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ASSESSMENT OF NATIVE SALMONIDS ABOVE HELLS CANYON DAM, IDAHO

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Snake River Native Salmonids Assessment

Project Progress Report

1999 Annual Report

By

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PART #I: EVALUATING THE EFFECTIVENESS OF THE PIKE'S FORK BROOK TROUT REMOVAL PROJECT

ABSTRACT

In August 1999, brook trout *Salvelinus fontinalis* were removed for the second year from Pike's Fork of the Crooked River in a multiagency effort to eliminate the exotic salmonid and facilitate bull trout *S. confluentus* recovery in the stream. The removed brook trout were retained for aging and demographic analysis (sex, maturity, etc.). Abundance of age-1+ brook trout did not change from 1998 to 1999 in the lower 4.5 km of stream that was treated in each year. Age-0 brook trout abundance, however, decreased dramatically, demonstrating that successful spawning was drastically reduced after one year of removal. Redband trout *Oncorhynchus mykiss* and bull trout abundance did not change. Brook trout removal efficiency was high in 1999, and it was estimated that only 53 age-1+ and 110 age-0 brook trout remained in the stream following removal efforts. Mortality decreased significantly from 1998 to 1999, but few other demographic parameters changed. A number of age-4 brook trout were captured in 1999, whereas none were captured in 1998. Based on fecundity and mortality, it was estimated that 192 age-0 and 77 age-1+ brook trout would remain in the stream by summer 2000. Bull trout will likely need to be reintroduced to Pike's Fork, thereby giving them the best possible chance to reestablish before any remaining brook trout can recover once removal efforts are concluded.

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INTRODUCTION

A steady decline in the distribution and abundance of bull trout *Salvelinus confluentus* culminated in 1998 with the species being listed as threatened under the U.S. Endangered Species Act (U.S. Office of the Federal Register 64[210]:58910). Reasons for population declines generally include habitat alteration and the expansion of exotic species (Ratliff and Howell 1992; Markel 1992; Ziller 1992; Rieman and McIntyre 1993; Leary et al. 1993). Most notably among exotic species, the introduction of brook trout *S. fontinalis* has deleteriously affected bull trout through competitive interactions and hybridization between the two species (Markel 1992; Rieman and McIntyre 1993).

Though brook trout have been documented in only 14 of the 108 subwatersheds of the upper Boise River basin, they are considered to pose a serious risk to several populations of bull trout in the upper Boise River watershed (SBNFWAG 1998). Removal or suppression of brook trout where they coexist with bull trout has been recommended as a conservation action in six Priority 1 subwatersheds of the Boise River basin, including Pike's Fork of the Crooked River (SBNFWAG 1998). However, the effectiveness of removing brook trout where rare native salmonids occur has not been fully evaluated, especially with respect to bull trout conservation (Clancy et al. 1997). Thompson and Rahel (1996) effectively removed 73% to 100% of age-0 and 59% to 100% of age-1+ brook trout from three study streams, but failed to completely eradicate brook trout from any of them. Furthermore, any remaining brook trout may compensate after the fish population is reduced, through increased growth and fecundity and decreased natural mortality (McFadden 1961, 1976), negating some or all effects of the removal. Before brook trout removal or suppression is considered for additional waters on a broader scale, the population-level effects should be more thoroughly studied.

OBJECTIVES

1. To assess whether an intensive brook trout removal effort over three years in a small stream can effectively eliminate brook trout and lead to an increase in bull trout numbers in subsequent years.

2. To assess whether any remaining brook trout undergo a compensatory response that has the potential to negate the effects of the removal effort.

STUDY AREA

Pike's Fork Creek is a second-order tributary of the Crooked River, which flows into the North Fork of the Boise River. Mean summer stream width, gradient, and elevation is 2.8 m, 3.0%, and 1750 m, respectively. A wire gabion barrier constructed in 1998 above the Banner Creek confluence (Figure 1) by the U.S. Forest Service was designed to prevent upstream migration by resident brook trout while allowing migratory bull trout (i.e., fish >300 mm) to pass. Pike's Fork contains native redband trout *Oncorhynchus mykiss*, a remnant population of bull trout, and the exotic brook trout. The only nongame fish encountered were shorthead sculpin *Cottus confusus*.

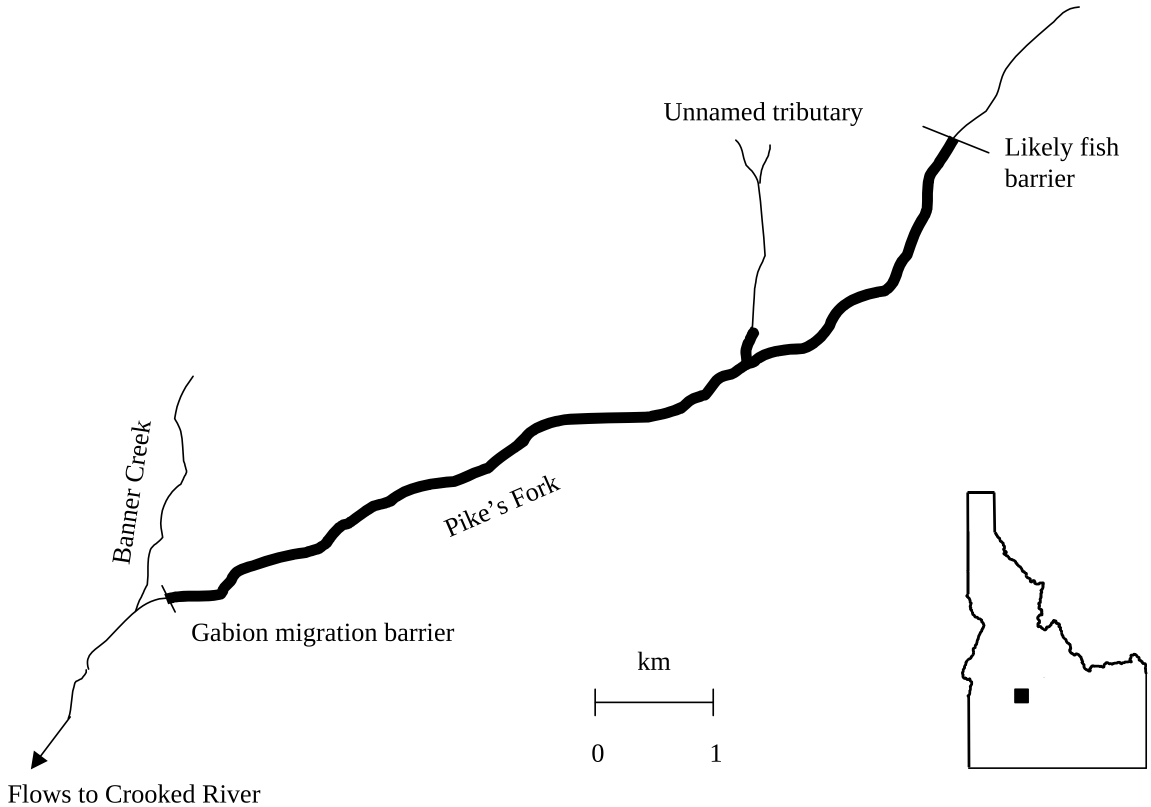

Figure 1. Location of gabion migration barrier and area where brook trout removal efforts occurred (darkened stream section) in 1999 in Pike's Fork, Idaho.

METHODS

The Pike's Fork project was initiated in August 1998 by the Southwest Basin Native Fish Watershed Advisory Group (SBNFWAG). Meyer (1999) reported on methods and results from the first year of removal. In summary, about 4.5 km of Pike's Fork above the confluence of Banner Creek were electrofished to remove brook trout. It was discovered during the 1998 removal effort that brook trout extended farther upstream than originally suspected. To more accurately assess brook trout distribution in the watershed prior to removal efforts in 1999, we snorkeled 50 m sections throughout the stream (about one section per km) and found no trout above a high gradient stretch of stream 9.4 km above the gabion barrier. This 9.4 km of stream, along with 80 m of an unnamed tributary, was divided into 29 sections averaging 328 m in length. Five crews (five to seven persons per crew), each with two backpack electrofishing units and at least two netters, were established for each day, and each crew covered one reach at a time. The crews made two electrofishing passes with one electrofishing operator proceeding upstream in front of the other by about 20 m. All brook trout and a subsample of redband trout (n=29) were retained for population dynamics analysis. The remaining redband trout, all shorthead sculpin not retained for identification, and all bull trout were measured for total length (to nearest millimeter) and released in the section from which they were captured after electrofishing was completed.

Population abundance, upper and lower 95% confidence intervals, and capture probability (CP) for each species in each reach were estimated with the removal-depletion maximum-likelihood model using the MicroFish software package (Van Deventer and Platts 1989). Estimates were made for age-0 (<80 mm) and age-1+ (>80 mm) fish. Lower 95% confidence intervals were always less than the total catch and are not presented. Brook trout removal efficiency was calculated by comparing the total catch to the population estimate in each removal section. Results from 1998 indicated that age-0 and age-1 brook trout were probably not fully recruited to the sampling gear, and thus the assumption of equal catchability was probably violated. This should be kept in mind when considering abundance, removal efficiency, and age-frequency estimates. I assumed that within each age class, catchability was equal, and thus the remaining parameter estimates should be unbiased.

Brook trout were transported to the IDFG Nampa Research Station where length and weight, and age, mortality, growth, age at sexual maturity, fecundity, longevity, and sex ratio, were determined. We collected paired scale and otolith samples from 269 randomly selected fish to age brook trout. Scales were removed from the area immediately dorsal to the lateral line and posterior to the dorsal fin, placed on paper strips in envelopes, and subsequently mounted on acetate slides using a scale press. Otoliths were removed and stored in vials containing glycerin. Otolith readings gave older ages and were assumed to be more accurate than scales (Meyer 1999); thus, we only read scales when the age from otoliths could not be ascertained. Because this occurred only 11 times, we did not attempt to correct the scale age readings. Readers had no knowledge of fish length during readings. A final determination of age for each fish was made by comparing results between two or three readers and resolving any differences with additional joint readings.

Once age was determined for the 269 fish used for aging analysis, the age of the remaining 972 brook trout was assigned using an age-length key (DeVries and Frie 1996) and professional judgment. All demographic parameters, however, were estimated only from the fish that were directly aged. Mortality estimates followed Robson and Chapman (1961) and used catch curves (age frequency) and Heincke's estimate. Growth was assessed by comparing average length of brook trout between sexes and age groups. Fish were rated as immature or mature by laboratory examination of ovaries and testes. Mature males were those with large extended testes, whereas immature males had minute, strand-like testes. Mature females contained large, developed eggs, whereas immature females contained granular eggs that obviously would not reach ripeness by fall. The sex of most immature fish could not be determined. Maturity percentages were calculated for each age class. Sex ratio was expressed as the proportion of the population that was female. Comparisons between sexes and age classes were made for each parameter when possible. Ninety-five percent confidence intervals around the estimates were calculated from Robson and Chapman (1961) for mortality and from McFadden (1961) for all other parameters. I used a student's *t*-test (Zar 1996) to test for a difference in the fecundity regressions between 1998 and 1999. These demographic estimates and their confidence intervals were compared between 1998 and 1999 to assess whether brook trout had undergone any compensatory responses one year after the first removal.

I estimated the number of eggs that were deposited in Pike's Fork in fall 1999 (by brook trout that were not removed) and the number of brook trout that may be present during the 2000 removal. Using the age frequency distribution, I assigned an age to brook trout that were estimated to remain following the 1999 removal effort. Based on the demographic parameters above, I estimated the proportion that were females, an average length, and the number of eggs that would have been produced per remaining female. From these values, and assuming that all mature females successfully spawned with a ripe male brook trout, I estimated the total number of fertilized eggs that may have been deposited in fall 1999. I assumed survival rates of 5% from egg deposition to late summer fry (Shetter 1961) and 50% for all other age groups to calculate the total number of brook trout in each age group that may be expected to be encountered during the year 2000 removal efforts.

RESULTS

Age-1+ brook trout abundance in the lower 4.5 km of Pike's Fork did not decrease one year after the initial removal. In both 1998 and 1999, it was estimated that 699 age-1+ brook trout were present in the lower 4.5 km (Figure 2). The estimated abundance in the entire 9.4 km in 1999 was 1180. Age-1+ redband trout abundance also did not change (Figure 2). In contrast, the abundance of age-0 brook trout captured was substantially reduced, from 796 in the lower 4.5 km in 1998 to 110 in 1999. Only 224 age-0 brook trout were estimated to be present in the entire 9.4 km of treated stream. Age-0 redband trout abundance did not change (Figure 2). The drastic reduction of age-0 brook trout was evident when comparing cumulative length frequencies of fish in Pike's Fork; there was a significant change in the cumulative length frequency of brook trout (*P*-value <0.001), but not of redband trout (*P*-value = 0.480) (Figure 3).

Only five bull trout were captured in 1999, compared to four bull trout and one bull x brook hybrid in 1998. All bull trout collected in 1999 were between 180 mm and 210 mm in length.

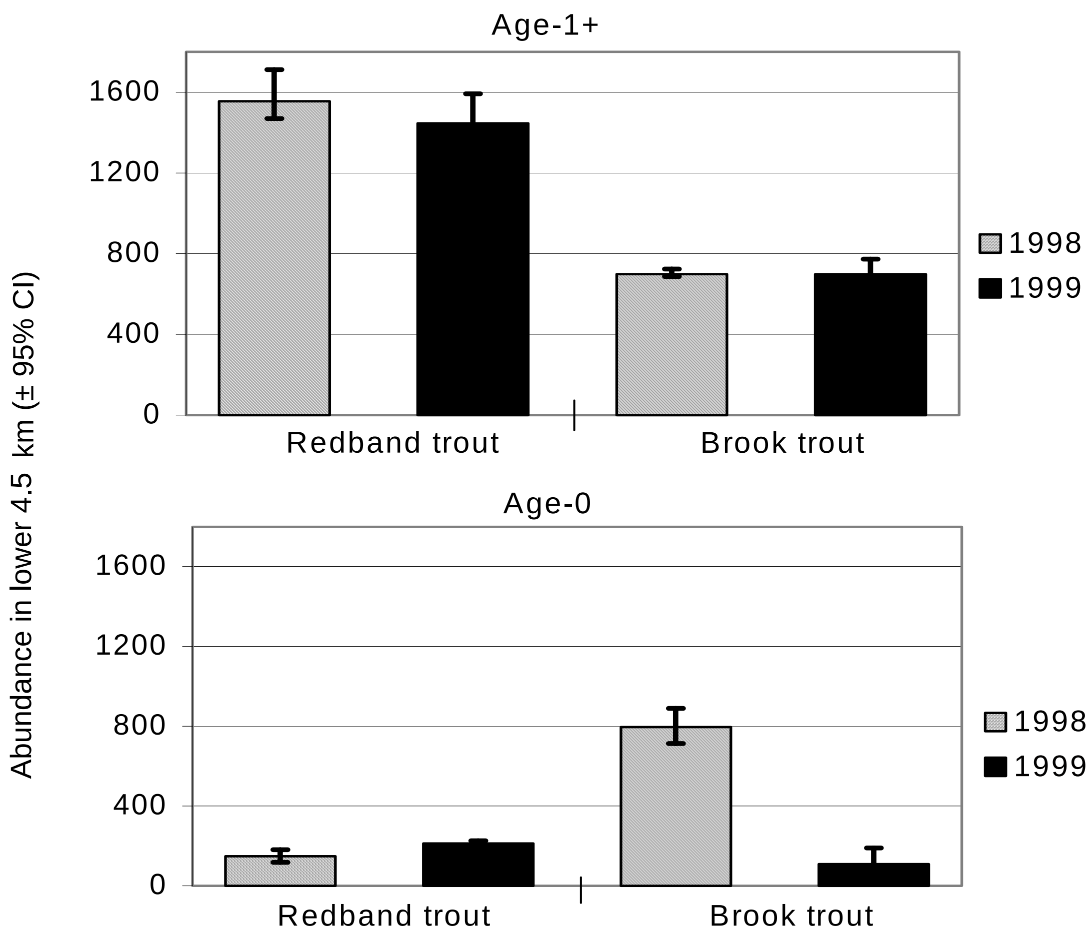

Figure 2. Abundance of brook trout and redband trout in the lower 4.5 km where electrofishing was used to removal brook trout in 1998 and 1999 in Pike's Fork, Idaho.

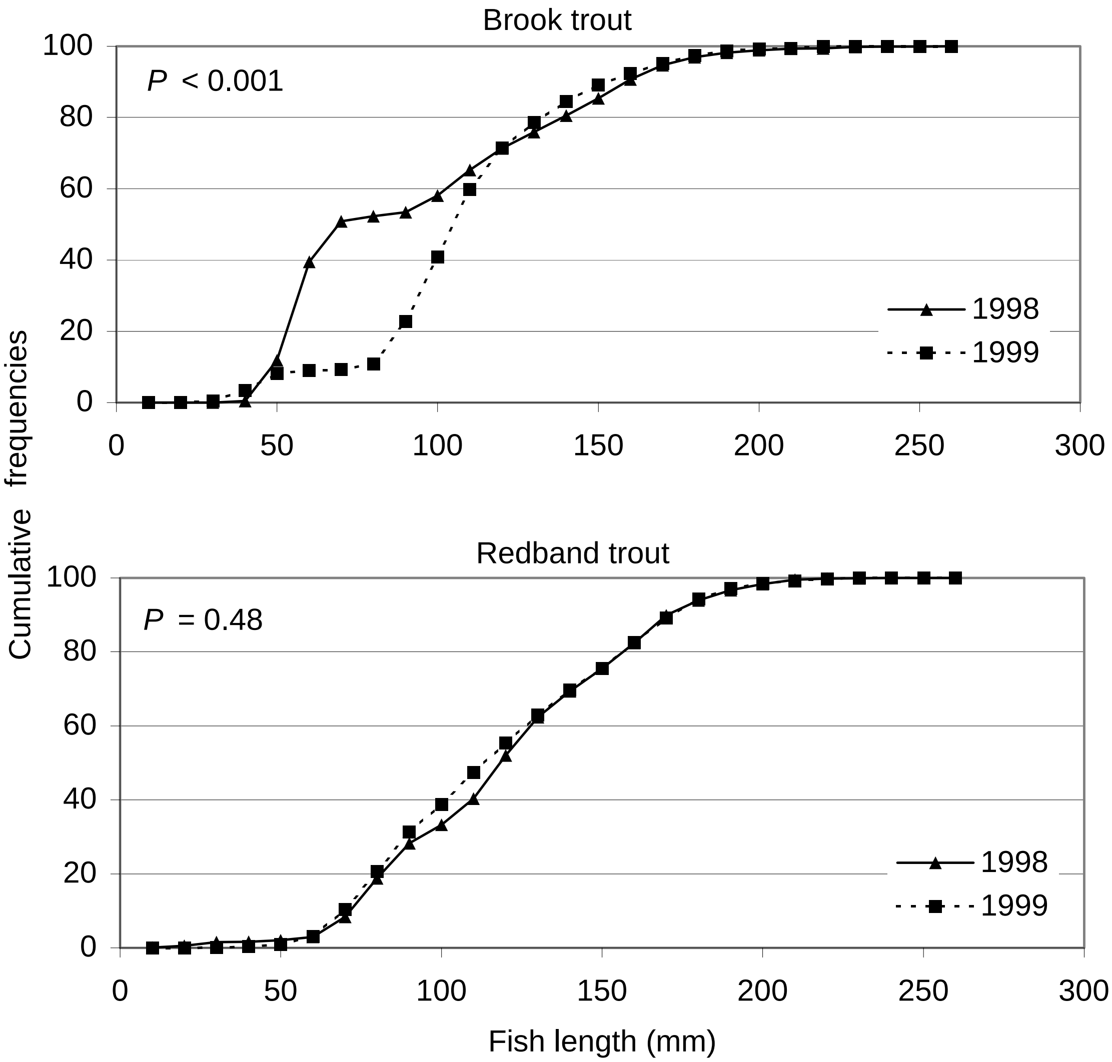

Figure 3. Cumulative length frequency of brook trout and redband trout in 1998 and 1999 in Pike's Fork, Idaho.

Removal efficiency (i.e., total catch ÷ population estimate) in 1999 was high for age-1+ brook trout (95.5%; Table 1). Based on this efficiency, I estimated that about 53 (95% CI 0-132) brook trout >80 mm remain in Pike's Fork above the gabion barrier (Table 1). Removal efficiency was low for age-0 brook trout (50.9%); however, this was a product of the low abundance of age-0 brook trout throughout the stream. Typically only a few age-0 brook trout were captured in each section, and instead of making estimates of abundance for each section, I pooled all first passes and second passes together and made one population estimate of 224 age-0 fish (Table 1). Thus, the estimate of age-0 brook trout remaining (110 fish; 95% CI 0-274) was not very precise. The maximum-likelihood model estimate of capture probability for each reach was high for age-1+ brook trout (mean 0.81; range 0.58 - 0.94; Table 1), and was not estimated for age-0 brook trout.

Table 1. Total catch, population estimates, and removal efficiencies of redband trout and brook trout in 9.4 km of Pike's Fork, Idaho in 1999.

	Redband age-1+ (> 80 mm)						Brook trout age-1+ (> 80 mm)						Brook trout age-0 (< 80 mm)					
Reach name	1st pass	2nd pass	Total caught	Pop. Estimate (# in reach)	Upper CI	Capt. Prob.	1st pass	2nd pass	Total caught	Pop. Estimate (# in reach)	Upper CI	Capt. Prob.	1st pass	2nd pass	Total caught	Pop. Estimate (# in reach)	Upper CI	Capt. Prob.
0.0 B	43	9	52	53	56.7	0.83	31	3	34	34	35.1	0.92	1	0	1			
0.0 C	51	22	73	87	106.6	0.59	19	5	24	24	26.5	0.83	2	0	2			
0.5 A	35	10	45	47	52.5	0.76	21	3	24	24	25.4	0.89	3	4	7			
0.5 B	95	15	110	112	116.2	0.85	42	6	48	48	49.9	0.89	1	1	2			
0.5 C	52	10	62	63	66.6	0.84	22	2	24	24	24.9	0.92	0	1	1			
1.0 A	75	30	105	122	141.9	0.62	28	6	34	35	38.4	0.81	1	3	4			
1.0 B	109	20	129	132	137.4	0.83	30	2	32	32	32.8	0.94	1	3	4			
1.0 C	62	15	77	80	86	0.79	23	4	27	27	28.8	0.87	0	0	0			
1.5 A	40	18	58	70	88.9	0.58	26	7	33	34	38	0.79	0	0	0			
1.5 B	78	6	84	84	85.4	0.93	26	1	27	27	27.4	0.96	0	1	1			
1.5 C	86	21	107	112	119.6	0.78	20	6	26	27	31.2	0.77	0	0	0			
2.0 A	67	12	79	81	85.3	0.83	34	10	44	47	53.6	0.73	1	0	1			
2.0 B	94	22	116	121	128.5	0.78	80	16	96	99	104.5	0.81	13	4	17			
2.0 C	70	12	82	84	88.2	0.84	74	9	83	83	85.2	0.90	2	3	5			
2.5 A	59	27	86	105	129.3	0.57	38	17	55	66	83.9	0.59	1	5	6			
2.5 B	27	8	35	37	42.5	0.75	16	7	23	26	34.7	0.64	1	0	1			
2.5 C	44	10	54	56	60.8	0.79	26	11	37	42	52.9	0.64	1	3	4			
3.0 A	37	11	48	51	57.6	0.74	41	3	44	44	45	0.94	23	4	27			
3.0 B	37	11	48	51	57.6	0.74	20	4	24	24	26	0.86	0	0	0			
3.0 C	20	8	28	31	39	0.67	23	10	33	38	49.3	0.62	1	0	1			
3.5 A	25	3	28	28	29.3	0.90	29	9	38	40	45.7	0.75	1	0	1			
3.5 B	22	4	26	26	27.8	0.87	22	5	27	27	29.3	0.85	4	5	9			
3.5 C	10	6	16	20	33.6	0.53	19	3	22	22	23.5	0.88	3	2	5			
4.0 A	57	6	63	63	64.6	0.91	39	8	47	48	51.5	0.83	2	5	7			
4.0 B	18	11	29	40	66.4	0.47	44	11	55	57	62.1	0.79	0	2	2			
4.0 C	22	7	29	31	36.7	0.73	39	18	57	69	88.2	0.58	0	1	1			
4.5 A	17	3	20	20	21.6	0.87	80	17	97	100	105.7	0.81	4	1	5			
4.5 B	5	0	5	5	5[a]	NA	11	0	11	11	11[a]	NA	0	0	0			
Unnamed trib.	2	0	2	2	2[a]	NA	1	0	1	1	1[a]	NA	0	0	0			
Total	1359	337	1696	1814	2034	.75[b]	924	203	1127	1180	1312	0.81[b]	66	48	114	224[c]	390[c]	NA
Removal efficiency (%)				NA	NA					95.5	85.9					50.9	29.2	

[a] All fish captured on first run, thus CI could not be calculated.

[b] Average, not total.

[c] Estimated from total catch from all reaches, not each individual reach.

In general, there were few changes in brook trout demographics one year after the initial removal effort. Of the 1,241 brook trout captured and removed from Pike's Fork in 1999, the majority of fish were age-1, followed by age-2 (Table 2). There were few fish in any other age group. As in 1998, there was substantial overlap in length-at-age. A number of age-4 fish were captured in 1999, while in 1998 we captured no fish over age-3. Results from 1998 demonstrated that only age-2 and older brook trout were fully recruited to the sampling gear, and thus are the only fish that were used for mortality estimates. Using catch curve data, mortality was estimated to be 81.8%, a significant reduction from the estimate of 94.2% in 1998 (Figure 4). Heincke's estimate of 80.2% corroborated the catch curve estimate from 1999.

Mean length-at-age decreased significantly from 1998 to 1999 in almost every age class (Figure 5), but the changes were extremely minor and probably not biologically significant. Average lengths for age-0 to age-4 were 52 mm, 105 mm, 138 mm, 168 mm, and 167 mm respectively. The length-weight relationship was nearly identical between years (Figure 6).

Table 2. Age-frequency distribution of brook trout removed in 1999 from Pike's Fork, Idaho. Distribution was computed using an age-length key (n=269).

Fish length	Age group					
(mm)	0	1	2	3	4	Total
30	6					6
40	36					36
50	59					59
60	11					11
70	2					2
80		21				21
90		147				147
100		206	19			225
110		178	57			235
120		89	55			144
130		11	78			89
140			52	21		73
150			47	12		59
160			25	12	3	40
170			26	6	3	35
180			13	12	2	27
190				15	1	16
200				5	1	6
210				2	1	3
220				5	1	6
230				1		1
Total	114	652	372	91	12	1241
Percent	9.2	52.5	30.0	7.3	1.0	100.0

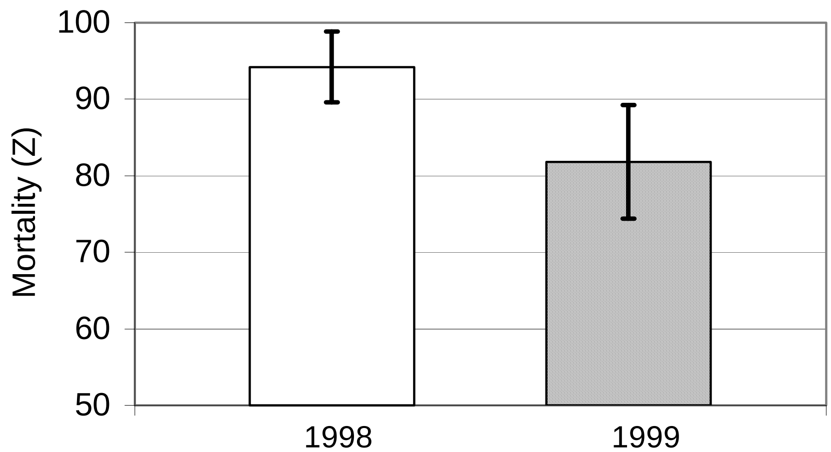

Figure 4. Total mortality estimate derived from catch curve analysis of electrofishing data for brook trout in Pike's Fork, Idaho.

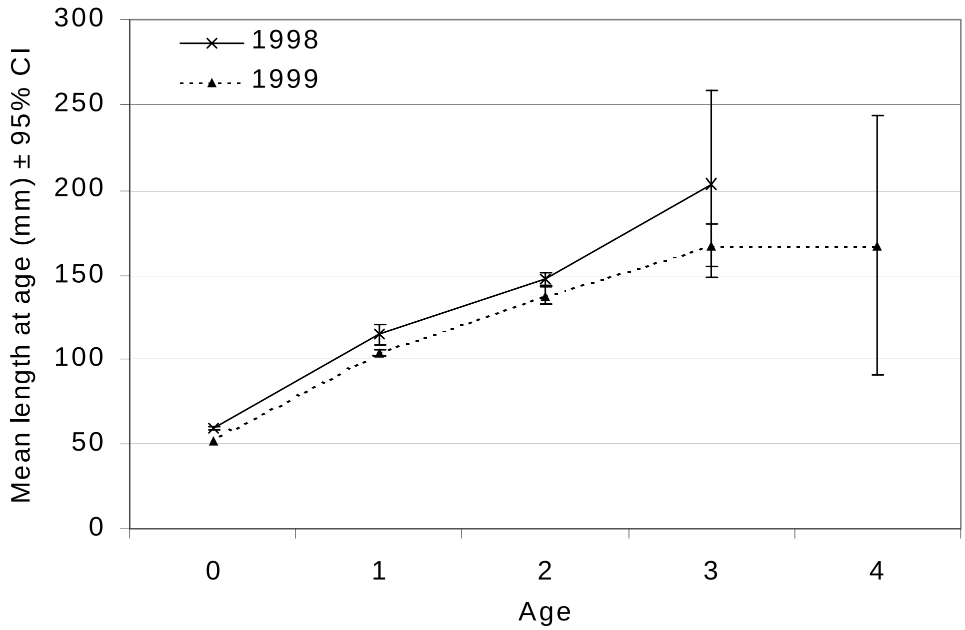

Figure 5. Growth of brook trout from 1998 and 1999 in Pike's Fork, Idaho.

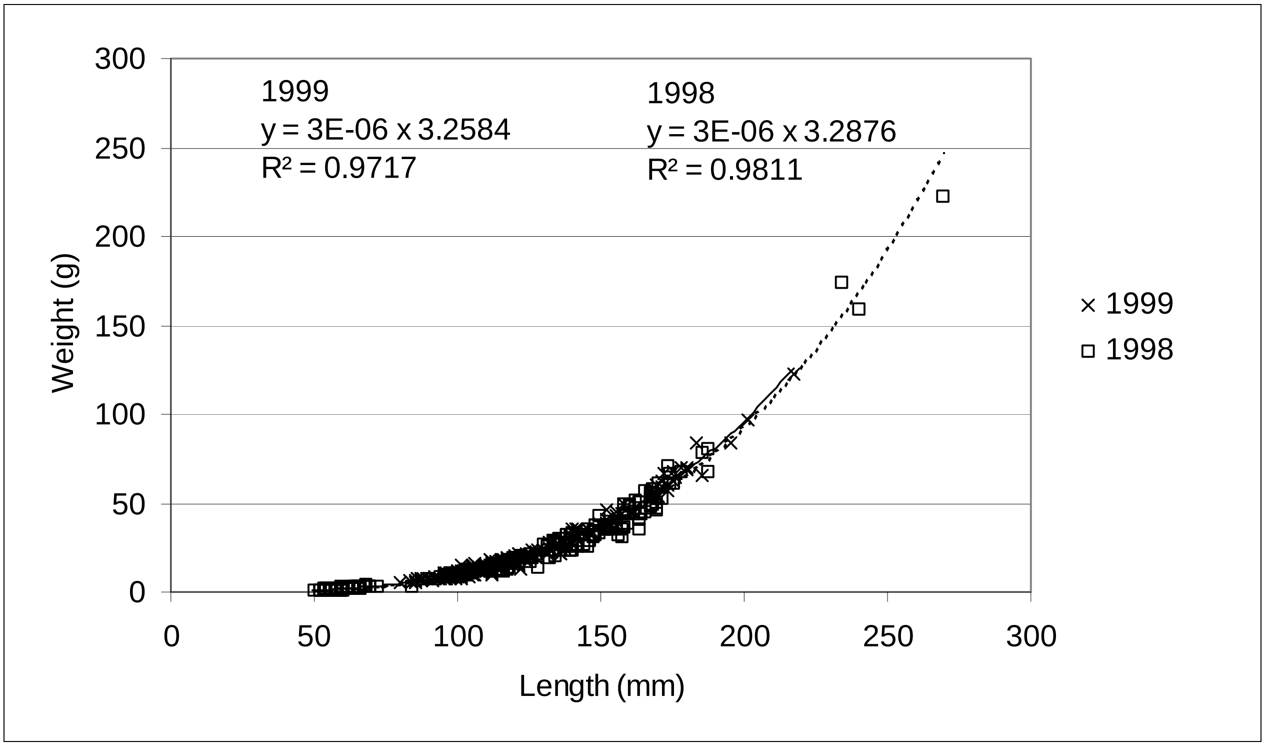

Figure 6. Length-weight relationship for brook trout in 1998 and 1999 in Pike's Fork, Idaho.

As in 1998, there tended to be a higher proportion of mature males than females for each age class, but in 1999 there were no significant differences between sexes for any age group (Figure 7). The smallest mature male was 105 mm, and the largest immature male was 121 mm, whereas for females the smallest mature and largest immature fish were 106 mm and 180 mm, respectively (Table 3). There were no significant changes between years in mean length-at-age for any comparison of mature or immature fish for either sex (Figures 8 and 9). For age-2 fish, mature brook trout were longer than immatures for both males (*P*-value = 0.005) and females (*P*-value = 0.002); this was the only age group where sample size was adequate to make meaningful comparisons. There were no differences in mean length-at-age between sexes for any age group (Table 3). The slopes of the fish length-fecundity relationship did not differ between years (*P*-value = 0.250; Figure 10). The average fecundity was 289 eggs per female, compared to 235 per female in 1998.

Of the brook trout whose sex could be determined, females outnumbered males for each year class except age-1 (Table 3). The proportion of brook trout that were females was 0.33 (SE ±0.11) for age-1, 0.55 (±0.09) for age-2, and 0.63 (±0.12) for age-3; over all age classes, the proportion was 0.53 (±0.05). Based on the assumptions that all remaining female brook trout successfully spawned in 1999, and that their demographics were equivalent to those that were captured and removed, I estimated that 1,918 eggs were deposited in Pike's Fork in the fall, after the removal project. Assuming 5% survival for the eggs and 50% survival for the remaining age groups, I estimated that 96 age-0 and 77 age-1+ brook trout would remain in Pike's Fork in the summer of 2000 (Table 4).

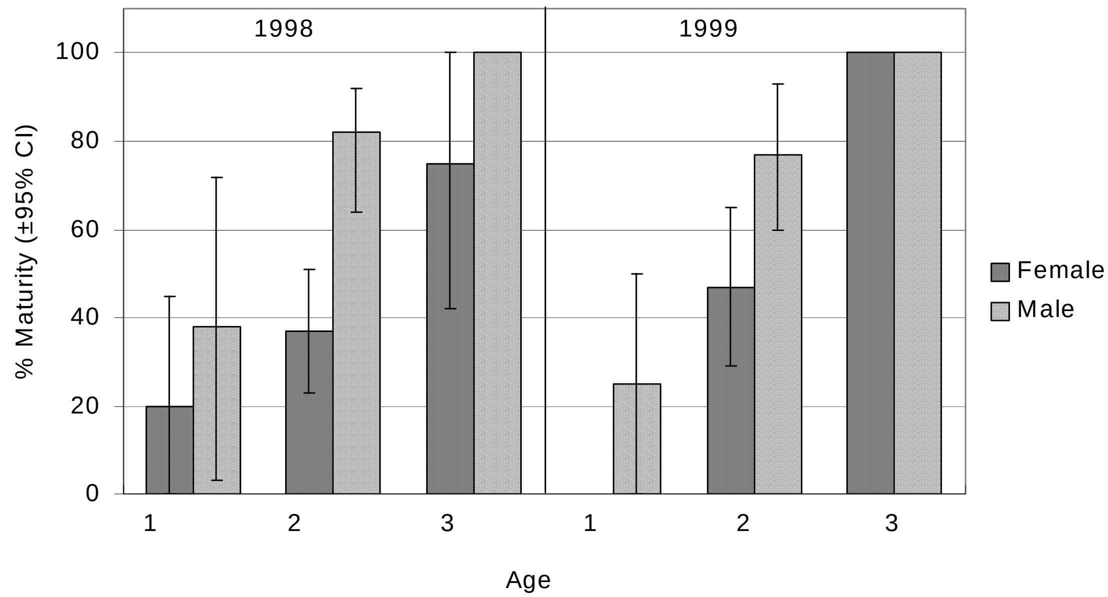

Figure 7. Proportion of male and female brook trout mature at age in 1998 and 1999 in Pike's Fork, Idaho.

Table 3. The length of male and female brook trout at age in 1999 in Pike's Fork, Idaho.

Age	Sex	Maturity	Fish length (mm) n	Mean	SE	Range	P-value Maturity	Sex
1	F	I	6	114.0	1.5	109-120	NA	
		M	0					
		combined	6	114.0	1.5	109-120		0.287
	M	I	9	117.2	2.3	106-130	0.544	
		M	3	121.0	8.5	105-134		
		combined	12	118.2	2.5	105-134		
2	F	I	15	153.6	4.2	119-180	0.0005	
		M	17	133.5	3.7	106-168		
		combined	32	142.9	3.3	106-180		0.968
	M	I	6	116.7	1.1	113-121	0.0002	
		M	20	150.5	4.1	126-183		
		combined	26	142.7	4.2	113-183		
3	F	I	0				NA	
		M	10	162.4	5.6	140-185		
		combined	10	162.4	5.6	140-185		0.287
	M	I	0				NA	
		M	6	176.0	13.1	142-217		
		combined	6	176.0	13.1	142-217		
4	F	I	0				NA	
		M	2	167.0	6.0	161-173		
		combined	2	167.0	6.0	161-173		
	M	I	0					
		M	0					
		combined	0					

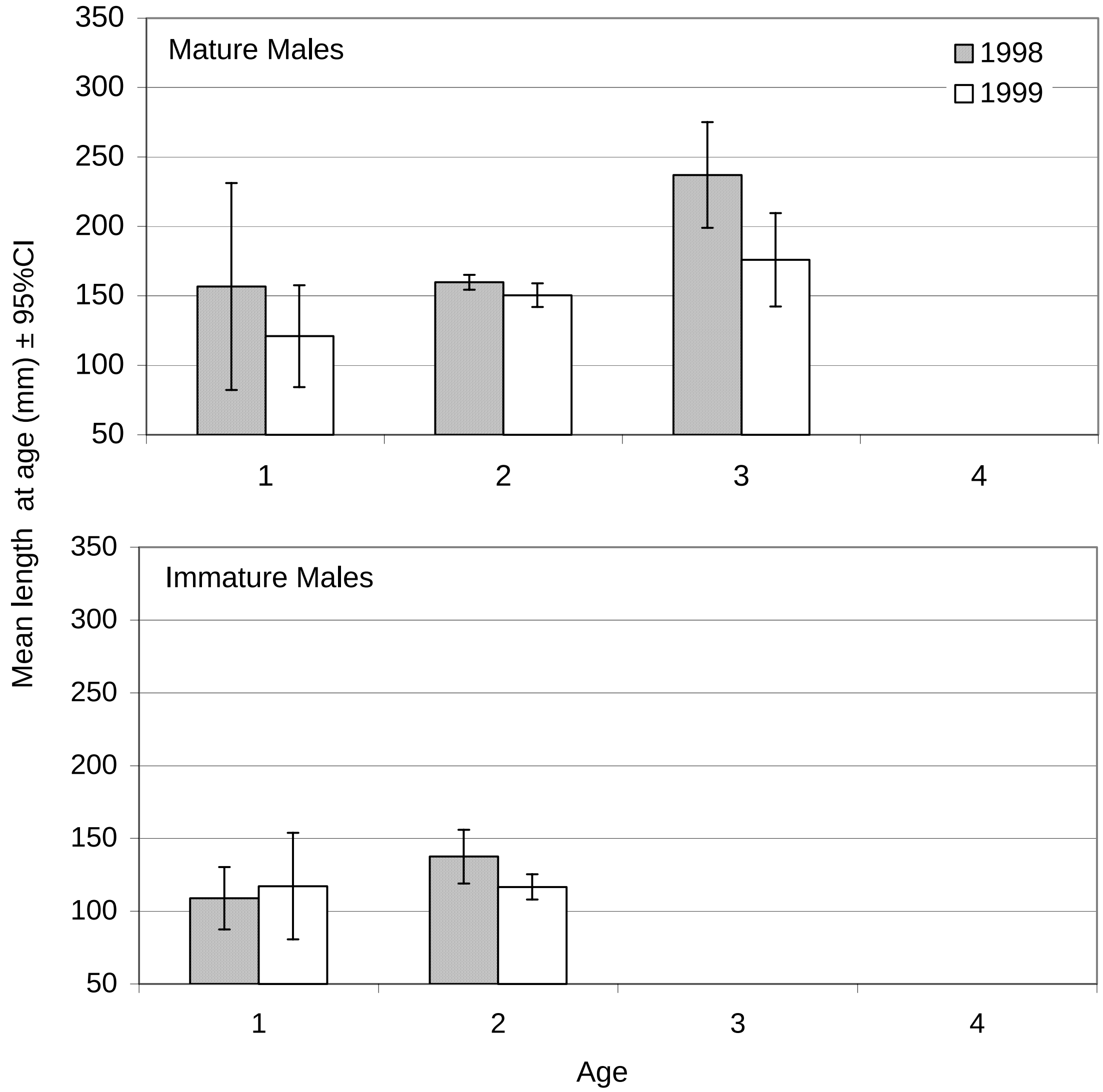

Figure 8. Mean length at age for mature and immature male brook trout in 1998 and 1999 in Pike's Fork, Idaho.

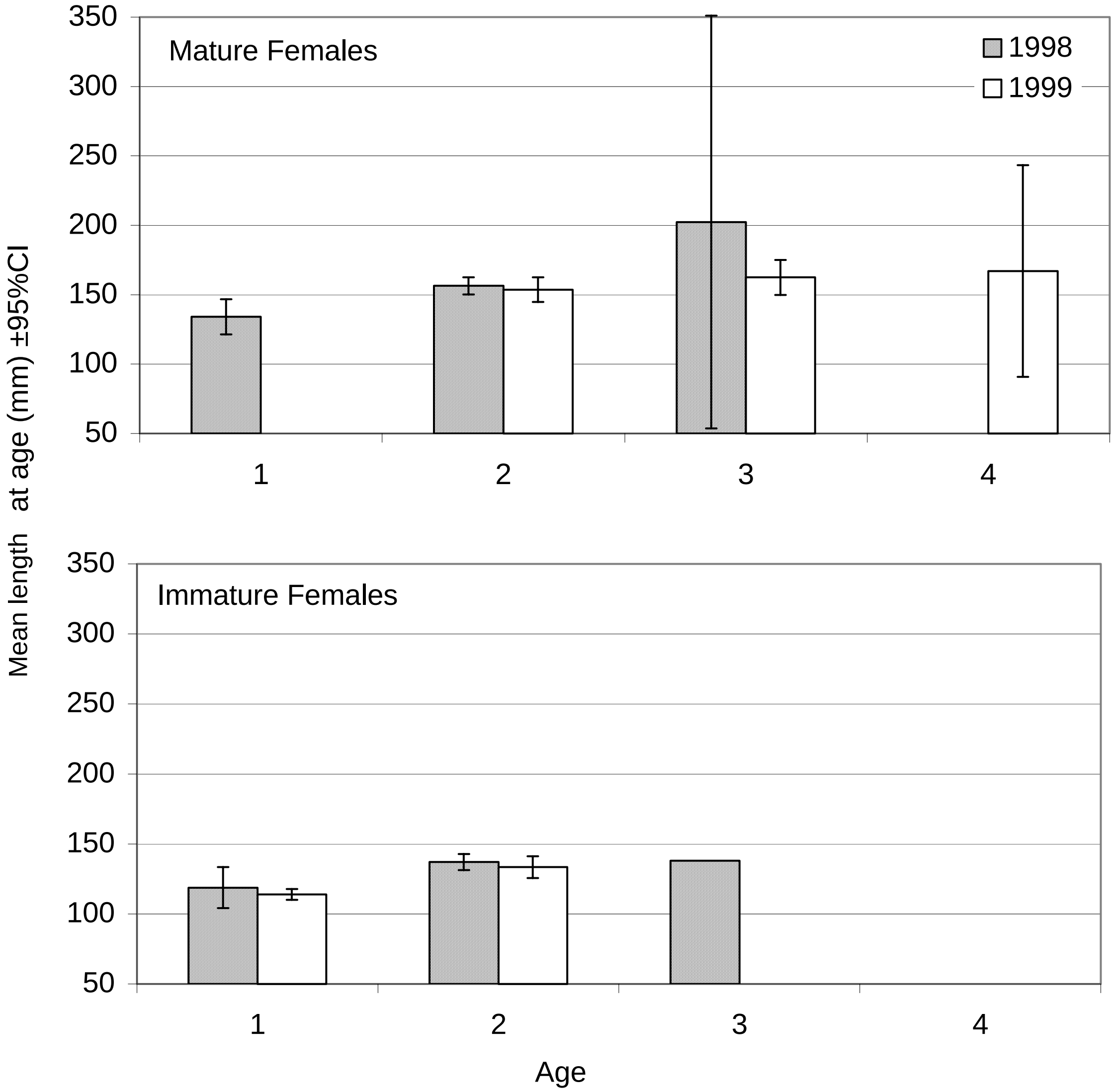

Figure 9. Mean length at age for mature and immature female brook trout in 1998 and 1999 in Pike's Fork, Idaho.

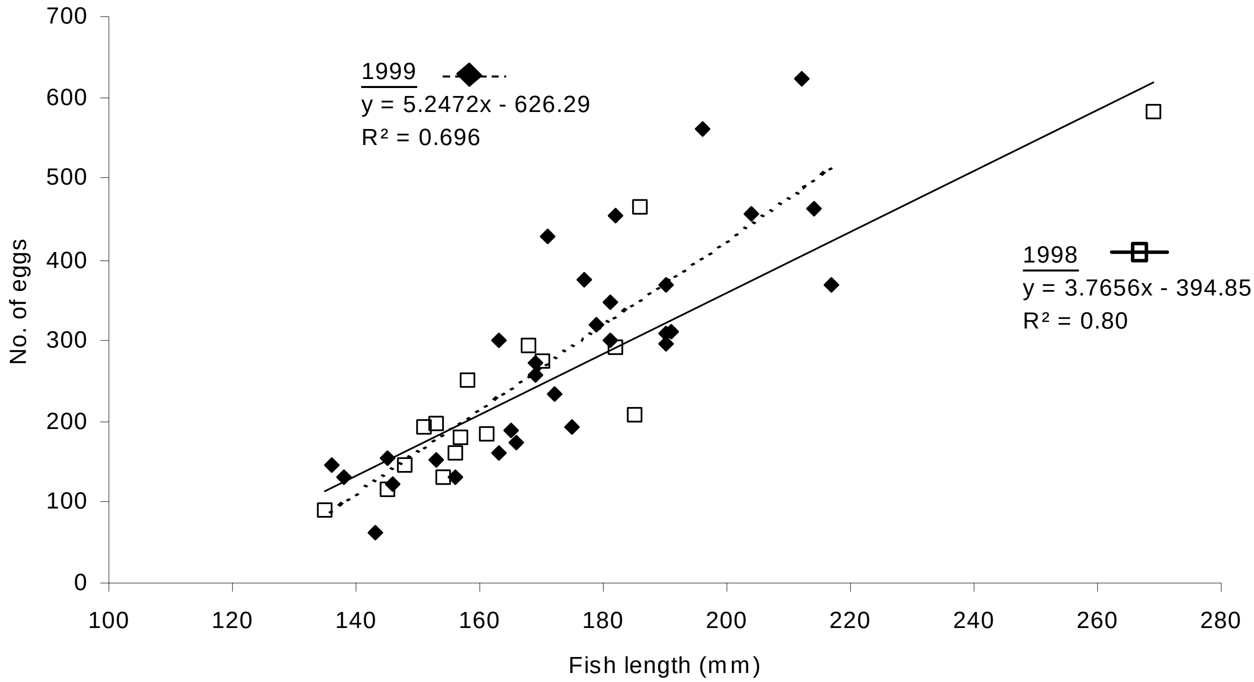

Figure 10. The relationship between fish length and fecundity of female brook trout in 1998 and 1999 in Pike's Fork, Idaho.

Table 4. An estimate of the number of brook trout remaining to be removed in the 2000 removal efforts in Pike's Fork, Idaho.

Estimate of:	Age group 0	1	2	3	4	Total
The no. of bkt remaining in Pike's Fork after the 1999 removal	110	30.7	17.5	4.3	0.6	
The no. that are females	NA	10	10	3	0	
The mean length of females	NA	114	143	163	167	
The mean no. of eggs produced per female	NA	0	124	226	250	
Total eggs produced per age class	NA	0	1240	678	0	1918
The no. of bkt remaining for 2000 removal effort per age group	96	55	15	5	2	

DISCUSSION

The lack of a reduction of age-1+ brook trout in the lower section of Pike's Fork that was treated for removal in the first year could be due to several reasons. Most likely, age-0 and age-1+ brook trout in the upper, untreated portion of fish-bearing streams probably drifted downstream after the removal efforts of 1998, filling the habitat that was voided by the removed fish. These emigrants would have experienced reduced competition for food and space, especially important during winter (Chapman 1966). Such a reduction in competition may have led to the decrease in mortality I observed. In addition, fry are generally not captured as efficiently with electrofishing as larger fish (Reynolds 1996), and those fry that escaped capture in 1998 and survived their first winter became age-1+ fish before the 1999 removal efforts. It is also possible that some age-1+ brook trout may have migrated over the gabion barrier, recolonizing the stream. The vertical drop at high flow is 0.5 m and at low flow is 0.8 m. Adams et al. (2000) found similar-sized brook trout ascending drops from 0.5 m to 1.2 m high. Conversely, I may have overestimated removal efficiency by underestimating population estimates. Riley and Fausch (1992) found that two-pass electrofishing underestimated the number of trout present by 9%. Although these results are not directly comparable because in this study two electrofishing units were used instead of one for each pass, I may still have underestimated the true population size.

Since we failed to reduce brook trout abundance in the stream one year after the first removal, it is not surprising that most demographic parameters did not change significantly. Such a response is more likely in 2000, after the stream was more thoroughly treated in 1999. However, Cooper et al. (1962) found no increase in brook trout growth after using rotenone in a stream to severely reduce the number of brook trout. Instead, brook trout abundance quickly recovered and within two years was no different than before the treatment. Almost all brook trout two years after the rotenone treatment were age-0 or age-1. That mortality was reduced in this study after the first year of exploitation demonstrates that some compensatory response did occur. McFadden (1961) found a strong negative relationship between exploitation and natural mortality rate over a number of years in a brook trout population.

The estimated number of brook trout remaining in Pike's Fork in 2000 may be an underestimate for several reasons. First, the 5% rate of egg survival I used may have been too low. Shetter (1961) found that brook trout egg survival from deposition to the following fall averaged 5% over six years (range 3%-9%), but fry that were spawned after our removal efforts most likely would have experienced less competition for food and space than they would have under normal conditions. In addition, Vladykov (1956 as cited in Shetter 1961) found that eggs atrophied in the female between August and the time at which brook trout spawned later in the fall; following Shetter (1961), I reduced the fecundity estimate by 20% to account for this, which further reduced the estimated number of fry remaining. As previously mentioned, if capture efficiency was overestimated, or brook trout recolonized the stream by circumventing the barrier or because they were distributed beyond the treatment area, then the estimated number remaining in Pike's Fork may be underestimated. Alternatively, the 50% survival rate I used for all other age classes may be too high. In 1998 and 1999, survival was only 5.8% and 18.2%, respectively. Even if the remaining brook trout undergo a significant compensatory increase in survival between 1999 and 2000, it probably will not reach 50%.

As in 1998, bull trout were nearly absent in 1999. Whether adfluvial bull trout are currently using Pike's Fork or would recolonize the stream is not known. Considering the slow rate at which bull trout reach maturity (Fraley and Shepard 1989; Scott and Crossman 1973) compared to brook trout (McFadden 1961; Scott and Crossman 1973), and the low numbers of bull trout currently present, brook trout may recolonize Pike's Fork before bull trout can recover, unless all brook trout are completely eliminated or bull trout from a nearby watershed are used to restock the stream. As Leary et al. (1993) argued, the more numerous and faster maturing species has the advantage because less of their total reproductive effort is spent on unproductive hybrid production. Additionally, with very few bull trout remaining, the probability that they could successfully locate a spawning partner is extremely low. A nearby source of bull trout, such as the headwater reaches of the Crooked River, should be considered by the SBNFWAG as a source to help reestablish a stable population of bull trout into Pike's Fork. This should be done when all removal efforts have been completed, giving bull trout the best chance possible to recover before any remaining brook trout can recover from the removal efforts.

Removal efforts in 1999 required 59 man-days alone, not including preparation time. Efforts in 1998 were similar but somewhat less. By the end of the 2000 removal efforts, up to 200 man-days will have been expended on this brook trout removal project. Whether or not the expenditure of time is worthwhile depends in part on the results of the removal efforts, and should dictate whether or not removals can be considered a cost-effective method for future use in other Snake River tributaries to reduce the risk that brook trout pose on native resident salmonids.

ACKNOWLEDGMENTS

The brook trout removal project was initiated and carried out by a number of people from a number of organizations, including Idaho Division of Environmental Quality, Idaho Department of Fish and Game, U.S. Forest Service, Boise Cascade, Idaho Department of Lands, U.S. Bureau of Reclamation, and a number of volunteers. Jeff Rice and Tony Lamansky performed aging analysis, and Cheryl Leben assisted in report preparation. Funding for the evaluation phase of the removal project was provided by Bonneville Power Administration.

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PART II: DISTRIBUTION AND STATUS OF NATIVE SALMONIDS IN PORTIONS OF THE UPPER SNAKE RIVER BASIN IN IDAHO

ABSTRACT

In 1999, 182 streams were sampled for fish and habitat in several subbasins within the upper Snake River basin; fish were present in 165 streams. Redband trout *Oncorhynchus mykiss gairdneri* were the most common species of fish sampled (found in 65% of sites sampled), followed by mottled sculpin *Cottus bairdi* (28%), speckled dace *Rhinichthys osculus* (16%), brook trout *Salvelinus fontinalis* (14%), bull trout *S. confluentus* (11%), and redside shiners *Richardsonius balteatus* (9%). Bull trout occurred in only two subbasins, and were present in 22% of the sites sampled in those subbasins.

Variables that influenced the presence/absence and density of redband trout and bull trout were assessed in the subbasins in which each species occurred. Sites that contained redband trout tended to have more jams and pieces of large woody debris, dammed pool habitat, a higher gradient, and were higher in elevation than sites without redband trout. Sites that contained bull trout were higher in elevation and had higher percentages of cobble substrate and turbulent fastwater habitat than sites without bull trout. Several variables, such as conductivity and the percentages of scour pool habitat and surface fine sediment, were positively related to salmonid density and biomass; percentages of overhanging vegetation and shading were negatively correlated to density and biomass estimates.

In a direct comparison of 21 streams that were sampled in the 1980s and resampled in 1999, Yellowstone cutthroat trout *O. clarki bouvieri* densities did not change. This was the first full year of a multiyear inventorying schedule to assess the current status and distribution of native salmonids in the upper Snake River basin above Hell's Canyon Dam.

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INTRODUCTION

Declines in the distribution and abundance of native salmonids in the interior Columbia River basin of the northwestern United States have been dramatic over the last several decades, culminating with the listing of bull trout *Salvelinus confluentus* as threatened under the U.S. Endangered Species Act. Additional petitions have been filed requesting listing of redband trout *Oncorhynchus mykiss gairdneri*, westslope cutthroat trout *O. clarki lewisi*, and Yellowstone cutthroat trout *O. clarki bouvieri*. Despite the sensitive status of these fish, quantified data on the current distribution, trends, habitat, life history needs, limiting factors, and threats to persistence of native salmonids is minimal throughout much of their range (Thurow et al. 1997; Rieman et al. 1997), including in the upper Snake River basin.

Causes of decline are attributed largely to habitat alteration and degradation, competition from and hybridization with exotic salmonids, and construction and operation of hydropower and irrigation dams and diversions (Rieman and McIntyre 1993; Young 1995). Those populations that have survived tend to be located at high elevation, steep gradient reaches that are relatively unproductive (Rieman and McIntyre 1995; Young 1995). Studies identifying specific reasons for salmonid persistence in some areas and decline in other areas, however, have been rare. In 1998, Idaho Department of Fish and Game undertook a multistage project, funded by Bonneville Power Administration, to protect and restore native resident salmonids in the upper Snake River basin to self-sustaining, harvestable levels. The first phase is to fully inventory the current status and trends of salmonid populations throughout Snake River tributaries above Hell's Canyon Dam. This report documents the first full year of data collection in this phase. I also report results from a paired-sample study designed to assess whether Yellowstone cutthroat trout density in southeastern Idaho has changed at sites that were sampled in the 1980s.

OBJECTIVES

1. Assess distribution and abundance of native salmonids in selected subbasins throughout the upper Snake River subbasin.

2. Assess the influence stream attributes have on salmonid distribution and abundance.

3. Determine whether Yellowstone cutthroat trout densities at fixed stream locations in southeastern Idaho have changed from the mid-1980s to 1999.

METHODS

Native Salmonid Inventory

Stream and fish surveys took place in the Owyhee, Weiser, North Fork (NF) Payette, South Fork (SF) Boise, Raft, Goose, Portneuf, McCoy, and Salt river subbasins in the upper Snake River basin (Figure 11). The physical characteristics of the streams varied between subbasins (Table 5). Our sampling was concentrated on public land, though some sampling was done on private property; streams that had been quantitatively sampled numerous times in the recent past were avoided. Within a subbasin, streams greater than first order (determined on Bureau of Land Management 1:100,000 maps) were identified, then selected randomly until 50% had been chosen. I randomly selected three 100 m sampling sites from the mouth to the headwaters (i.e., the end of perennial flow) in all streams between 5 km and 25 km in length. In streams less than 5 km or greater than 25 km long, two or four sites were established, respectively. Sampling occurred during low to moderate flow conditions (after spring runoff and before the onset of winter) to facilitate effective fish capture.

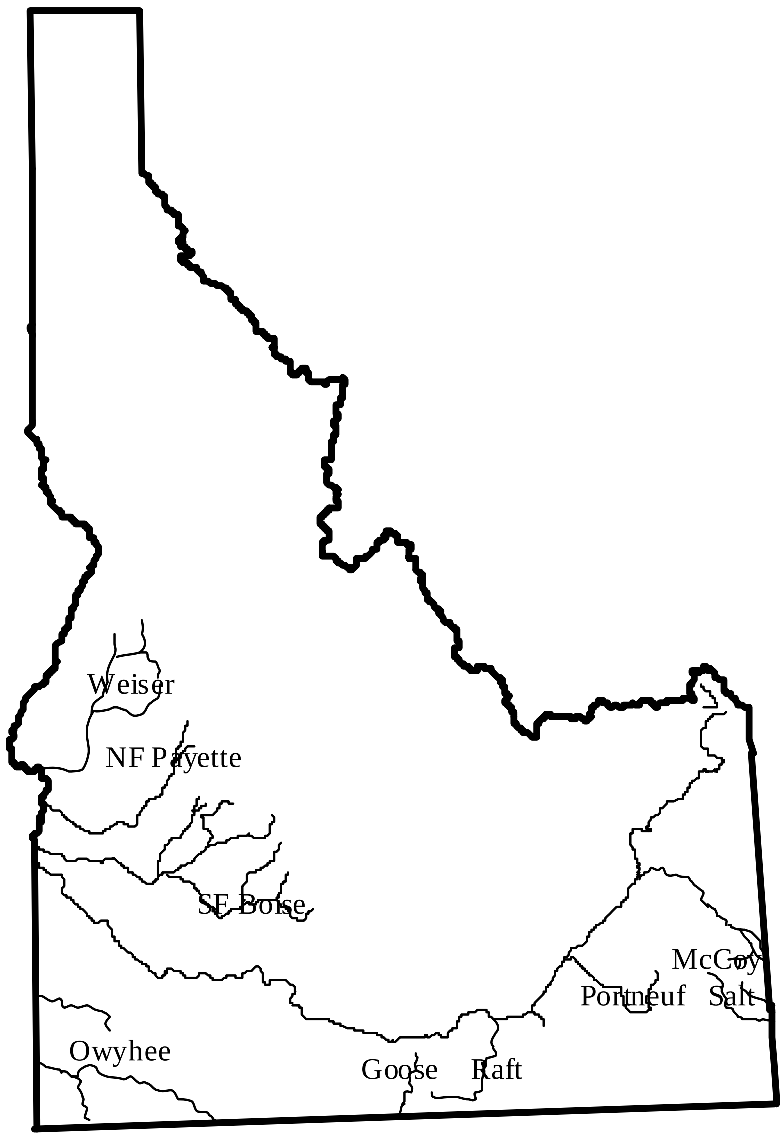

Figure 11. Map of the subbasins sampled for fish and habitat in 1999 in the upper Snake River basin, Idaho.

Table 5. Mean stream attribute values from sites within each subbasin sampled in 1999 in the upper Snake River basin, Idaho.

	Conductivity			Stream elevation			Average:			Percent of reach comprised of:			
							%	Stream	Max pool	Turbulent	\on-turbulen	Scour	Dammed
Subbasin	mean	min	max	mean	min	max	Gradient	width	depth	fastwater	fastwater	pool	pool
McCoy	316	181	400	1889	1743	2018	2.8	3.1	0.50	69.9	3.9	23.8	2.0
NF Payette	13	4	26	1843	1533	2071	5.0	4.7	0.64	54.9	14.7	20.5	9.9
Owyhee	54	14	200	1639	1399	1939	2.3	2.6	0.38	61.4	8.2	28.5	1.8
Portneuf	258	203	331	1826	1762	1926	2.7	3.3	NA	NA	NA	NA	NA
Raft/Goose	77	9	200	2216	1402	1843	2.7	2.8	0.54	50.2	14.2	26.9	8.7
Salt	431	312	790	1919	1774	2045	2.4	4.3	0.76	39.3	19.7	30.8	10.1
SF Boise	74	21	237	1906	1347	2548	5.7	3.2	0.37	73.6	4.5	18.1	3.8
Weiser	44	16	89	1559	1030	1981	5.0	3.7	0.43	79.8	3.3	15.0	1.9

To increase the number of sites that could be sampled in a given amount of time, we did not make multipass removals at every site. Instead, I developed a relationship between the number of fish captured in the first pass and the removal-depletion maximum-likelihood model estimates (n=116) from the MicroFish software package (Van Deventer and Platts 1989). From this relationship, I then predicted abundance at sites (n=70) where only a single removal pass was made (Jones and Stockwell 1995; Kruse et al. 1998). Standardized residuals were investigated to remove outliers from the regression model (Montgomery 1991). MicroFish also produced upper and lower 95% confidence intervals for the abundance estimates. Blocknets installed at the upper and lower end of the sites were used to meet the modeling assumption that the populations were closed. Fish were separated into age-0 [<100 mm total length (TL)] and age-1+ (>100 mm TL) categories, and abundance estimates were made separately for each size group. Not all populations of native salmonids in the upper Snake River basin adhere to such a length-age cutoff, but for the sake of consistency I applied this rule-of-thumb to all populations. Length was recorded for each salmonid captured and weight (g) recorded for approximately 30 fish per site. Capture efforts were focused on trout species, but at each site where they occurred, nongame fish were captured, identified to species, categorized as absent, sparse (1-10), many (10-50), or numerous (>50), and a subsample of 20 was measured and weighed.

After completing the fish survey, we measured 12 physical stream characteristics (Appendix A) and delineated and characterized habitat units within the site. Physical characteristics included Rosgen channel type (Rosgen 1994), stream order, conductivity (µS/cm), water temperature (°C), dominant left- and right-bank riparian vegetation, percent gradient, sinuosity, valley bottom type, angling pressure, streamflow condition, and land use activity. Gradient was measured with a hand-level and stadia rod at some sites and from 1:24,000 U.S. Geological Survey topographic maps at all sites. I compared the results from each method using a paired *t*-test. Habitat units were classified, following Hawkins et al. (1993), as turbulent fastwater, nonturbulent fastwater, scour pool, and dammed pool. For each habitat type, we measured the following characteristics: length, mean width, mean and maximum depth, the number of pieces or jams (two or more overlapping pieces) of large woody debris (LWD) greater than 10 cm in diameter and 2 m in length, and the number of pocketwater pockets (fastwater only). We also estimated percent of substrate that was fine (<1 mm), sand (1 mm-5 mm), gravel (5 mm-76 mm), cobble (76 mm-300 mm), boulder (>300 mm), or bedrock; percent LWD cover; percent boulder cover; percent undercut bank cover; percent overhanging vegetation cover; percent stream shading; and percent unstable banks. All percent measurements were categorized into one of the following ratings: 1 for less than 10%, 2 for 10%-25%, 3 for 25%-50%, 4 for 50%-75%, and 5 for greater than 75%.

Results from 1999 comprise the first full year of a multiyear inventory effort; thus, analysis is limited to descriptive statistics, correlation analysis, and simple regressions. A full analysis of the data collected in 1999 will be made when the inventory phase for each species of native salmonid is completed. At that time, all raw data will be included in Appendix form. For this report, I calculated mean values for each physical stream characteristic within a subbasin and tested their influence on the mean values of salmonid density, biomass, and species richness with linear regression analysis. I used *t*-tests to assess differences in physical stream characteristics with and without redband trout from sites in the Owyhee, Weiser, NF Payette, and SF Boise subbasins; differences for bull trout were assessed from sites in the Weiser, NF Payette, and SF Boise subbasins.

Yellowstone Cutthroat Trout Surveys

In October 1999, we resurveyed 21 sites in southeastern Idaho where Yellowstone cutthroat trout had been previously inventoried in the mid- to late-1980s. We chose locations where permanent markers had been made in the 1980s that could be relocated in 1999, and consequently sampled precisely the same reaches of stream for each time period. We sampled fish using multipass removal methods as above, except that in the 1980s, blocknets were not used to prevent fish movement. Based on visual examination, obvious rainbow/cutthroat hybrids that occurred at four sites in 1999 and six sites in the 1980s were considered cutthroat trout for this analysis. I calculated age-0 and age-1+ density estimates for cutthroat trout and for all salmonids collected in 1999, and reanalyzed all 1980s data, using the MicroFish software package (Van Deventer and Platts 1989). I used a paired *t*-test to assess whether densities had changed from the 1980s to 1999. In 1999 we collected genetic samples from nine of these sites to assess the degree of hybridization occurring in these streams, but the results are not available at this time.

RESULTS

Native Salmonid Inventory

We sampled 186 stream reaches, of which, based on 1:24,000 USGS topographical maps, 22% (n=42) were first order, 42% (n=78) were second order, 33% (n=62) were third order, and 2% (n=3) were fourth order. Four reaches were dry and were not sampled. Mean conductivity, stream elevation, and average maximum pool depth was highest in the Salt River subbasin (Table 5). Conductivity ranged from a low of 4 µS/cm in a North Fork Payette River tributary to a high of 790 in a Salt River tributary (Table 5). In general, subbasins whose streams had the lowest conductivities had the highest mean stream gradient. Salt River tributaries on average had higher percentages of pool habitat and lower percentages of turbulent fastwater habitat than any other subbasin, followed by Raft/Goose river subbasin streams (Table 5). Weiser and SF Boise river subbasin streams had the least amount of pool habitat. Subbasins whose streams had higher gradients generally had lower amounts of fine sediment and higher amounts of cobble and boulder substrate, and vice versa for subbasins whose streams had lower gradients (Tables 5 and 6). Gradient measurements from maps exceeded those from the hand level by 35% (P = 0.0013; n=46; Figure 12).

Table 6. Average substrate ratings from sites within each subbasin sampled in 1999 in the upper Snake River basin, Idaho.

	Average substrate rating					
Subbasin	Fines	Sands	Gravels	Cobbles	Boulders	Bedrock
McCoy	2.3	1.3	2.5	3.0	1.8	1.0
NF Payette	1.1	2.1	2.4	2.6	1.9	1.0
Owyhee	1.6	1.9	2.8	2.4	1.6	1.1
Portneuf	NA	NA	NA	NA	NA	NA
Raft/Goose	2.3	1.1	3.0	2.4	1.2	1.0
Salt	3.2	1.1	2.3	2.2	1.3	1.0
SF Boise	1.2	1.9	2.6	2.8	1.8	1.0
Weiser	1.5	1.3	2.2	2.9	2.2	1.0

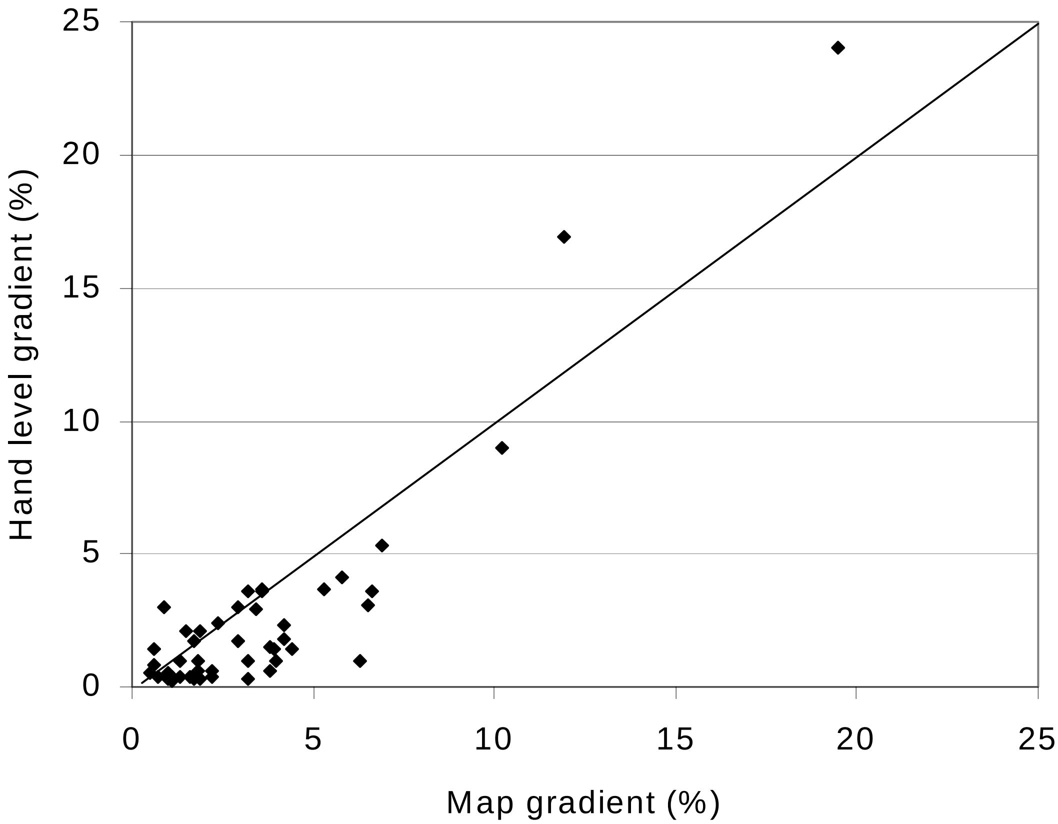

Figure 12. Comparison of stream slope estimates using a map-wheel and hand-level from a subsample of sites sampled in 1999 in the upper Snake River basin, Idaho. Line depicts a 1:1 ratio.

Of the 182 sites where fish were captured, redband trout were present in 119 (65%) sites and in five of the seven subbasins sampled (Table 7). Cutthroat were found in 20% of the sites, followed by brook trout (14%), bull trout (11%), brown trout (3%), cutthroat/redband hybrids (3%), and whitefish (1%). Bull trout occurred in two subbasins and were present in 16

(22%) sites sampled within those subbasins; they were found in elevations as low as 1350 m. Of the nongame fish sampled, sculpin were present in 34% of the sites, followed by dace (16%). Fish were absent in 9% of the sites we sampled. The number of salmonids captured in the first pass was strongly related to the corresponding multipass abundance estimate in each subbasin where the method was applied (Figures 12-16). The only factor that significantly influenced the strength of the subbasin regression models was mean percentage of turbulent fastwater for age-1+ salmonids ($r^2 = 0.96$; $P = 0.02$; n=4).

Several variables differed between sites with and without redband trout and bull trout. Sites that contained redband trout tended to have more jams and pieces of LWD, a higher percentage of dammed pool habitat, a higher gradient, and were higher in elevation than sites that were void of redband trout (Table 8). Sites where bull trout were found had a higher percentage of cobble substrate, a higher percentage of turbulent fastwater habitat, and were higher in elevation (Table 9).

Salmonid biomass on average was highest in the Salt River subbasin tributaries, followed by the McCoy Creek subbasin tributaries (Table 10). North Fork Payette River subbasin tributaries on average had the lowest salmonid densities and biomasses and also had the lowest species richness. Several variables were highly correlated with salmonid density, salmonid biomass, and species richness (Table 11). Conductivity and the percentages of scour pool habitat and surface fine sediment were positively related to juvenile and adult salmonid density, salmonid biomass, and species richness. The percentages of scour pool habitat and surface fine sediment was also positively related to juvenile salmonid density, whereas the percentage of overhanging vegetative cover and shading were negatively correlated to density and biomass. Species richness increased as the percentage of boulder substrate decreased and the percentage of total pool habitat increased.

Table 7. Summary of fish captures from sites within each subbasin sampled in 1999 in the upper Snake River basin, Idaho.

	Number of Sites Containing:											Total No.
Subbasin	**Redband**	**Cutt-bow**	**Bull**	**Brook**	**Cutthroat**	**Brown**	**Whitefish**	**Sculpin**	**Dace**	**Other**	**No. Fish**	**of Sites**
McCoy	0	0	0	0	8	0	0	3	2	2	0	8
NF Payette	11	1	0	10	3	0	0	0	0	0	9	23
Owyhee	23	0	0	0	0	0	0	4	20	13	1	36
Portneuf	1	2	0	0	4	0	0	3	0	0	0	4
Raft/Goose	21	0	0	5	10	0	0	7	4	3	0	12
Salt	0	0	0	0	10	6	2	6	4	3	0	10
SF Boise	51	2	16	0	1	0	0	32	0	0	10	67
Weiser	12	0	4	10	0	0	0	6	0	0	1	22
Totals	**119**	**5**	**20**	**25**	**36**	**6**	**2**	**61**	**30**	**21**	**21**	**182**

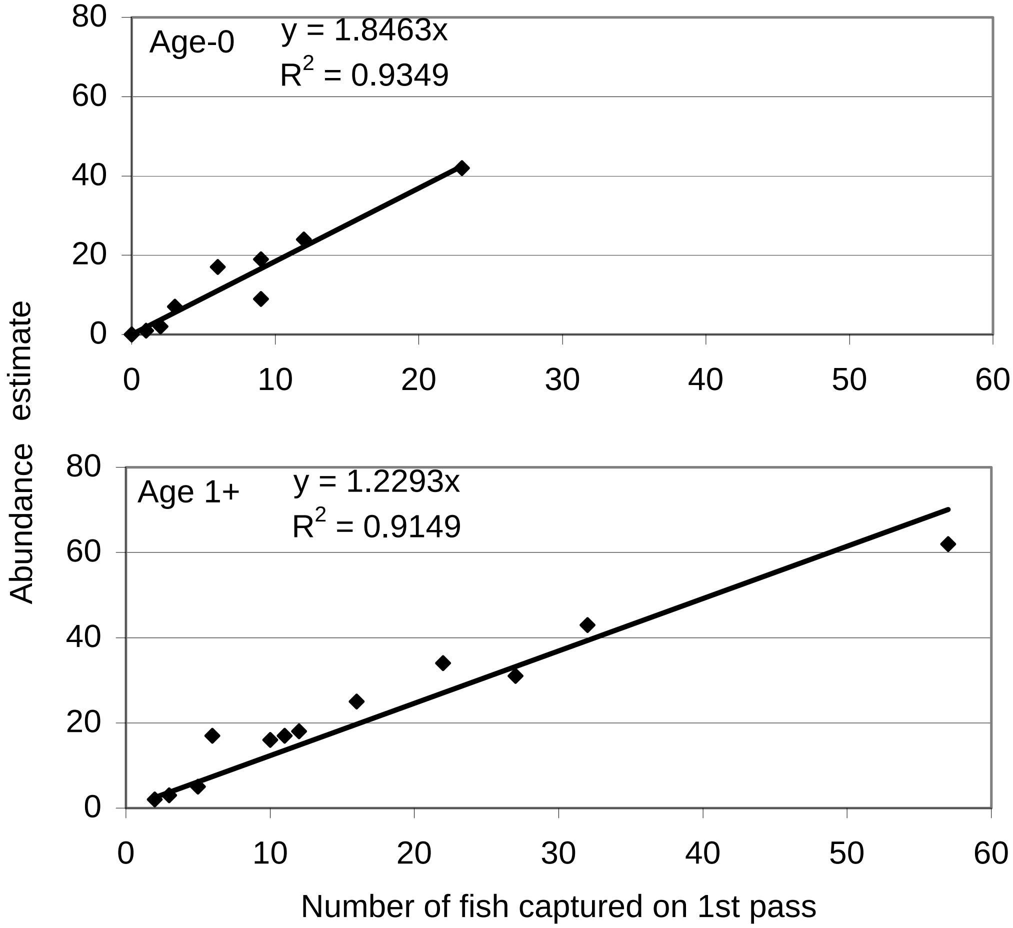

Figure 13. The relationship between the first pass and the corresponding abundance estimate of age-0 and age-1+ salmonids from North Fork Payette River tributaries in 1999.

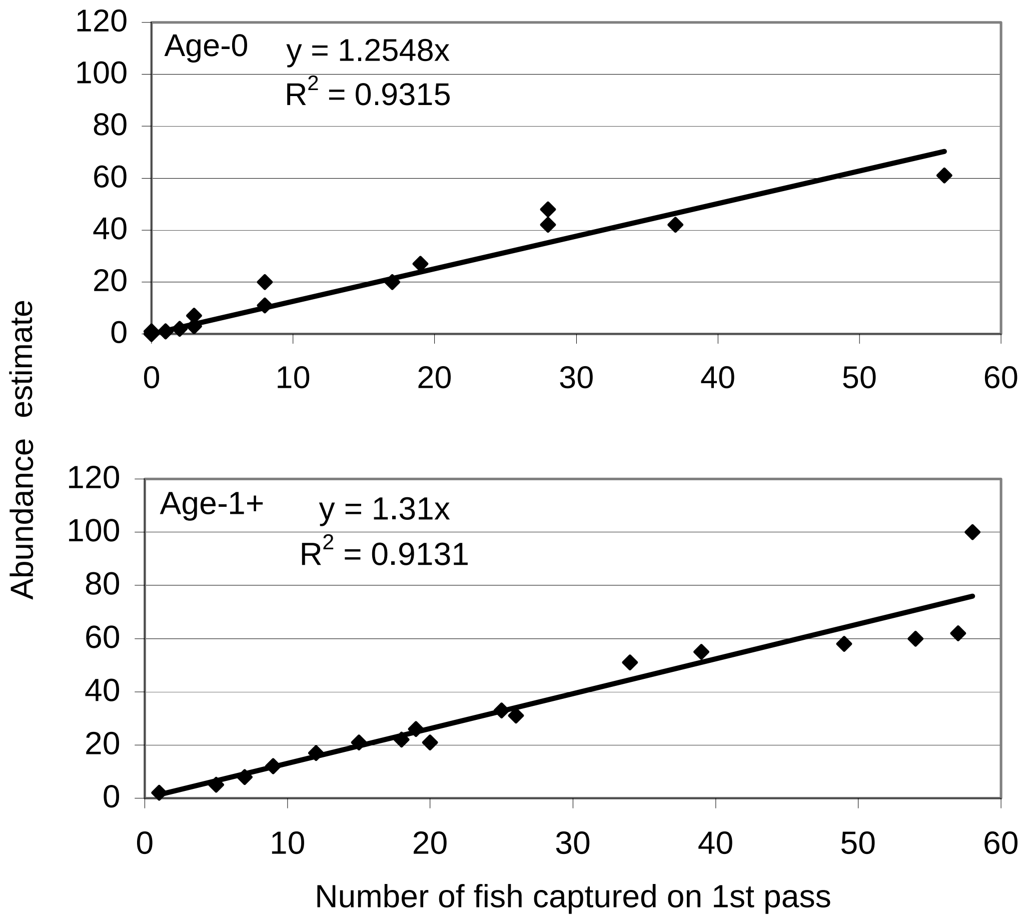

Figure 14. The relationship between the first pass and the corresponding abundance estimate of age-0 and age-1+ salmonids from Owyhee River tributaries in 1999.

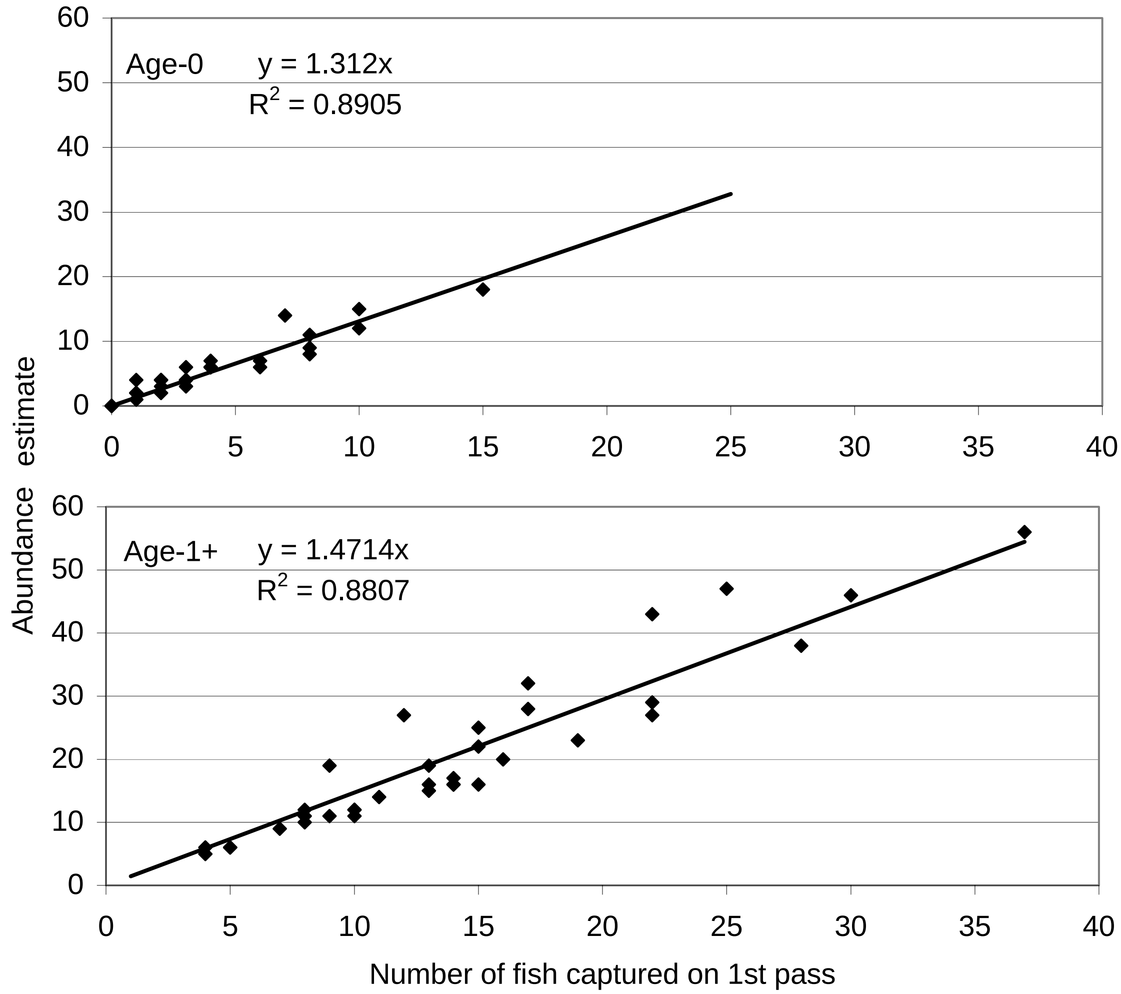

Figure 15. The relationship between the first pass and the corresponding abundance estimate of age-0 and age-1+ salmonids from South Fork Boise River tributaries in 1999.

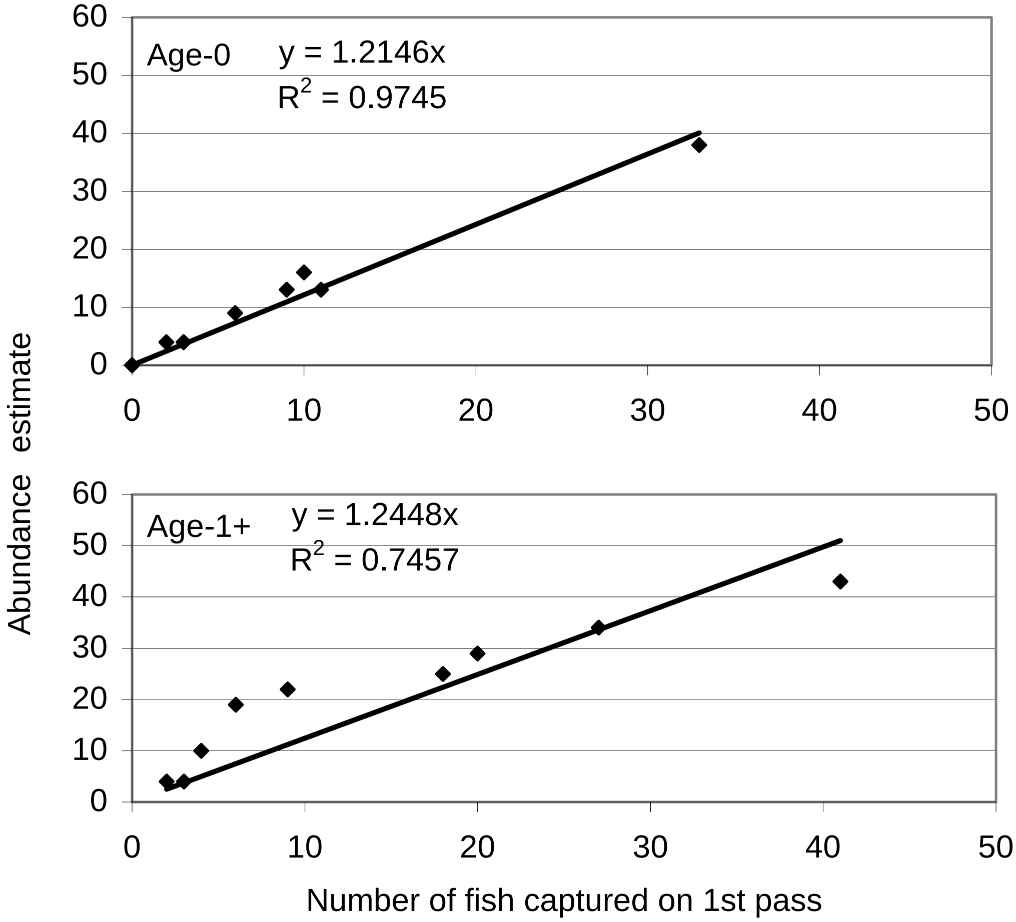

Figure 16. The relationship between the first pass and the corresponding abundance estimate of age-0 and age-1+ salmonids from Weiser River tributaries in 1999.

Table 8. Differences between sites with and without redband trout sampled in 1999 within their native range in the upper Snake River basin, Idaho.

	With redband trout		Without redband trout		
Variable	Mean	95% CI	Mean	95% CI	*P* -value
Unstable banks	1.16	0.15	1.27	0.15	0.32
Shading	2.42	0.38	2.38	0.23	0.84
Overhanging veg. cover	1.33	0.17	1.48	0.15	0.20
Undercut bank cover	1.20	0.13	1.09	0.06	0.07
Boulder cover	1.20	0.14	1.25	0.11	0.53
LWD cover	1.23	0.12	1.12	0.06	0.07
Percent boulder	1.82	0.23	1.81	0.15	0.94
Percent cobble	2.58	0.23	2.76	0.16	0.20
Percent gravel	2.55	0.21	2.52	0.16	0.85
Percent sands	1.84	0.23	1.86	0.14	0.90
Percent fines	1.37	0.27	1.30	0.14	0.61
Number of LWD jams	2.29	0.71	1.24	0.40	0.01
Number of LWD pieces	6.54	2.42	3.87	0.95	0.02
Average depth	0.14	0.02	0.13	0.01	0.20
Average maximum pool depth	0.47	0.23	0.40	0.05	0.11
Average width	3.65	0.79	3.27	0.30	0.29
% dammed pool	6.99	4.52	2.64	1.59	0.03
% scour pool	22.88	6.88	19.34	3.86	0.34
% total pool	29.87	7.24	21.98	3.98	0.04
% turbulent fastwater	63.43	8.23	70.83	4.71	0.10
Conductivity	45.62	12.09	59.08	7.92	0.06
Gradient	5.57	1.30	4.16	0.61	0.03
Elevation	6100	233	5712	174	0.01

Table 9. Differences between sites with and without bull trout sampled in 1999 within their native range in the upper Snake River basin, Idaho.

	With bull trout		Without bull trout		
Variable	Mean	95% CI	Mean	95% CI	*P* -value
Unstable banks	1.03	0.04	1.22	0.13	0.21
Shading	1.94	0.53	2.51	0.25	0.07
Overhanging veg. cover	1.17	0.22	1.48	0.16	0.10
Undercut bank cover	1.09	0.11	1.16	0.08	0.47
Boulder cover	1.33	0.37	1.20	0.10	0.34
LWD cover	1.21	0.16	1.19	0.08	0.87
Percent boulder	2.10	0.36	1.83	0.16	0.18
Percent cobble	3.28	0.27	2.67	0.17	0.00
Percent gravel	2.58	0.31	2.44	0.16	0.46
Percent sands	1.54	0.28	1.90	0.16	0.06
Percent fines	1.00	0.00	1.31	0.16	0.09
Number of LWD jams	2.47	1.23	1.83	0.47	0.28
Number of LWD pieces	5.47	2.95	5.71	1.39	0.89
Average depth	0.14	0.02	0.14	0.02	0.74
Average maximum pool depth	0.48	0.10	0.43	0.05	0.41
Average width	4.30	0.87	3.51	0.44	0.14
% dammed pool	1.40	1.98	5.52	2.71	0.19
% scour pool	16.17	5.47	18.45	3.92	0.62
% total pool	17.56	6.02	23.96	4.37	0.22
% turbulent fastwater	81.32	6.16	68.32	5.42	0.04
Conductivity	57.50	11.52	54.24	8.24	0.75
Gradient	5.71	1.32	5.32	0.82	0.70
Elevation	6369	389	5925	189	0.05

Table 10. Average salmonid density, biomass, and species richness from sites within each subbasin sampled in 1999 in the upper Snake River basin, Idaho.

Subbasin	Salmonid density (# fish/m²) < 100 mm	> 100 mm	Biomass (g/m²)	Avg # of species
McCoy	0.15	0.15	6.5	2.1
NF Payette	0.03	0.05	1.4	1.1
Owyhee	0.09	0.14	4.6	2.3
Portneuf	0.41	0.12	5.6	2.5
Raft/Goose	0.08	0.08	5.0	2.8
Salt	0.19	0.16	8.5	3.4
SF Boise	0.03	0.06	2.4	1.5
Weiser	0.02	0.06	1.9	1.6

Table 11. Correlations between stream attributes and salmonid density, biomass, and species richness from sites within each subbasin sampled in 1999 in the upper Snake River basin, Idaho.

	Trout density						Average no.	
	< 100 mm		> 100 mm		Biomass		of species present	
	r	P	r	P	r	P	r	P
Conductivity	0.65	0.08	0.80	0.02	0.90	< 0.01	0.70	0.05
Elevation	0.08	0.84	0.00	0.99	0.34	0.41	0.40	0.33
Gradient	-0.59	0.13	-0.85	0.01	-0.85	0.01	-0.84	0.01
Stream width	-0.09	0.84	0.23	0.58	-0.15	0.72	0.21	0.61
Max pool depth	0.55	0.21	-0.27	0.56	0.49	0.27	-0.46	0.30
% Turbulent Fastwater	-0.58	0.17	-0.38	0.39	-0.59	0.17	-0.68	0.09
% Non-turbulent Fastwater	0.42	0.34	0.20	0.66	0.42	0.35	0.56	0.20
% Scour pool	0.80	0.03	0.78	0.04	0.83	0.02	0.84	0.02
% Dammed pool	0.20	0.67	-0.10	0.82	0.19	0.68	0.31	0.49
% Total pools	0.66	0.10	0.50	0.25	0.68	0.09	0.75	0.05
Surface fines rating	0.91	0.01	0.75	0.05	0.95	< 0.01	0.92	< 0.01
Sand rating	-0.56	0.19	-0.39	0.38	-0.65	0.11	-0.72	0.07
Gravel rating	0.00	0.97	0.03	0.94	0.10	0.84	0.25	0.59
Cobble rating	-0.40	0.38	-0.33	0.47	-0.45	0.31	-0.68	0.09
Boulder rating	-0.60	0.15	-0.47	0.29	-0.70	0.08	-0.89	0.02
Bedrock rating	0.03	0.94	0.37	0.42	0.04	0.92	0.10	0.83
LWD cover	-0.52	0.23	-0.21	0.64	-0.47	0.29	-0.37	0.42
Boulder cover	-0.64	0.12	-0.39	0.38	-0.73	0.06	-0.74	0.06
Bank cover	0.30	0.51	0.46	0.30	0.40	0.38	0.64	0.12
Vegetation cover	-0.92	< 0.01	-0.92	< 0.01	-0.89	0.01	-0.73	0.06
shading	-0.90	0.01	-0.95	< 0.01	-0.83	0.02	-0.64	0.12
unstable banks	0.72	0.06	0.53	0.22	0.70	0.08	0.72	0.07

Yellowstone Cutthroat Trout Surveys

Yellowstone cutthroat trout density did not differ between the two time periods for age-0 (P = 0.572; Table 12) or age-1+ (P = 0.825; Table 13) fish. Average density of age-0 cutthroat increased 4% from the 1980s to 1999, while age-1+ density decreased 6%. With the exception of Sage Creek, cutthroat trout made up the bulk of the salmonids captured during both time periods. In the 1980s, cutthroat trout constituted 94% and 91% of all age-0 and age-1+ salmonids caught, respectively, while in 1999 they constituted 97% and 94%.

Table 12. Comparisons of cutthroat trout and total salmonid density (fish <100 mm) between the 1980s and 1999 in southeastern Idaho.

	1980s			1999		
	Density (fish/m²)		Percent	Density (fish/m²)		Percent
Site	Cutthroat	All Salmonids	cutthroat	Cutthroat	All Salmonids	cutthroat
Barnes Creek, lower	NA[1]	NA[1]		0.259	0.259	100
Barnes Creek, upper	NA[1]	NA[1]		0.085	0.085	100
Bear Canyon	1.631	1.631	100	0.900	0.900	100
Big Springs	NA[1]	NA[1]		NA[1]	NA[1]	
Clear Creek	NA[1]	NA[1]		0.016	0.016	100
Comb Creek	NS[1]	NS[1]		0.152	0.152	100
Crow Creek	0.050	0.050	100	0.249	0.255	98
Deer Creek	0.054	0.054	100	0.577	0.583	99
Fish Creek, lower	0.139	0.139	100	0.051	0.051	100
Fish Creek, upper	0.142	0.142	100	0.363	0.363	100
Horse Creek	0.079	0.079	100	0.313	0.385	81
Jackknife Creek	0.015	0.015	100	0.002	0.002	100
Jensen Creek, lower	0.095	0.095	100	0.173	0.173	100
McCoy Creek	NA[1]	NA[1]		0.091	0.091	100
NF Pebble Creek	0.916	0.916	100	0.979	0.979	100
Pebble Creek, middle	0.004	0.004	100	0.078	0.078	100
Pebble Creek, upper	0.190	0.190	100	0.184	0.184	100
Sage Creek	0.001	0.017	6	0.022	0.039	55
Squaw Creek	0.162	0.162	100	NS[1]	NS[1]	
Tincup Creek, lower	0.026	0.026	100	0.008	0.008	100
Tincup Creek, middle	0.053	0.053	100	0.049	0.049	100
Tincup Creek, upper	0.006	0.006	100	0.016	0.016	100
White Dugway Creek	0	0		0.020	0.020	100
Total	0.210	0.211	94.4	0.218	0.223	96.9

[1] NA = no estimate could be produced; NS = not sampled

Table 13. Comparisons of cutthroat trout and total salmonid density (fish >100 mm) between the 1980s and 1999 in southeastern Idaho streams.

	1980s			1999		
	Density (fish/m²)		Percent	Density (fish/m²)		Percent
Site	Cutthroat	All Salmonids	cutthroat	Cutthroat	All Salmonids	cutthroat
Barnes Creek, lower	0.076	0.076	100	0.120	0.120	100
Barnes Creek, upper	0.028	0.028	100	0.032	0.032	100
Bear Canyon	0.556	0.556	100	0.193	0.193	100
Big Springs	0.085	0.119	71	0.067	0.067	100
Clear Creek	0.158	0.158	100	0.098	0.098	100
Comb Creek	NS[1]	NS[1]		0.036	0.036	100
Crow Creek	0.292	0.292	100	0.249	0.276	90
Deer Creek	0.114	0.138	83	0.247	0.265	93
Fish Creek, lower	0.151	0.151	100	0.447	0.447	100
Fish Creek, upper	0.132	0.132	100	0.279	0.279	100
Horse Creek	0.162	0.171	95	0.273	0.300	91
Jackknife Creek	0.059	0.061	97	0.025	0.031	79
Jensen Creek, lower	0.081	0.081	100	0	0	
McCoy Creek	0.157	0.157	100	0.174	0.174	100
NF Pebble Creek	0.124	0.124	100	0.083	0.083	100
Pebble Creek, middle	0.069	0.087	80	0.100	0.107	94
Pebble Creek, upper	0.213	0.291	73	0.160	0.160	100
Sage Creek	0.038	0.266	14	0.055	0.317	18
Squaw Creek	0.108	0.108	100	NS[1]	NS[1]	
Tincup Creek, lower	0.111	0.112	99	0.121	0.123	98
Tincup Creek, middle	0.230	0.234	98	0.110	0.110	100
Tincup Creek, upper	0.129	0.129	100	0.042	0.042	100
White Dugway Creek	0.073	0.073	100	0.033	0.033	100
Total	0.143	0.161	91.4	0.134	0.150	93.5

[1] NS = not sampled

DISCUSSION

Native Salmonid Inventory

This was the first full year of data collection to assess the current status and distribution of native salmonids in the upper Snake River basin, and complete analysis of the factors that influence presence/absence, abundance, biomass, or other parameters is not possible at this time. Nevertheless, we found that, as is typical of many populations of native salmonids, sites where redband trout and bull trout tended to be present were higher in elevation and gradient than at sites where they were absent (Rieman and McIntyre 1995; Young 1995). It was surprising that overhanging vegetation and shading related inversely with salmonid density and biomass. However, Watson and Hillman (1997) also found a negative correlation between overhanging vegetation and abundance of bull trout and with presence-absence. It is generally accepted that overhanging vegetation is an important component of trout habitat in small streams, and that as overhanging vegetation increases, so does trout standing stock (Hunt 1976; Wesche et al. 1987). That conductivity and the percentages of fine sediment and scour pool habitat were directly related to salmonid density and biomass and to species richness indicates that fish production was higher and more diverse where slower velocity, lower gradient habitat prevailed. Such conditions have been previously shown to influence fish density, biomass, and species richness in a positive manner (Lanka et al. 1987; Rahel and Hubert 1991; Hubert et al. 1996).

In this study, gradient estimates from maps exceeded those from the hand-level by 35%. Similarly, Isaak et al. (1999) found that, on average, map wheel gradient estimates were 46% greater than hand-level estimates. They found that map wheel estimates were higher than estimates obtained with a surveying level, and attributed the overestimation to decreased resolution and the resultant inability of a map to precisely mimic stream sinuosity. However, they also found that hand-level estimates were less precise than map wheel estimates. Decreased precision may mask meaningful relations that exist between presence-absence or abundance of salmonids and stream gradient. It may be necessary to develop and apply a subbasin correction factor to map wheel measurements, based on the mean differences at sites where both measurements can be made.

Yellowstone Cutthroat Trout Surveys

Despite the fact that Yellowstone cutthroat trout abundance and distribution has been reported to be in decline over most of its range in the last several decades (Varley and Gresswell 1988; Gresswell 1995; Kruse 1998), abundance in our study streams has not changed over the last 10-15 years. Additional sites will be compared in the upcoming field season to strengthen and broaden the temporal comparison. One weakness of the comparison is that blocknets were not used in the 1980s surveys but were used in 1999, but I do not feel the conclusions would have changed. Until our genetics results are finalized, the purity status of sampled cutthroat trout is uncertain, but preliminary results suggest most populations are not introgressed with rainbow trout.

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APPENDICES

Appendix A. Description of the physical characteristics assessed at each site sampled in the upper Snake River basin during 1999.

Variable	Description
Rosgen stream type	Based on Rosgen's (1994) stream classification system of A through G.
Stream order	First-order streams are defined as the first solid blue line on USGS 1:24,000 USGS maps, second order streams form below the junction of two first-order streams, etc.
Water temperature	Instantaneous measurement (°C) at the time of sampling.
Gradient	Expressed as the percent of drop in water surface elevation per unit of channel length. Measured with hand-level at survey site or with a map wheel on a 1:24,000 USGS map.
Dominant riparian vegetation	Recorded separately for both sides of the stream as the type of vegetation making up the majority (>50%) of the stream margin riparian community. Options are; 1) non-vegetated, 2) grasses or forbs, 3) shrubs, 4) trees (including any woody material such as willows or alders).
Conductivity	Instantaneous measurement (µS/cm at 25°C) at the time of sampling.
Land use activity	One of twelve classifications to characterize the dominant land use practice in the reach. Options include; 1) agriculture, 2) forest fire, 3) young trees, 4) second-growth trees, 5) old-growth trees, 6) partial cut timber, 7) active timber harvest, 8) light grazing, 9) heavy grazing, 10) mining, 11) no use, 12) undetermined.
Streamflow conditions	One of six categories to characterize what type of streamflow is occurring during sampling. Options include; 1) dry, 2) puddled, 3) low, 4) moderate, 5) high, 6) bankfull.
Valley bottom type	One of five categories to indicate the shape of the valley bottom. Options include; 1) flat bottom, 2) v-shaped, 3) trough-like, 4) box canyon, 5) u-shaped.
Sinuosity	One of four categories to characterize the amount of curvature in the stream meanders. Options include; 1) low, 2) moderate, 3) high, 4) braided.
Angling pressure	One of three categories that indicate the level of anticipated angling pressure, ranging from low to medium to high. Observations are based on road accessibility and a visual assessment of angling

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