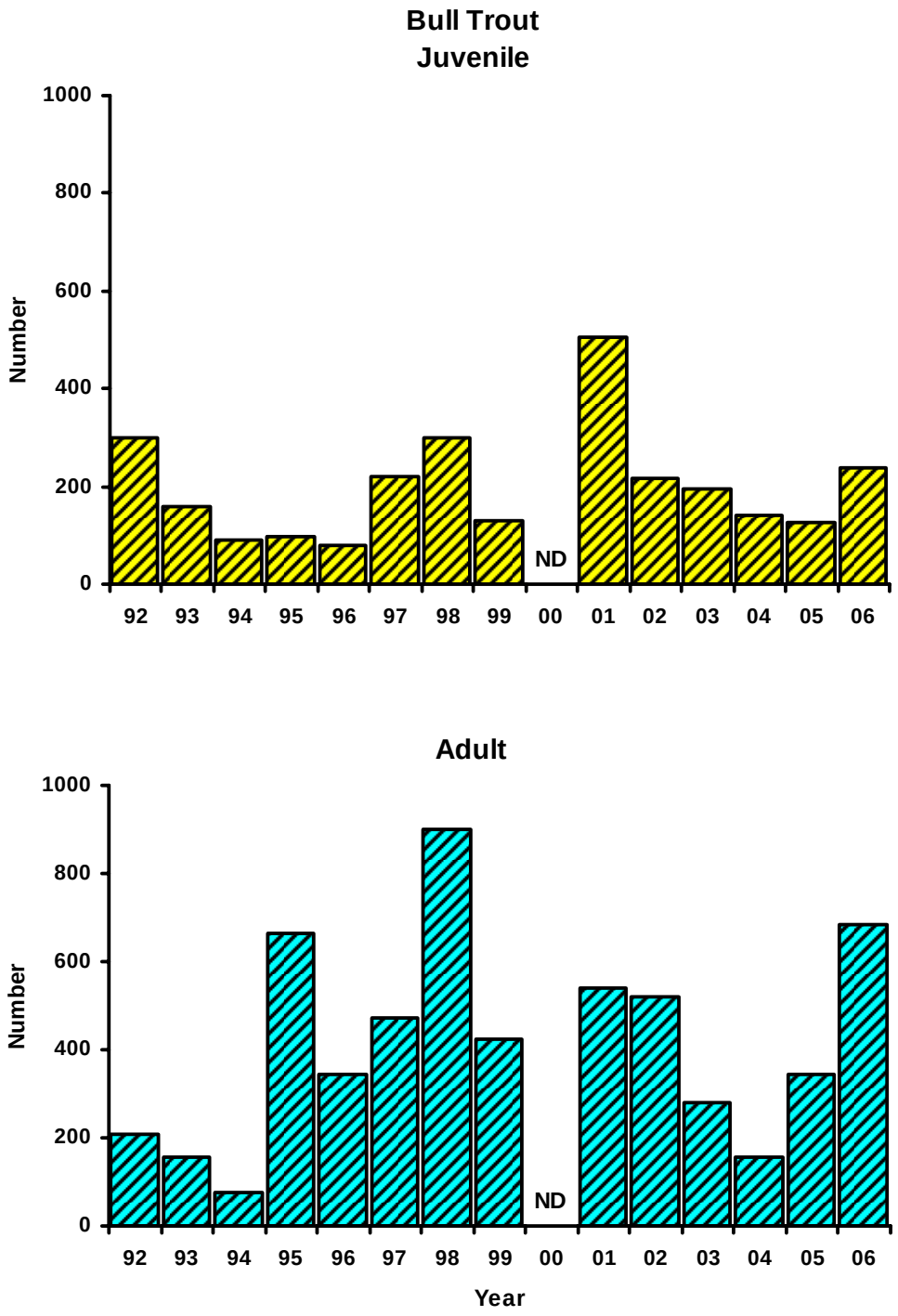


Figure 7. Numbers of juvenile (2-8 inches) and adult (>8 inches) bull trout within the Chiwawa River Basin in August 1992-2006; ND = no data.

Table 1. Description, location (river mile), and area (hectares) of land-class strata (reaches) used by age-0 Chinook salmon in the Chiwawa River basin, 2006. Reaches were classified according to geologic district, landtype association, valley-bottom type, stream state-type, and habitat type within the Cascade Ecoregion; MCV=moderately confined valley, CC=confined canyon, UCV=unconfined valley, G=glide, P= pool, R=riffle, and MC=multiple channel. See Hillman and Miller (2004) for definitions of stream state codes.

Reach	RM	Gradient	Geologic District	Landtype Association	Valley Bottom Type	Stream State Type	Habitat Type	Area (ha) Total	Area (ha) Sampled
				Chiwawa River					
1	0.00-3.77	0.007	Glacial Drift over	Glacial	MCV	NC/EB	G	1.15	1.15
			Chumstick Formation	Valley	Alluvial	NC/EB	P	1.35	0.88
						NC/EB	R	14.24	1.52
2	3.77-5.51	0.010	Glacial Drift over	Glacial	CC	NC/EB	P	0.53	0.27
			Chumstick Formation	Canyon	Fluvial	NC/EB	R	7.28	1.25
3	5.51-7.88	0.009	Glacial Drift over	Glacial	MCV	NC/S	R	2.57	0.79
			Chumstick Formation	Valley	Alluvial	NC/EB	G	0.30	0.30
						NC/EB	R	6.66	0.86
						MC	M	0.49	0.26
4	7.88-8.90	0.007	Glacial Drift over	Glacial	CC	NC/EB	P	0.77	0.43
			Chumstick Formation	Canyon	Fluvial	NC/EB	R	2.87	0.51
						MC	MC	0.42	0.42
5	8.90-10.83	0.011	Glacial Drift over	Glacial	MCV	NC/EB	P	0.17	0.17
			Chumstick Formation	Valley	Alluvial	NC/EB	R	7.38	0.77
6	10.83-11.80	0.008	Glacial Drift over	Glacial	CC	NC/EB	G	0.18	0.18
			Chumstick Formation	Canyon	Fluvial	NC/EB	P	0.15	0.15
						NC/EB	R	4.34	1.28
						MC	MC	0.57	0.57
7	11.80-20.03	0.001	Glacial Drift over	Glacial	UCV	NC	G	2.38	0.53
			Chumstick Formation	Valley	Alluvial	NC	P	4.42	1.41
						NC	R	1.48	1.00
						NC/S	P	0.73	0.39
						NC/S	R	1.34	0.45
						NC/EB	G	3.46	1.35
						NC/EB	P	6.17	1.75
						NC/EB	R	2.87	0.51
						MC	MC	4.68	2.32
8	20.03-25.42	0.003	Glacial Drift over	Glacial	UCV	NC	G	0.76	0.38
			Swakane Gneiss	Valley	Alluvial	NC	P	1.96	0.57
						NC	R	4.09	0.76
						NC/EB	G	0.79	0.48
						NC/EB	P	2.64	0.48
						NC/EB	R	1.43	0.52
						EB	P	0.29	0.29
						EB	R	0.17	0.17
						MC	MC	23.35	17.34
9	25.42-28.81	0.007	Glacial Drift over	Glacial	MCV	NC	G	0.79	0.79
			Swakane Gneiss	Valley	Alluvial	NC	P	0.66	0.43
						NC	R	2.02	0.50
						MC	MC	4.92	0.66
10	28.81-31.11	0.011	Pre-upper	Glacial	MCV	NC	P	0.33	0.22
			Jurassic Gneiss	Valley	Alluvial	NC	R	2.86	0.41
						MC	MC	5.04	3.08

Table 1. Concluded.

Reach	RM	Gradient	Geologic District	Landtype Association	Valley Bottom Type	Stream State Type	Habitat Type	Area (ha) Total	Area (ha) Sampled
				Phelps Creek					
1	0.00-0.35	0.043	Pre-upper	Glacial	MCV	NC	P	0.01	0.01
			Jurassic Gneiss	Valley	Alluvial	NC	R	0.18	0.18
						NC	MC	0.16	0.16
				Chikamin Creek[1]					
1	0.00-0.94	0.013	Glacial Drift	Glacial	UCV	NC	G	0.10	0.02
			over	Valley	Alluvial	NC	P	0.31	0.10
			Chumstick Formation			NC	R	0.39	0.09
						MC	MC	0.20	0.19
				Rock Creek					
1	0.00-0.73	0.020	Glacial Drift over	Glacial	UCV	NC	G	0.00	0.00
			Swakane Gneiss	Valley	Alluvial	NC	P	0.20	0.05
						NC	R	0.49	0.16
						MC	MC	0.20	0.12
				Peven Creek					
1	0.00-0.05		Pre-upper	Glacial	MCV	NC	P	0.04	0.04
			Jurassic Gneiss	Valley	Alluvial	NC	R	0.03	0.03
				Big Meadow Creek					
1	0.00-0.35	0.025	Glacial Drift over	Glacial	MCV	NC	G	0.05	0.02
			Chumstick Formation	Valley	Alluvial	NC	P	0.35	0.22
						NC	R	0.18	0.06
						MC	MC	0.16	0.02
				Alder Creek					
1	0.00-0.01		Glacial Drift over	Glacial	MCV	NC	P	0.01	0.01
			Chumstick Formation	Valley	Alluvial	NC	R	0.01	0.01
				Brush Creek					
1	0.00-0.01		Glacial Drift over	Glacial	UCV	NC	P	0.00	0.00
			Chumstick Formation	Valley	Alluvial	NC	R	0.00	0.00
				Y Creek					
1	0.00-0.05		Glacial Drift over	Glacial	UCV	NC	P	0.00	0.00
			Swakane Gneiss	Valley	Alluvial	NC	R	0.00	0.00

[1] Includes the lower 0.2 miles of Minnow Creek.

Table 2. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and percent error of the estimated total number of age-0 Chinook salmon in reaches in the Chiwawa River Basin, Washington, August 2006.

	Mean density		Surface area (ha)			Volume (m^3)		
Reach	**fish/ha**	**fish/m^3**	**Total No.**	**95% C.B.**	**± % error**	**Total No.**	**95% C.B.**	**± % error**
			CHIWAWA RIVER					
1	234.1	0.066	3918	±484	12.4	3851	±472	12.3
2	267.7	0.073	2091	±854	40.8	1945	±863	44.4
3	168.3	0.047	1685	±133	7.9	1842	±141	7.7
4	519.8	0.102	2117	±887	41.9	2084	±817	39.2
5	129.7	0.028	979	±56	5.7	824	±65	7.9
6	310.7	0.089	1627	±86	5.3	1270	±87	6.9
7	876.1	0.133	24117	±4914	20.4	24128	±7935	32.9
8	486.3	0.083	17253	±13139	76.2	15702	±10797	68.8
9	1430.2	0.342	11988	±1740	14.5	11949	±1005	8.4
10	935.3	0.258	7703	±1170	15.2	7494	±317	4.2
			PHELPS CREEK					
1	326.9	0.118	113	±0	0.0	113	±0	0.0
			CHIKAMIN CREEK[1]					
1	2520.8	1.182	2500	±819	32.8	2192	±843	38.5
			ROCK CREEK					
1	1900.0	0.887	1681	±406	24.2	1928	±509	26.4
			PEVEN CREEK					
1	770.2	0.235	51	±0	0.0	51	±0	0.0
			BIG MEADOW CREEK					
1	2585.1	0.879	1890	±538	28.5	1667	±1059	0.0
			ALDER CREEK					
1	6502.2	6.255	62	±0	0.0	62	±0	0.0
			BRUSH CREEK					
1	24493.7	31.345	127	±0	0.0	127	±0	0.0
			Y CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
GRAND TOTAL	**596.0**	**0.123**	**79,902**	**±14,285**	**17.9**	**77,229**	**±13,580**	**17.6**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 3. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and percent error of the estimated total number of age-1+ Chinook salmon in reaches in the Chiwawa River Basin, Washington, August 2006.

	Mean density		Surface area (ha)			Volume (m^3)		
Reach	**fish/ha**	**fish/m^3**	**Total No.**	**95% C.B.**	**± % error**	**Total No.**	**95% C.B.**	**± % error**
			CHIWAWA RIVER					
1	1.8	0.001	30	±7	23.3	30	±7	23.3
2	1.8	0.001	14	±18	128.6	12	±18	150.0
3	0.0	0.000	0	±0	0.0	0	±0	0.0
4	11.5	0.002	47	±9	19.1	46	±7	15.2
5	0.0	0.000	0	±0	0.0	0	±0	0.0
6	0.0	0.000	0	±0	0.0	0	±0	0.0
7	0.0	0.000	0	±0	0.0	0	±0	0.0
8	2.1	0.000	75	±70	93.3	65	±72	110.8
9	12.7	0.003	106	±68	64.2	106	±55	51.9
10	8.9	0.002	73	±19	26.0	69	±10	14.5
			PHELPS CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			CHIKAMIN CREEK[1]					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			ROCK CREEK					
1	48.1	0.023	43	±57	132.6	50	±56	112.0
			PEVEN CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BIG MEADOW CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			ALDER CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BRUSH CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			Y CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
GRAND TOTAL	**2.9**	**0.001**	**388**	**±116**	**29.9**	**378**	**±109**	**28.9**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 4. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and percent error of the estimated total number of age-0 (<4 in) steelhead/rainbow in reaches in the Chiwawa River Basin, Washington, August 2006.

	Mean density		Surface area (ha)			Volume (m^3)		
Reach	**fish/ha**	**fish/m^3**	**Total No.**	**95% C.B.**	**± % error**	**Total No.**	**95% C.B.**	**± % error**
			CHIWAWA RIVER					
1	162.3	0.046	2717	±270	9.9	2676	±315	11.8
2	188.1	0.052	1469	±111	7.6	1398	±119	8.5
3	220.6	0.064	2209	±105	4.8	2493	±88	3.5
4	228.2	0.045	929	±166	17.9	922	±276	29.9
5	64.0	0.013	483	±53	10.9	393	±40	10.2
6	102.0	0.026	534	±19	3.6	374	±31	8.3
7	84.6	0.012	2328	±1514	65.0	2186	±1611	73.7
8	0.0	0.000	0	±0	0.0	0	±0	0.0
9	0.0	0.000	0	±0	0.0	0	±0	0.0
10	0.0	0.000	0	±0	0.0	0	±0	0.0
			PHELPS CREEK					
1	61.3	0.022	21	±0	0.0	21	±0	0.0
			CHIKAMIN CREEK[1]					
1	856.1	0.436	858	±226	26.3	809	±265	32.8
			ROCK CREEK					
1	986.0	0.450	872	±263	30.2	978	±265	27.1
			PEVEN CREEK					
1	513.5	0.157	34	±0	0.0	34	±0	0.0
			BIG MEADOW CREEK					
1	4988.6	1.790	3647	±1302	35.7	3393	±1876	55.3
			ALDER CREEK					
1	7684.5	7.393	73	±0	0.0	73	±0	0.0
			BRUSH CREEK					
1	13607.6	17.414	71	±0	0.0	71	±0	0.0
			Y CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
GRAND TOTAL	**121.2**	**0.025**	**16,245**	**±2,058**	**12.7**	**15,821**	**±2,541**	**16.1**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 5. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and percent error of the estimated total number of age-1+ (4-8 in) steelhead/rainbow in reaches in the Chiwawa River Basin, Washington, August 2006.

	Mean density		Surface area (ha)			Volume (m^3)		
Reach	**fish/ha**	**fish/m^3**	**Total No.**	**95% C.B.**	**± % error**	**Total No.**	**95% C.B.**	**± % error**
			CHIWAWA RIVER					
1	121.2	0.034	2029	±366	18.0	1996	±388	19.4
2	162.3	0.045	1267	±145	11.4	1199	±116	9.7
3	102.5	0.031	1026	±46	4.5	1226	±47	3.8
4	320.9	0.063	1307	±300	22.9	1293	±359	27.8
5	92.3	0.019	696	±38	5.5	571	±36	6.3
6	78.4	0.019	410	±40	9.8	274	±48	17.5
7	29.2	0.004	803	±333	41.5	745	±346	46.4
8	0.0	0.000	0	±0	0.0	0	±0	0.0
9	0.0	0.000	0	±0	0.0	0	±0	0.0
10	0.0	0.000	0	±0	0.0	0	±0	0.0
			PHELPS CREEK					
1	218.0	0.079	76	±0	0.0	76	±0	0.0
			CHIKAMIN CREEK[1]					
1	754.6	0.361	748	±414	55.3	670	±503	75.1
			ROCK CREEK					
1	1340.5	0.612	1186	±375	31.6	1329	±373	28.1
			PEVEN CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BIG MEADOW CREEK					
1	1347.8	0.471	985	±779	79.1	893	±993	111.2
			ALDER CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BRUSH CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			Y CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
GRAND TOTAL	**78.6**	**0.016**	**10,533**	**±1,131**	**10.7**	**10,272**	**±1,340**	**13.0**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 6. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and percent error of the estimated total number of steelhead/rainbow larger than 8 inches in reaches in the Chiwawa River Basin, Washington, August 2006.

	Mean density		Surface area (ha)			Volume (m^3)		
Reach	**fish/ha**	**fish/m^3**	**Total No.**	**95% C.B.**	**± % error**	**Total No.**	**95% C.B.**	**± % error**
			CHIWAWA RIVER					
1	1.7	0.001	28	±10	35.7	27	±10	37.0
2	0.8	0.000	6	±3	50.0	6	±3	50.0
3	0.0	0.000	0	±0	0.0	0	±0	0.0
4	0.7	0.000	3	±2	66.7	3	±2	66.7
5	0.4	0.000	3	±0	0.0	3	±0	0.0
6	0.2	0.000	1	±0	0.0	1	±0	0.0
7	0.2	0.000	5	±5	100.0	5	±4	80.0
8	0.0	0.000	0	±0	0.0	0	±0	0.0
9	0.0	0.000	0	±0	0.0	0	±0	0.0
10	0.0	0.000	0	±0	0.0	0	±0	0.0
			PHELPS CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			CHIKAMIN CREEK[1]					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			ROCK CREEK					
1	4.3	0.002	4	±5	125.0	4	±5	125.0
			PEVEN CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BIG MEADOW CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			ALDER CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BRUSH CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			Y CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
GRAND TOTAL	**0.4**	**0.000**	**50**	**±12**	**24.0**	**49**	**±12**	**24.5**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 7. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and percent error of the estimated total number of juvenile bull trout (2-8 in) in reaches in the Chiwawa River Basin, Washington, August 2006.

	Mean density		Surface area (ha)			Volume (m^3)		
Reach	**fish/ha**	**fish/m^3**	**Total No.**	**95% C.B.**	**± % error**	**Total No.**	**95% C.B.**	**± % error**
			CHIWAWA RIVER					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
2	0.0	0.000	0	±0	0.0	0	±0	0.0
3	0.0	0.000	0	±0	0.0	0	±0	0.0
4	0.0	0.000	0	±0	0.0	0	±0	0.0
5	0.0	0.000	0	±0	0.0	0	±0	0.0
6	0.0	0.000	0	±0	0.0	0	±0	0.0
7	0.1	0.000	4	±4	100.0	3	±5	166.7
8	0.0	0.000	0	±0	0.0	0	±0	0.0
9	0.9	0.000	8	±3	37.5	7	±4	57.1
10	5.3	0.002	44	±15	34.1	46	±20	43.5
			PHELPS CREEK					
1	77.9	0.028	27	±0	0.0	27	±0	0.0
			CHIKAMIN CREEK[1]					
1	13.1	0.007	13	±12	92.3	12	±13	108.3
			ROCK CREEK					
1	158.1	0.073	140	±83	59.3	159	±86	54.1
			PEVEN CREEK					
1	30.4	0.009	2	±0	0.0	2	±0	0.0
			BIG MEADOW CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			ALDER CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BRUSH CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			Y CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
GRAND TOTAL	**1.8**	**0.000**	**238**	**±86**	**36.1**	**256**	**±89**	**34.8**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 8. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and percent error of the estimated total number of adult bull trout (>8 in) in reaches in the Chiwawa River Basin, Washington, August 2006.

	Mean density		Surface area (ha)			Volume (m^3)		
Reach	**fish/ha**	**fish/m^3**	**Total No.**	**95% C.B.**	**± % error**	**Total No.**	**95% C.B.**	**± % error**
			CHIWAWA RIVER					
1	0.5	0.000	8	±3	37.5	7	±3	42.9
2	0.7	0.000	6	±4	66.7	5	±4	80.0
3	0.0	0.000	0	±0	0.0	0	±0	0.0
4	3.6	0.001	15	±6	40.0	14	±5	35.7
5	0.7	0.000	5	±0	0.0	5	±0	0.0
6	0.2	0.000	1	±0	0.0	1	±0	0.0
7	5.7	0.001	157	±60	38.2	154	±75	48.7
8	3.3	0.001	118	±94	79.7	104	±77	74.0
9	17.9	0.004	150	±28	18.7	145	±29	20.0
10	26.0	0.009	214	±49	22.9	255	±67	26.3
			PHELPS CREEK					
1	20.2	0.007	7	±0	0.0	7	±0	0.0
			CHIKAMIN CREEK[1]					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			ROCK CREEK					
1	6.1	0.003	5	±7	140.0	6	±7	116.7
			PEVEN CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BIG MEADOW CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			ALDER CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			BRUSH CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
			Y CREEK					
1	0.0	0.000	0	±0	0.0	0	±0	0.0
GRAND TOTAL	**5.1**	**0.001**	**686**	**±125**	**18.2**	**703**	**±130**	**18.5**

[1] Includes lower 0.2 miles of Minnow Creek.

APPENDIX A. Numbers of redds, eggs, and age-0 Chinook salmon, and percent egg-to-parr survival in the Chiwawa River Basin, 1991-2006. Numbers of eggs were calculated as the number of redds times the mean fecundity of females collected for broodstock.

Brood Year	Chinook Salmon			Egg-to-parr survival (%)
	Redds	Eggs (x1,000)	Age-0 (parr)	
1991	104	478.4	45,483	9.5
1992	302	1,389.2	79,113	5.7
1993	106	487.6	55,056	11.3
1994	82	377.2	55,240	14.6
1995	13	59.8	5,815	9.7
1996	23	105.8	16,066	15.2
1997	82	377.2	68,415	18.1
1998	41	188.6	41,628	22.1
1999	34	156.4	NS	NS
2000	128	588.9	114,617	19.5
2001	1,046	4,958.8	134,872	2.7
2002	345	1,573.9	91,278	5.8
2003	111	499.5	45,177	9.0
2004	253	1,194.2	49,631	4.2
2005	362	1,531.6	79,902	5.2
Average	**202**	**931.1**	**63,021**	**6.4**

APPENDIX B. Estimated numbers of salmonids (based on fish/ha) in the Chiwawa River Basin, Washington, 1992-2006; NS = not sampled.

Chiwawa River Reaaches	Length (miles)[1]	Numbers of age-0 Chinook salmon														
		1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1	3.77	684	1,416	1,163	2,687	834	682	1,588	1,254	NS	7,067	7,142	4,489	1,415	1,606	3,918
2	1.74	643	1,099	970	1,089	263	414	432	696	NS	2,850	2,152	1,486	592	855	2,091
3	2.37	712	1,195	915	931	630	1,183	962	756	NS	3,298	2,103	1,317	475	480	1,685
4	1.02	308	1,042	650	680	630	562	1,371	1,159	NS	2,895	2,579	1,473	560	517	2,117
5	1.93	392	925	579	407	525	450	634	667	NS	1,099	1,684	1,255	424	143	979
6	0.97	179	734	722	293	249	297	592	462	NS	461	635	676	254	214	1,627
7	8.23	3,161	10,210	5,652	25,029	1,373	4,732	12,522	6,322	NS	28,151	7,963	15,911	6,112	6,615	24,117
8	5.39	15,545	23,786	15,034	8,549	769	4,572	28,029	6,814	NS	16,321	20,901	20,000	6,711	8,011	17,253
9	3.39	12,848	20,171	9,143	8,335	227	1,127	10,859	5,155	NS	31,531	39,408	17,961	11,570	12,711	11,988
10	2.30	11,011	16,691	18,664	4,775	0	1,419	8,886	16,766	NS	13,080	32,663	15,682	15,247	14,847	7,703
Total	**31.11**	**45,483**	**77,269**	**53,492**	**52,775**	**5,500**	**15,438**	**65,875**	**40,051**	**NS**	**106,753**	**117,230**	**80,250**	**43,360**	**45,999**	**73,478**
								Tributaries								
Phelps	varies	NS	0	0	0	0	0	0	0	NS	168	75	4,508	102	71	113
Chikamin[2]	varies	NS	1,258	398	1,346	29	56	1,468	366	NS	2,077	8,233	1,570	717	2,092	2,500
Rock	varies	NS	586	474	210	10	92	496	592	NS	2,855	2,953	3,255	215	660	1,681
Peven	varies	NS	NS	68	0	0	0	57	0	NS	354	636	118	54	17	51
Meadow	varies	NS	NS	624	683	248	480	506	598	NS	2,332	5,021	1,510	637	792	1,890
Alder	varies	NS	NS	0	67	28	0	0	22	NS	78	429	22	21	0	62
Brush	varies	NS	NS	0	160	0	0	13	0	NS	0	0	45	71	0	127
Y	varies	NS	NS	0	0	0	0	0	0	NS	0	297	0	0	0	0
Grand Total		**45,483**	**79,113**	**55,056**	**55,241**	**5,815**	**16,066**	**68,415**	**41,628**	**NS**	**114,617**	**134,872**	**91,278**	**45,177**	**49,631**	**79,902**

[1] Lengths of sites surveyed in tributaries varied according to the presence of juvenile Chinook salmon.
[2] Includes lower 0.2 miles of Minnow Creek.

APPENDIX B. Continued.

Chiwawa River Reaches	Length (miles)[1]	Numbers of age-1+ Chinook salmon														
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	3.77	8	25	11	4	0	5	22	0	NS	0	4	0	0	22	30
2	1.74	38	22	3	0	0	0	15	0	NS	0	0	0	0	0	14
3	2.37	0	28	0	0	0	0	11	17	NS	0	0	0	5	0	0
4	1.02	4	24	0	0	0	0	9	24	NS	28	0	0	0	3	47
5	1.93	0	4	0	0	0	0	0	0	NS	0	28	0	0	0	0
6	0.97	0	0	0	9	0	0	0	0	NS	0	0	0	0	0	0
7	8.23	57	71	0	0	22	0	6	0	NS	11	0	60	9	17	0
8	5.39	184	0	0	0	0	0	0	0	NS	0	0	74	0	5	75
9	3.39	116	0	0	0	0	0	0	0	NS	27	0	0	0	15	106
10	2.30	156	0	0	0	0	0	0	0	NS	0	0	0	0	0	73
Total	**31.11**	**563**	**174**	**14**	**13**	**22**	**5**	**63**	**41**	**NS**	**66**	**32**	**134**	**14**	**62**	**345**
							Tributaries									
Phelps	varies	NS	0	0	0	0	0	0	0	NS	0	0	0	0	0	0
Chikamin[2]	varies	NS	0	0	0	0	0	0	0	NS	3	0	0	0	17	0
Rock	varies	NS	0	4	0	0	0	0	0	NS	0	0	0	0	0	43
Peven	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Big Meadow	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	7	0	0
Alder	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Brush	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Y	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Grand Total		**563**	**174**	**18**	**13**	**22**	**5**	**63**	**41**	**NS**	**69**	**32**	**134**	**21**	**79**	**388**

[1] Lengths of sites surveyed in tributaries varied according to the presence of juvenile Chinook salmon.
[2] Includes lower 0.2 miles of Minnow Creek.

APPENDIX B. Continued.

Chiwawa River Reaches	Length (miles)[1]	Numbers of age-0 steelhead/rainbow trout														
		1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1	3.77	435	416	171	2,075	428	892	584	1,323	NS	7,046	3,665	2,821	2,131	2,282	2,717
2	1.74	654	397	313	997	204	557	148	467	NS	3,422	987	1,041	769	617	1,469
3	2.37	1,183	318	185	1,210	576	1,009	439	691	NS	5,560	1,895	2,393	1,548	728	2,209
4	1.02	209	352	73	170	156	1,022	214	440	NS	3,887	748	430	390	354	929
5	1.93	252	253	7	396	140	633	215	410	NS	4,359	1,196	790	974	154	483
6	0.97	225	445	55	469	79	504	186	309	NS	1,644	442	513	314	158	534
7	8.23	412	341	149	70	310	769	367	398	NS	6,178	2,376	1,726	552	312	2,328
8	5.39	579	663	0	469	725	358	442	161	NS	1,091	75	0	882	200	0
9	3.39	600	278	0	149	575	220	205	143	NS	1,399	194	132	37	47	0
10	2.30	378	0	0	0	51	995	172	718	NS	1,173	559	65	867	0	0
Total	**31.11**	**4,927**	**3,463**	**953**	**6,005**	**3,244**	**6,959**	**2,972**	**5,060**	**NS**	**35,759**	**12,137**	**9,911**	**8,464**	**4,852**	**10,669**
								Tributaries								
Phelps	Varies	NS	0	0	0	0	224	22	20	NS	192	0	296	110	120	21
Chikamin[2]	varies	NS	356	256	744	71	84	280	253	NS	1,449	2,252	996	583	2,931	858
Rock	varies	NS	185	24	90	40	324	96	189	NS	1,826	889	1,166	113	477	872
Peven	varies	NS	NS	0	0	0	0	113	0	NS	0	0	96	40	45	34
Big Meadow	varies	NS	NS	177	371	763	1,124	397	255	NS	6,345	4,948	5,366	957	2,973	3,647
Alder	varies	NS	NS	0	40	127	58	18	34	NS	156	277	73	35	65	73
Brush	varies	NS	NS	0	107	0	50	22	27	NS	0	18	116	78	0	71
Y	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Grand Total		**4,927**	**3,974**	**1,410**	**7,357**	**4,245**	**8,823**	**3,921**	**5,838**	**NS**	**45,727**	**20,521**	**18,020**	**10,380**	**11,463**	**16,245**

[1] Lengths of sites surveyed in tributaries varied according to the presence of juvenile Chinook salmon.
[2] Includes lower 0.2 miles of Minnow Creek.

APPENDIX B. Continued.

Chiwawa River Reaches	Length (miles)[1]	Numbers of age-1+ steelhead/rainbow trout														
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	3.77	105	470	1,233	2,889	1,528	647	1,124	2,765	NS	1,377	1,875	965	1,266	941	2,029
2	1.74	264	247	588	1,316	560	558	442	2,370	NS	1,079	390	302	291	221	1,267
3	2.37	228	633	613	1,087	1,147	533	933	2,460	NS	1,077	990	543	820	376	1,026
4	1.02	164	307	237	479	1,487	569	664	1,253	NS	493	610	584	464	150	1,307
5	1.93	113	108	633	641	1,475	395	834	1,307	NS	677	351	195	176	75	696
6	0.97	107	271	372	245	552	303	349	1,517	NS	508	274	236	194	35	410
7	8.23	26	117	724	1,054	1,929	1,465	2,109	3,711	NS	2,552	1,558	879	1,444	685	803
8	5.39	398	219	409	992	1,215	564	1,941	1,840	NS	784	323	294	927	822	0
9	3.39	246	158	163	66	1,309	567	1,268	2,173	NS	343	263	103	857	468	0
10	2.30	882	0	0	0	179	973	739	2,383	NS	478	566	644	1,261	851	0
Total	**31.11**	**2,533**	**2,530**	**4,972**	**8,769**	**11,381**	**6,574**	**10,403**	**21,779**	**NS**	**9,368**	**7,200**	**4,745**	**7,700**	**4,624**	**7,538**
							Tributaries									
Phelps	varies	NS	0	0	0	0	160	0	0	NS	16	0	362	107	63	76
Chikamin[2]	varies	NS	228	476	494	6	0	133	68	NS	186	199	426	209	957	748
Rock	varies	NS	102	296	71	27	105	49	201	NS	407	165	599	0	257	1,186
Peven	varies	NS	NS	5	0	0	0	0	0	NS	0	0	0	0	0	0
Big Meadow	varies	NS	NS	107	183	435	66	0	82	NS	646	1,526	47	174	287	985
Alder	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Brush	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Y	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Grand Total		**2,533**	**2,860**	**5,856**	**9,517**	**11,849**	**6,905**	**10,587**	**22,128**	**NS**	**10,623**	**9,092**	**6,179**	**8,190**	**6,188**	**10,533**

[1] Lengths of sites surveyed in tributaries varied according to the presence of juvenile Chinook salmon.
[2] Includes lower 0.2 miles of Minnow Creek.

APPENDIX B. Continued.

Chiwawa River Reaches	Length (miles)[1]	Numbers of steelhead/rainbow trout[2] (>8 in)														
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	3.77	4	3	13	1	20	20	18	8	NS	204	87	19	3	3	28
2	1.74	7	1	2	0	3	0	5	7	NS	63	12	0	5	0	6
3	2.37	42	7	7	0	4	15	17	0	NS	28	5	0	0	0	0
4	1.02	15	3	5	7	4	0	8	4	NS	27	17	21	0	0	3
5	1.93	0	0	17	2	17	9	17	0	NS	33	10	0	0	7	3
6	0.97	19	8	4	0	0	0	0	0	NS	1	0	0	0	1	1
7	8.23	9	23	17	120	22	2	8	9	NS	55	20	4	0	0	5
8	5.39	1,059	581	2	7	8	2	5	3	NS	4	13	5	0	0	0
9	3.39	108	92	0	0	0	0	0	2	NS	0	14	0	0	9	0
10	2.30	606	50	0	2	0	0	0	0	NS	0	0	0	0	28	0
Total	**31.11**	**1,869**	**768**	**67**	**139**	**78**	**48**	**78**	**33**	**NS**	**415**	**178**	**49**	**8**	**48**	**46**
							Tributaries									
Phelps	varies	NS	0	0	0	0	0	0	0	NS	0	0	0	0	0	0
Chikamin[3]	varies	NS	0	0	0	0	0	0	0	NS	1	0	0	0	0	0
Rock	varies	NS	0	0	0	0	0	0	0	NS	3	0	0	0	0	4
Peven	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Big Meadow	varies	NS	NS	0	1	0	0	0	0	NS	1	3	0	0	0	0
Alder	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Brush	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Y	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Grand Total		**1,869**	**768**	**67**	**140**	**78**	**48**	**78**	**33**	**NS**	**420**	**181**	**49**	**8**	**48**	**50**

[1] Lengths of sites surveyed in tributaries varied according to the presence of juvenile Chinook salmon.
[2] During 1992-1993, numbers included both hatchery and wild rainbow trout. Thereafter only wild trout were observed.
[3] Includes lower 0.2 miles of Minnow Creek.

APPENDIX B. Continued.

Chiwawa River Reaches	Length (miles)[1]	Numbers of juvenile bull trout (2-8 in)														
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	3.77	0	0	0	0	0	0	6	0	NS	7	7	19	0	0	0
2	1.74	0	0	0	0	0	0	2	2	NS	0	2	8	0	0	0
3	2.37	0	0	0	0	3	9	3	0	NS	0	0	0	0	0	0
4	1.02	0	0	0	2	0	12	5	0	NS	3	3	0	0	0	0
5	1.93	0	0	0	0	0	0	10	0	NS	0	0	0	0	2	0
6	0.97	0	0	0	0	0	0	4	0	NS	0	0	0	3	0	0
7	8.23	0	6	0	0	20	13	26	27	NS	31	14	11	3	6	4
8	5.39	22	9	0	20	14	0	18	8	NS	10	6	14	3	0	0
9	3.39	18	0	0	18	31	10	70	5	NS	5	19	3	21	10	8
10	2.30	259	100	18	14	0	51	90	58	NS	16	49	31	12	8	44
Total	**31.11**	**299**	**115**	**18**	**54**	**68**	**95**	**234**	**100**	**NS**	**72**	**100**	**86**	**42**	**26**	**56**
								Tributaries								
Phelps	varies	NS	0	0	0	0	16	6	8	NS	52	30	53	17	15	27
Chikamin[2]	varies	NS	15	28	30	3	46	56	11	NS	161	46	4	38	56	13
Rock	varies	NS	28	29	4	3	61	4	11	NS	213	40	49	43	28	140
Peven	varies	NS	NS	1	0	0	0	0	0	NS	2	1	4	0	0	2
Big Meadow	varies	NS	NS	14	9	5	2	0	0	NS	5	0	0	0	0	0
Alder	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Brush	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Y	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Grand Total		**299**	**158**	**90**	**97**	**79**	**220**	**300**	**130**	**NS**	**505**	**217**	**196**	**140**	**125**	**238**

[1] Lengths of sites surveyed in tributaries varied according to the presence of juvenile Chinook salmon.
[2] Includes lower 0.2 miles of Minnow Creek.

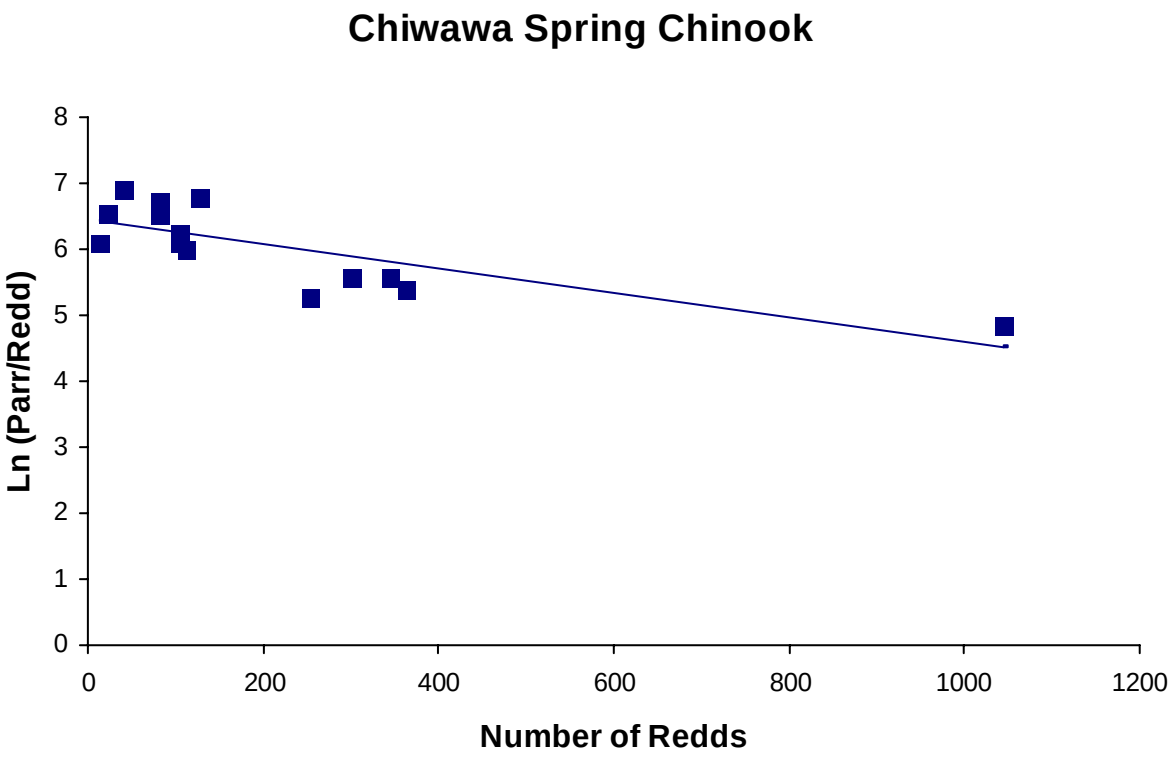
APPENDIX B. Concluded.

Chiwawa River Reaches	Length (miles)[1]	Numbers of adult bull trout (>8 in)														
		1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1	3.77	4	0	3	32	20	46	78	59	NS	76	34	10	8	8	8
2	1.74	0	2	0	46	12	13	21	16	NS	28	8	0	9	32	6
3	2.37	0	3	0	0	13	15	37	9	NS	3	8	1	0	3	0
4	1.02	8	0	1	33	20	9	13	6	NS	8	17	13	2	4	15
5	1.93	3	0	0	10	6	2	21	20	NS	14	20	5	2	7	5
6	0.97	0	0	0	2	7	3	20	22	NS	0	1	1	0	1	1
7	8.23	3	11	23	222	107	85	190	100	NS	147	70	69	34	57	157
8	5.39	22	55	10	122	62	74	143	65	NS	50	132	37	31	54	118
9	3.39	14	15	2	126	90	58	224	51	NS	116	123	66	9	59	150
10	2.30	154	62	35	71	5	137	150	64	NS	86	94	65	51	115	214
Total	**31.11**	**208**	**148**	**74**	**664**	**342**	**442**	**897**	**412**	**NS**	**528**	**507**	**267**	**146**	**340**	**674**
								Tributaries								
Phelps	varies	NS	0	0	0	0	6	1	6	NS	5	4	4	7	5	7
Chikamin[2]	varies	NS	5	1	0	0	2	1	0	NS	3	5	0	4	0	0
Rock	varies	NS	3	1	0	0	21	1	5	NS	6	5	10	0	0	5
Peven	varies	NS	NS	0	0	0	0	0	0	NS	0	0	1	0	1	0
Big Meadow	varies	NS	NS	0	0	1	1	0	0	NS	0	0	0	0	0	0
Alder	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Brush	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Y	varies	NS	NS	0	0	0	0	0	0	NS	0	0	0	0	0	0
Grand Total		**208**	**156**	**76**	**664**	**343**	**472**	**900**	**423**	**NS**	**542**	**521**	**282**	**157**	**346**	**686**

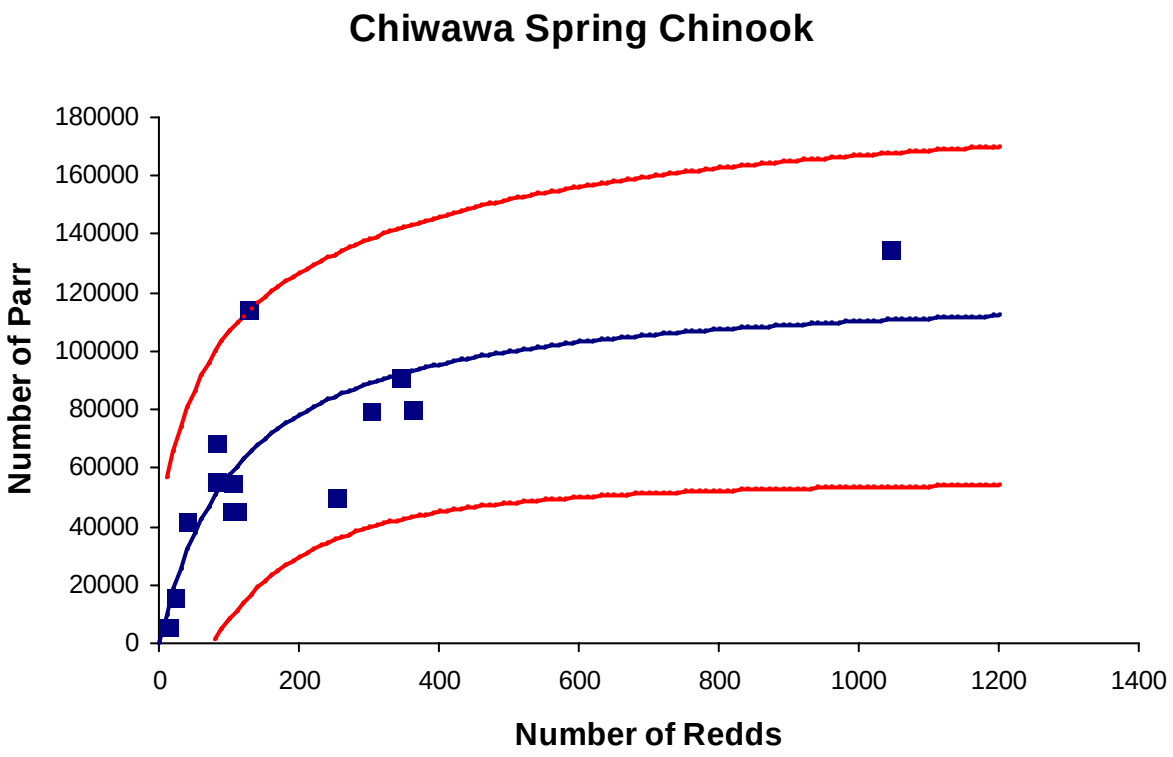
[1] Lengths of sites surveyed in tributaries varied according to the presence of juvenile Chinook salmon.
[2] Includes lower 0.2 miles of Minnow Creek.

APPENDIX C. Proportion of total habitat available, fraction of all age-0 Chinook within each habitat type, and densities (fish/ha) and numbers of age-0 Chinook within each habitat type in the Chiwawa River Basin, 1992-2006.

Habitat	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean
Proportion of total habitat available																
Glide	0.10	0.09	0.10	0.10	0.10	0.09	0.09	0.09	NS	0.07	0.08	0.07	0.07	0.08	0.08	**0.09**
Pool	0.19	0.19	0.21	0.18	0.18	0.17	0.16	0.17	NS	0.15	0.16	0.17	0.16	0.16	0.16	**0.17**
Riffle	0.61	0.61	0.57	0.59	0.58	0.57	0.58	0.55	NS	0.49	0.48	0.49	0.50	0.47	0.47	**0.54**
M. Chan	0.10	0.11	0.12	0.13	0.14	0.17	0.17	0.19	NS	0.29	0.28	0.26	0.27	0.29	0.29	**0.20**
Fraction of all age-0 Chinook within habitat types																
Glide	0.07	0.03	0.02	0.01	0.02	0.01	0.01	0.01	NS	0.03	0.01	0.02	0.01	0.01	0.03	**0.02**
Pool	0.30	0.28	0.22	0.21	0.30	0.16	0.17	0.14	NS	0.23	0.24	0.23	0.07	0.19	0.31	**0.22**
Riffle	0.18	0.16	0.12	0.11	0.43	0.23	0.08	0.11	NS	0.18	0.15	0.15	0.15	0.07	0.12	**0.14**
M. Chan	0.45	0.53	0.64	0.67	0.25	0.60	0.74	0.74	NS	0.57	0.60	0.60	0.77	0.73	0.54	**0.62**
Densities of age-0 Chinook within habitat types (fish/ha)																
Glide	254	251	93	55	11	12	78	13	NS	351	187	200	58	49	237	**128**
Pool	584	1,049	619	541	82	122	607	257	NS	1,392	1,468	951	155	492	1,240	**680**
Riffle	116	188	124	91	38	52	79	62	NS	336	300	216	101	60	166	**136**
M. Chan	1,710	3,408	2,985	2,328	84	449	2,620	1,201	NS	1,820	2,069	1,626	1,008	1,057	1,147	**1,545**
Number of age-0 Chinook within habitat types																
Glide	2,967	2,458	857	623	137	130	837	157	NS	3,231	1,931	1,884	540	442	2,498	**1,335**
Pool	13,468	21,814	12,131	11,294	1,755	2,553	11,454	5,933	NS	25,890	32,612	21,091	3,183	9,626	26,754	**14,254**
Riffle	8,531	12,616	6,698	6,197	2,525	3,699	5,392	4,626	NS	20,629	19,754	13,783	6,501	3,367	10,753	**8,934**
M. Chan	20,517	42,225	35,370	36,965	1,396	9,682	50,728	30,912	NS	64,866	80,576	54,519	34,952	36,196	46,580	**38,963**



Appendix D1. Relationship between natural log parr/redd and numbers of redds in the Chiwawa River Basin, 1993-2006. No sampling was conducted in 2000. Estimates for 1993-2006 included the Chiwawa River and its tributaries; the 1992 estimate included only the Chiwawa River. The relationship LN(P/R) = 6.44 – 0.002(Redd) is significant with P = 0.001; R^2 = 0.61.



Appendix D2. Relationship between numbers of parr and redds in the Chiwawa River Basin, 1993-2006. No sampling was conducted in 2000. Estimates for 1993-2006 included the Chiwawa River and its tributaries; the 1992 estimate included only the Chiwawa River. The blue line represents the Beverton-Holt asymptotic recruitment curve, which is given by Parr = α*Redds / (β + Redds), where α = 122,649 (95% CI: 74,937 to 170,360), β = 114 (95% CI: -7 to 235), and R^2 = 0.66. The red lines indicate the upper and lower 95% CI. Maximum parr production is α = 122,649 and maximum parr/redd is α/β = 1,076.