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A Long-Term Comparison of Yellowstone Cutthroat Trout Abundance and Size Structure in Their Historical Range in Idaho

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Abstract.—We compared estimates of population abundance and size structure for Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri* obtained by electrofishing 77 stream segments across southeastern Idaho in the 1980s and again in 1999–2000 to test whether populations of Yellowstone cutthroat trout had changed. Sites sampled in the 1980s were relocated in 1999–2000 by using maps and photographs or by finding original site-boundary stakes, so that the same reach of stream was sampled during both periods. Abundance of Yellowstone cutthroat trout longer than 10 cm did not change, averaging 41 fish/100 m of stream during both the 1980s and 1999–2000. The proportion of the total catch of trout composed of Yellowstone cutthroat trout also did not change, averaging 82% in the 1980s and 78% in 1999–2000. At the 48 sites where size structure could be estimated for both periods, the proportion of Yellowstone cutthroat trout that were 10–20 cm long declined slightly (74% versus 66%), but the change was due entirely to the shift in size structure at the Teton River sites. The number of sites that contained rainbow trout *O. mykiss* or cutthroat trout × rainbow trout hybrids rose from 23 to 37, but the average proportion of the catch composed of rainbow trout and hybrids did not increase (7% in both the 1980s and 1999–2000). Although the distribution and abundance of Yellowstone cutthroat trout have been substantially reduced in Idaho over the last century, our results indicate that Yellowstone cutthroat trout abundance and size structure in Idaho have remained relatively stable at a large number of locations for the last 10–20 years. The expanding distribution of rainbow trout and hybrids in portions of the upper Snake River basin, however, calls for additional monitoring and active management actions.

Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri* are more abundant and have a broader distribution than any other nonanadromous cutthroat trout subspecies (Varley and Gresswell 1988; Behnke 1992). Since European settlement of the western United States, the abundance and distribution of Yellowstone cutthroat trout have declined considerably in portions of their historical range (Gresswell 1995; May 1996; Kruse et al. 2000). Factors contributing to this decline include hybridization with or displacement by nonnative trout, past overharvest from sport fishing, and habitat alterations attributable to water storage and diversion, grazing, mineral extraction, and timber harvest (Thurow et al. 1988; Varley and Gresswell 1988; Gresswell 1995). Such declines led to a petition in August 1998 to list Yellowstone cutthroat trout under the Endangered Species Act (USFWS 2001).

The extent of this decline, however, remains unclear because most assessments of Yellowstone cutthroat trout status have been largely qualitative (Thurow et al. 1988; Varley and Gresswell 1988; May 1996; Thurow et al. 1997). May (1996), summarizing results from questionnaires completed by biologists with personal knowledge of localized systems, suggested that viable populations were present in only 43% of their historical range in Idaho. Thurow et al. (1997), using a similar method, estimated that Yellowstone cutthroat trout populations were strong in 32% of their entire potential range, nearly all of which occurred in Wyoming. Quantitative assessments have also focused on the proportion of historical range now occupied. For example, Kruse et al. (2000) found that 26% of the 104 trout-bearing streams in the Greybull

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and Shoshone river drainages in Wyoming outside of Yellowstone National Park contained genetically pure Yellowstone cutthroat trout.

An alternative method of assessing declines in abundance and distribution is long-term monitoring of specific populations over a broad geographic area. In 1999 and 2000, Idaho Department of Fish and Game (IDFG) personnel revisited numerous locations throughout the historical range of Yellowstone cutthroat trout in southeastern Idaho that had been sampled between 1980 and 1989. The objective of this study was to assess changes in Yellowstone cutthroat trout populations between the 1980s and 1999–2000 by comparing estimates of abundance, distribution, and size structure from these locations.

Study Area

The historical distribution of Yellowstone cutthroat trout in Idaho includes the Snake River drainage upstream from Shoshone Falls and a now extinct population from Waha Lake (Behnke 1992). The climate of the upper Snake River basin is semiarid, and many watersheds in the basin exceed 3,000 m in elevation. Discharge in most tributary streams is driven by snowmelt and peaks between April and June, but flows in the Snake River and South Fork Snake River are controlled by reservoir releases of irrigation water and often peak during the summer. Most streams are relatively productive for the Rocky Mountains, with conductivity exceeding 200 μS/cm. Mountain whitefish *Prosopium williamsoni* is the only other salmonid native to the study area, but rainbow trout *O. mykiss*, brook trout *Salvelinus fontinalis*, and brown trout *Salmo trutta* have been introduced throughout much of the upper Snake River basin. Two species of Cottidae, three species of Catostomidae, and four species of Cyprinidae are also indigenous to the upper Snake River basin (Simpson and Wallace 1982).

The study area included a large number of individual sampling sites from six main drainages within the upper Snake River basin that were originally sampled during the 1980s with electrofishing gear to obtain Yellowstone cutthroat trout abundance estimates (Figure 1). Sites ranged from 49 to 7,300 m long, from 2 to 79 m wide, and from 1,457 to 2,097 m in elevation in first- to sixth-order streams.

Methods

In 1999 and 2000, IDFG personnel involved in the original sampling from 1980 to 1989 returned to identify sites and locate site boundaries. Only those sites for which survey boundaries could clearly be determined from surveyor's stakes, field notes, maps, and photographs were chosen for resampling; subsequently, 77 sites were selected for paired sampling comparisons (Figure 1). To minimize the effect that seasonal changes can have on fish abundance (Decker and Erman 1992), sampling was replicated as close to the original calendar date as possible. Sixty-five percent of the sites were resampled within 2 weeks of the original calendar date, 88% within 4 weeks, and all within 6 weeks. All sampling occurred between mid-July and early November under base flow conditions, most of the sites (71%) being sampled in September and October.

In shallow streams less than about 8 m wide, two- or three-pass electrofishing removals were made by using backpack-mounted units and pulsed DC. Maximum-likelihood estimates of trout abundance and associated 95% confidence intervals were calculated by using the MicroFish software package (Van Deventer and Platts 1989). Where all trout were captured on the first pass, confidence intervals were not estimated. For larger streams, mark–recapture electrofishing passes were made with a canoe- or boat-mounted unit and DC or pulsed DC. Log-likelihood estimates of trout abundance and associated 95% confidence intervals were made by using the Mark Recapture for Windows software package (Montana Fish, Wildlife and Parks 1997). Mark–recapture estimates were made for each 10-cm size-class and summed for an estimate of the total number of trout present. Total length (mm) and weight (g) was measured for all captured trout. Because quantitative data were not consistently collected for mountain whitefish or for nongame fish species in the 1980s, we did not include them in the analysis.

At each site, methods used to collect fish and estimate abundance in 1999–2000 mimicked those used in the 1980s with the following exceptions: at the lower and upper sites on the Blackfoot River, depletion estimates were made in 1986 and mark–recapture estimates were made in 2000; at the upper site on Willow Creek, a mark–recapture estimate was made in 1984 but a depletion estimate was made in 2000; and block nets were not used at depletion-removal sites in the 1980s but were used at 39 (65%) of the depletion-removal sites in 1999–2000.

Abundance estimates were made only for trout longer than 10 cm and were converted to numbers of fish per 100 m of stream. Abundance of each

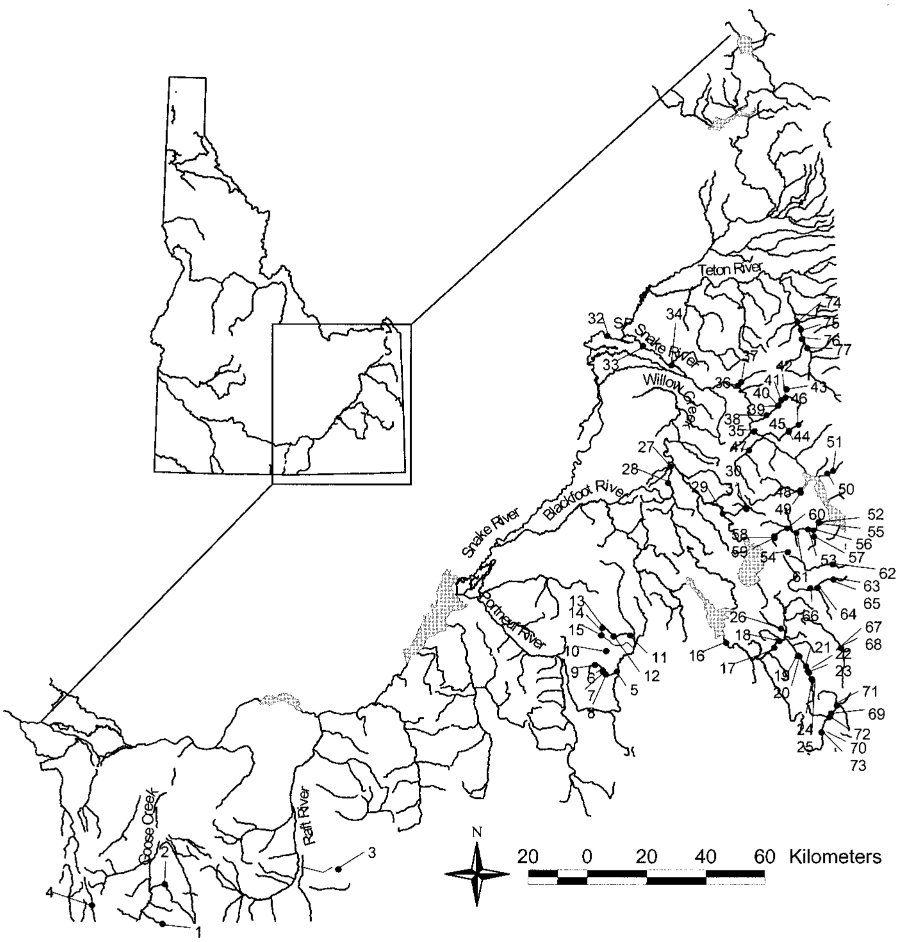

FIGURE 1.—Locations of study sites sampled in the 1980s and again in 1999–2000 across the historical range of Yellowstone cutthroat trout in Idaho. Numbers correspond to those in Table 1.

individual species of trout was estimated by multiplying the total trout abundance estimate by the proportion of the catch composed of each species. At each site, we calculated the proportion of Yellowstone cutthroat trout that were 10–20, 20–30, 30–40, and >40 cm total length and compared the proportions between periods to test for changes in Yellowstone cutthroat trout size structure. In the size-structure analysis we included only those sites where more than 20 Yellowstone cutthroat trout were caught during both sampling periods.

Many streams included in the study contained more than one sampling site. We assumed that multiple sample sites within one stream were independent samples because fish abundance did not consistently increase or decrease at sites within the same stream; of the 19 streams with more than one sampling site, nearly half (9) contained some sites that increased and others that decreased. Thus, to avoid masking the existence of such fluctuations, we did not pool sites within streams.

Yellowstone cutthroat trout, rainbow trout, and cutthroat trout × rainbow trout hybrids (hereafter called hybrids) were identified by visual examination of morphological characteristics. Yellowstone cutthroat trout were considered pure when the fish had red throat slashes, lacked white margins on the pelvic fins, and contained fewer, larger spots concentrated posteriorly. Any fish in the genus *Oncorhynchus* that had white fin margins, numerous spots toward the anterior of the body (especially the head area), and no or a faint red slash on the throat were pooled into a category of ''rainbow trout and hybrids''; estimates of abundance and proportion of catch were made for rainbow trout and hybrids combined.

TABLE 1.—Comparison of trout abundance estimates (fish/100 m for fish >10 cm) derived from removal (D) or mark–recapture (MR) methods at 77 study sites across southeastern Idaho between the 1980s and 1999–2000. Stream numbers correspond to Figure 1. Ninety-five percent confidence intervals (CIs) are blank where estimates were not possible; NA means not available.

		Study site			Total trout abundance					
					1980s			1999–2000		
Site	Stream[a]	Length (m)	Width (m)	Method	Estimate	95% CI	Year	Estimate	95% CI	Year
				Raft River and Goose Creek drainages						
1	Birch Creek	80	1.9	D	3		1987	31	31–31	2000
2	Cold Creek	60	1.5	D	5	5–10	1987	6	6–9	2000
3	Eightmile Creek	82	1.3	D	6	6–8	1986	23	23–25	2000
4	Trout Creek	110	3.2	D	55		1987	8	8–9	2000
				Portneuf River drainage						
5	Pebble Creek	207	2.3	D	59	57–62	1986	15		2000
6	Pebble Creek	98	4.6	D	39	38–43	1986	52	52–54	1999
7	Pebble Creek	104	3.6	D	80	77–85	1986	58	58–59	1999
8	Pebble Creek, NF	133	1.8	D	35	35–36	1986	15		1999
9	Big Springs Creek	105	NA	D	29	29–30	1986	28	28–30	1999
10	King Creek	70	11.3	D	7	7–9	1986	0		2000
11	Toponce Creek	180	1.7	D	1		1986	0		2000
12	Toponce Creek	89	6.6	D	112	101–127	1986	35	35–37	2000
13	Toponce Creek, MF	80	NA	D	79	79–81	1986	96	96–97	2000
14	Toponce Creek, SF	99	2.7	D	134		1987	47	45–53	2000
15	Toponce Creek, SF	113	7.2	D	31	31–32	1987	154	150–159	2000
				Blackfoot River drainage						
16	Blackfoot River	4,720	NA	D/MR	1	1–1	1988	14	12–17	2000
17	Blackfoot River	1,712	NA	MR	15	12–19	1988	44	39–48	2000
18	Blackfoot River	1,760	NA	D/MR	6	6–7	1988	20	13–27	2000
19	Diamond Creek	180	4.8	D	10	10–11	1988	11	11–12	2000
20	Diamond Creek	147	5.5	D	135	131–140	1980	69	69–70	2000
21	Diamond Creek	150	4.1	D	176	172–180	1980	67	67–69	2000
22	Diamond Creek	165	3.4	D	27	25–33	1987	71	70–73	2000
23	Diamond Creek	87	3.3	D	12	12–15	1987	48	48–49	2000
24	Diamond Creek	75	2.4	D	52	52–54	1987	56	47–77	2000
25	Diamond Creek	165	2.8	D	23	23–23	1988	48	44–54	2000
26	Sheep Creek	161	2.7	D	5		1987	6	6–7	2000
				Willow Creek drainage						
27	Willow Creek	886	8.2	MR	25	19–32	1984	5	3–6	2000
28	Willow Creek	571	NA	MR/D	92	75–109	1984	25	21–30	2000
29	Brockman Creek	93	NA	D	10	10–10	1983	27	25–34	2000
30	Corral Creek	71	1.2	D	65	52–89	1982	6	6–8	2000
31	Corral Creek	127	2.0	D	28	28–29	1982	15	15–16	2000
				Main-stem Snake River drainage						
32	Snake River	7,300	79.0	MR	21	6–55	1988	41	8–135	2000
				South Fork Snake River drainage						
33	Snake River, SF	4,800	46.0	MR	64	11–186	1989	147	30–300	1999
34	Snake River, SF	2,900	66.0	MR	95	25–200	1989	260	58–463	2000
35	Snake River, SF	4,900	71.0	MR	180	52–303	1989	282	58–514	1999
36	Burns Creek	85	5.9	D	57	53–65	1980	54	45–71	2000
37	Burns Creek	86	5.3	D	7	7–8	1980	37	37–39	2000
38	Pine Creek	66	11.0	D	52	50–57	1980	77	74–85	2000
39	Pine Creek	90	10.6	D	78	78–79	1988	24	24–27	2000
40	Pine Creek	74	5.1	D	155	135–182	1980	152	129–178	2000
41	Pine Creek	80	4.9	D	54	54–56	1988	90	90–92	2000
42	Pine Creek, NF	72	5.4	D	22	22–24	1982	18	18–19	2000
43	Pine Creek, NF	80	7.9	D	44	44–47	1981	10	10–13	2000
44	Rainey Creek	160	5.7	D	1		1980	39	34–48	2000
45	Rainey Creek	123	6.1	D	7	7–9	1980	4	4–7	2000
46	Rainey Creek	167	7.8	D	13	13–14	1980	53	53–54	2000
47	Fall Creek	133	6.0	D	13	13–15	1988	61	54–71	2000
48	Bear Creek	246	8.3	D	18	10–42	1980	72	70–74	2000
49	Elk Creek	146	3.6	D	25	19–38	1980	36	36–39	2000

TABLE 1.—Extended.

		Individual species abundance							
		Yellowstone cutthroat trout		Rainbow trout and hybrids		Brown trout		Brook trout	
Site	Stream[a]	1980s	1999–2000	1980s	1999–2000	1980s	1999–2000	1980s	1999–2000
	Raft River and Goose Creek drainages								
1	Birch Creek	1	0					1	31
2	Cold Creek	5	0					0	6
3	Eightmile Creek	6	23						
4	Trout Creek	4	7	51	1				
	Portneuf River drainage								
5	Pebble Creek	44	14	14	1			1	0
6	Pebble Creek	33	45	6	7				
7	Pebble Creek	76	44	4	14				
8	Pebble Creek, NF	35	15						
9	Big Springs Creek	24	26	5	2				
10	King Creek	7	0						
11	Toponce Creek	1	0						
12	Toponce Creek	8	5	105	1	0	29		
13	Toponce Creek, MF	3	17	76	78				
14	Toponce Creek, SF	116	46	19	1				
15	Toponce Creek, SF	29	147	2	7				
	Blackfoot River drainage								
16	Blackfoot River	1	13	0	2				
17	Blackfoot River	15	37	0	7			0	0
18	Blackfoot River	6	13	0	6			0	1
19	Diamond Creek	8	11					1	0
20	Diamond Creek	130	62	0	7			5	0
21	Diamond Creek	174	61	0	6			1	0
22	Diamond Creek	25	64	0	7			3	0
23	Diamond Creek	9	44	0	5			2	0
24	Diamond Creek	51	44	0	12			1	0
25	Diamond Creek	18	29	0	19			5	0
26	Sheep Creek	5	6						
	Willow Creek drainage								
27	Willow Creek	21	4	1	0	3	1		
28	Willow Creek	67	23	1	0	24	2		
29	Brockman Creek	8	27			2	0		
30	Corral Creek	65	6						
31	Corral Creek	28	15						
	Main-stem Snake River drainage								
32	Snake River	8	8	3	3	10	30		
	South Fork Snake River drainage								
33	Snake River, SF	21	34	0	1	42	112		
34	Snake River, SF	48	73	0	2	47	185		
35	Snake River, SF	160	177	7	55	12	51		
36	Burns Creek	57	33	0	20				
37	Burns Creek	7	31	0	2	0	4		
38	Pine Creek	52	71	0	6				
39	Pine Creek	78	24						
40	Pine Creek	155	147	0	5				
41	Pine Creek	54	83	0	8				
42	Pine Creek, NF	22	18						
43	Pine Creek, NF	44	9	0	1				
44	Rainey Creek	1	38			0	2		
45	Rainey Creek	7	4						
46	Rainey Creek	9	40	0	2	4	11		
47	Fall Creek	13	61						
48	Bear Creek	18	72	0	0				
49	Elk Creek	25	36						

TABLE 1.—Continued.

Site	Stream[a]	Study site: Length (m)	Study site: Width (m)	Method	Total trout abundance, 1980s: Estimate	1980s: 95% CI	1980s: Year	1999–2000: Estimate	1999–2000: 95% CI	1999–2000: Year
50	Big Elk Creek	97	6.9	D	8	8–9	1980	33	32–37	2000
51	Big Elk Creek	146	7.7	D	20	17–27	1980	61	58–66	2000
52	McCoy Creek	375	9.3	MR	73	47–100	1986	37	33–40	2000
53	McCoy Creek	388	8.7	MR	109	85–132	1986	118	79–156	2000
54	McCoy Creek	144	3.3	D	53	50–58	1986	57	55–61	1999
55	Jensen Creek	49	3.6	D	163	92–304	1986	0		1999
56	Fish Creek	79	1.9	D	48	45–57	1986	167	163–173	1999
57	Fish Creek	92	3.2	D	44	42–47	1986	90	86–97	1999
58	Barnes Creek	99	2.7	D	24	24–26	1986	34	28–45	1999
59	Barnes Creek	76	3.2	D	8	8–10	1986	11		1999
60	Clear Creek	122	3.2	D	62	38–107	1986	31	30–34	1999
61	Iowa Creek	97	3.6	D	26	26–27	1986	31	31–33	2000
62	Jackknife Creek	107	5.7	D	30	30–31	1987	14	14–15	1999
63	Tincup Creek	155	6.3	D	64	56–75	1987	77	73–84	1999
64	Tincup Creek	117	6.8	D	133	128–139	1987	64	62–68	1999
65	Tincup Creek	100	5.1	D	66	65–69	1987	21	21–23	1999
66	Bear Canyon Creek	52	1.8	D	88	88–92	1987	34	34–37	1999
67	Stump Creek	441	7.0	MR	54	43–66	1986	149	135–163	2000
68	Horse Creek	86	2.2	D	41	41–43	1986	75	75–77	1999
69	Crow Creek	309	5.3	MR	9	8–10	1986	43	38–47	2000
70	Crow Creek	111	4.2	D	85	82–90	1986	126	126–128	1999
71	Sage Creek	215	5.7	D	120	107–132	1987	140	139–141	1999
72	Deer Creek	157	NA	D	45	38–56	1986	85	85–86	1999
73	White Dugway Creek	84	1.8	D	14	14–17	1986	6		1999
				Teton River drainage						
74	Teton River	4,900	26.0	MR	69	8–363	1987	18	5–66	1999
75	Teton River	5,500	37.0	MR	59	10–196	1987	25	4–105	2000
76	Teton River	7,100	37.0	MR	54	10–174	1987	25	4–116	2000
77	Teton River	5,800	42.0	MR	78	10–338	1987	19	6–45	1999
Average					51			54		

[a] NF = North Fork, MF = Middle Fork, and SF = South Fork.

Fin clips were collected randomly from individuals of *Oncorhynchus* spp. at all locations. Genetic analysis for 17 arbitrarily selected sites was performed by the Aquaculture Research Institute at the University of Idaho, which followed procedures described by Campbell et al. (2002). The extent of rainbow trout introgression occurring at the study sites was assessed genetically by using species-specific restriction fragment length polymorphisms (RFLPs) of nuclear DNA (nDNA) and mitochondrial DNA (mtDNA) gene loci. Fish identified with rainbow trout nDNA or mtDNA were assigned to the category ''rainbow trout and hybrids.'' Results, reported as the proportion of individual *Oncorhynchus* fin clips that contained rainbow trout nDNA or mtDNA, were compared against our visual estimate of the rate of rainbow trout introgression (i.e., the proportion of the total catch of *Oncorhynchus* composed of rainbow trout and hybrids) based on phenotypic characteristics.

We tested whether Yellowstone cutthroat trout abundance or proportional size structure had changed from the 1980s to 1999–2000 by using paired *t*-tests (Zar 1996) and 95% confidence intervals around $\bar{d}$, the difference between means (Johnson 1995). Proportional data are known to be binomially rather than normally distributed. However, data do not need to be normally distributed for the *t*-test to apply; only the means need to be, and that property is assured by the Central Limit Theorem (Johnson 1995). Therefore, we made no transformation to the percentage data. However, because the four stock structure comparisons were not independent, we used the Bonferroni method (Sokal and Rohlf 1987) of reducing the significance value for each comparison so that the experimental type I error rate (α) did not exceed 0.05; thus the adjusted $\alpha = 0.05 \div 4 = 0.0125$.

Results

Yellowstone cutthroat trout abundance at the 77 paired sites was not different between time peri-

TABLE 1.—Extended. (Continued)

		Individual species abundance							
		Yellowstone cutthroat trout		Rainbow trout and hybrids		Brown trout		Brook trout	
Site	Stream[a]	1980s	1999–2000	1980s	1999–2000	1980s	1999–2000	1980s	1999–2000
50	Big Elk Creek	8	33						
51	Big Elk Creek	20	61						
52	McCoy Creek	72	36	0	0	1	1		
53	McCoy Creek	108	118			1	0		
54	McCoy Creek	53	57						
55	Jensen Creek	163	0						
56	Fish Creek	48	167						
57	Fish Creek	44	90						
58	Barnes Creek	24	34						
59	Barnes Creek	8	11						
60	Clear Creek	62	31						
61	Iowa Creek	26	31						
62	Jackknife Creek	29	14			1	0		
63	Tincup Creek	63	76	1	0	1	1		
64	Tincup Creek	129	64	1	0	3	0		
65	Tincup Creek	66	21						
66	Bear Canyon Creek	88	32	0	2				
67	Stump Creek	44	124			10	26	1	0
68	Horse Creek	41	71			0	5		
69	Crow Creek	4	10			5	32		
70	Crow Creek	84	117			1	9		
71	Sage Creek	19	31			100	109		
72	Deer Creek	37	79	0	1	8	6		
73	White Dugway Creek	13	6			1	0		
	Teton River drainage								
74	Teton River	12	8	46	7			12	3
75	Teton River	16	14	29	7			14	4
76	Teton River	25	15	17	7	0	0	12	4
77	Teton River	42	11	5	2			31	6
Average		41	41	5	4	4	8	1	1

ods, averaging 41 fish/100 m of stream in both the 1980s and 1999–2000 ($\bar{d} = 0.3 \pm 8.7$; $t = -0.05$; $P = 0.96$; Table 1). Abundance was lower than in 1999–2000 at 33 locations and higher at 44 locations. We also found no differences between time periods within individual drainages (Table 2), but sample sizes were low for most of these comparisons. At five locations, no Yellowstone cutthroat trout longer than 10 cm were captured in 1999–2000 where they had been captured in the 1980s, but one of these sites did contain Yellowstone cutthroat trout smaller than 10 cm. Overall trout abundance also remained relatively unchanged between time periods, averaging 51 fish/100 m in the 1980s, compared with 54 in 1999–2000 (Table 1).

Yellowstone cutthroat trout on average made up a similar proportion of the catch in the 1980s

TABLE 2.—Sample size and mean abundance (fish/100 m for fish >10 cm) of Yellowstone cutthroat trout in Idaho and *t*-test summary statistics by drainage; $\bar{d}$ is the difference between the mean for the 1980s and that for 1999–2000.

		Mean abundance		
Drainage	*n*	1980s	1999–2000	$\bar{d} \pm$ 95% CI
Raft River and Goose Creek	4	4	8	4 ± 15
Portneuf River	11	34	33	−1 ± 32
Blackfoot River	11	40	35	−5 ± 39
Willow Creek	5	38	15	−23 ± 37
South Fork Snake River	41	49	55	6 ± 14
Teton River	4	24	12	−12 ± 21
Total	77	41	41	0.3 ± 10

TABLE 3.—Comparison of the estimates of genetic and visual rates of introgression at the study sites. The genetic rate of introgression is the proportion of individual fin clips from *Oncorhynchus* spp. containing rainbow trout nuclear DNA (nDNA) or mitochondrial DNA (mtDNA), and the visual rate of introgression is the proportion of the total catch of *Oncorhynchus* spp. with phenotypic characteristics of rainbow trout and hybrids. Yellowstone cutthroat trout populations in which no hybridization was detected have introgression rates of zero; *n* is the sample size.

		Genetic rates of introgression			Visual rates of introgression	
Site	Stream[a]	*n*	nDNA	mtDNA	1980s	1999–2000
	Raft River and Goose Creek drainages					
1	Birch Creek				0	
2	Cold Creek				0	100
3	Eightmile Creek	20	0	0	0	0
4	Trout Creek				92	11
	Portneuf River drainage					
5	Pebble Creek				24	6
6	Pebble Creek				16	14
7	Pebble Creek				5	23
8	Pebble Creek, NF	47	2.1	0	0	0
9	Big Springs Creek	48	4.3	0	13	7
10	King Creek				0	
11	Toponce Creek				0	
12	Toponce Creek				93	19
13	Toponce Creek, MF				96	84
14	Toponce Creek, SF				12	5
15	Toponce Creek, SF				6	2
	Blackfoot River drainage					
16	Blackfoot River				0	13
17	Blackfoot River	24	25.0	20.8	1	16
18	Blackfoot River				2	33
19	Diamond Creek				0	0
20	Diamond Creek				0	10
21	Diamond Creek				0	9
22	Diamond Creek				0	9
23	Diamond Creek				0	10
24	Diamond Creek				0	23
25	Diamond Creek				0	39
26	Sheep Creek				0	0
	Willow Creek drainage					
27	Willow Creek	46	0	0	6	0
28	Willow Creek				1	0
29	Brockman Creek				0	0
30	Corral Creek				0	0
31	Corral Creek				0	0
	Main-stem Snake River drainage					
32	Snake River				27	29
	South Fork Snake River drainage					
33	Snake River, SF				3	4
34	Snake River, SF				0	3
35	Snake River, SF				4	24
36	Burns Creek	48	6.3	2.1	0	11
37	Burns Creek				0	7
38	Pine Creek				0	8
39	Pine Creek				0	0
40	Pine Creek				0	3
41	Pine Creek	47	22.9	13.0	0	8
42	Pine Creek, NF				0	0
43	Pine Creek, NF				0	12
44	Rainey Creek				0	0
45	Rainey Creek				0	0
46	Rainey Creek				0	4
47	Fall Creek				0	0
48	Bear Creek				0	1
49	Elk Creek				0	0
50	Big Elk Creek	30	0	0	0	0

TABLE 3.—Continued.

Site	Stream[a]	Genetic rates of introgression			Visual rates of introgression	
		n	nDNA	mtDNA	1980s	1999–2000
51	Big Elk Creek				0	0
52	McCoy Creek				0	1
53	McCoy Creek				0	0
54	McCoy Creek	38	0	0	0	0
55	Jensen Creek	30	0[b]	0[b]	0	0[b]
56	Fish Creek	48	0	0	0	0
57	Fish Creek				0	0
58	Barnes Creek	45	0	0	0	0
59	Barnes Creek				0	0
60	Clear Creek	48	0	0	0	0
61	Iowa Creek				0	0
62	Jackknife Creek				0	0
63	Tincup Creek				1	0
64	Tincup Creek				1	0
65	Tincup Creek	48	0	0	0	0
66	Bear Canyon Creek				0	6
67	Stump Creek				0	0
68	Horse Creek	48	0	0	0	0
69	Crow Creek				0	0
70	Crow Creek	44	0	0	0	0
71	Sage Creek				0	0
72	Deer Creek				0	1
73	White Dugway Creek				0	0
	Teton River drainage					
74	Teton River				80	46
75	Teton River				64	34
76	Teton River				41	28
77	Teton River	63	20.8	17.7	11	16

[a] NF = North Fork, MF = Middle Fork, and SF = South Fork.
[b] Based on fish <10 cm at site.

(82%) as in 1999–2000 (78%; Table 1). Yellowstone cutthroat trout made up 100% of the catch at 33 sites in the 1980s, compared with 100% at 25 sites in 1999–2000. The proportion of rainbow trout and hybrids in the catch also did not change, averaging 7% in the 1980s and in 1999–2000, but the number of locations where rainbow trout and hybrids were present increased from 23 to 37 sites (Table 1). Most (76%) of the expanded distribution of rainbow trout and hybrids occurred in the Blackfoot River drainage (41% of the expansion) and in two tributaries (Burns Creek and Pine Creek, including the North Fork) of the South Fork Snake River (35%). Rainbow trout and hybrids made up less than 10% of the catch at 67 sites in the 1980s and at 59 sites in 1999–2000. Brown trout and brook trout were present in 20 and 18 sites in the 1980s and in 15 and 8 sites in 1999–2000, respectively.

In general, genetic results corroborated our visual assessment of the rates of introgression at our study sites. At the 12 sites where no hybridization was visually identified and genetic results were available, no hybridization was detected in the nDNA or mtDNA of fish from 11 of the sites, whereas a rainbow trout allele was detected in the nDNA of one fish at the other site (Table 3). Of the five sites that did contain rainbow trout and hybrids based on visual identification and for which genetic results were available, percent introgression averaged 12% for visual identification, 16% for nDNA, and 11% for mtDNA (Table 3).

Yellowstone cutthroat trout size structure also remained relatively unchanged from the 1980s to 1999–2000 (Table 4). At the 48 sites where Yellowstone cutthroat trout sample sizes were large enough to calculate size structure for both periods, there was a slight but significant decrease from the 1980s to 1999–2000 in the proportion of fish that were 10–20 cm long (74% versus 66%; $\bar{d} = -8 \pm 7$; $t = -3.13$; $P = 0.003$), but the proportion of fish 20–30 cm (16% versus 18%; $\bar{d} = 2 \pm 6$; $t = 0.74$; $P = 0.47$), 30–40 cm (8% versus 12%; $\bar{d} = 4 \pm 5$; $t = 2.21$; $P = 0.03$), and longer than 40 cm (3% versus 4%; $\bar{d} = 2 \pm 3$; $t = 1.60$; $P = 0.12$) were not different between time periods. The slight

TABLE 4.—Comparison of Yellowstone cutthroat trout size structure at study sites across southeastern Idaho between the 1980s and 1999–2000. Some of the 77 sites sampled did not contain enough Yellowstone cutthroat trout to report any size structure data for a particular time period.

		Percent of Yellowstone cutthroat trout catch per size category (cm)							
		1980s				1999–2000			
Site	Stream[a]	10–20	20–30	30–40	>40	10–20	20–30	30–40	>40
		Portneuf River drainage							
5	Pebble Creek	92	8	0	0	97	3	0	0
6	Pebble Creek	90	10	0	0	68	30	2	0
7	Pebble Creek	97	3	0	0	74	26	0	0
8	Pebble Creek, NF	100	0	0	0	95	5	0	0
14	Toponce Creek, SF	74	26	0	0	83	17	0	0
15	Toponce Creek, SF	91	9	0	0	93	7	0	0
		Blackfoot River drainage							
16	Blackfoot River	14	50	14	21	15	53	5	27
17	Blackfoot River	91	6	3	0	95	2	1	2
18	Blackfoot River	35	27	25	13	43	8	18	31
20	Diamond Creek	94	6	0	0	92	8	0	0
21	Diamond Creek	98	2	0	0	97	3	0	0
22	Diamond Creek	97	3	0	0	99	1	0	0
23	Diamond Creek					100	0	0	0
24	Diamond Creek	97	3	0	0	96	0	4	0
25	Diamond Creek	93	7	0	0	98	2	0	0
		Willow Creek drainage							
27	Willow Creek	22	67	7	3	14	36	45	5
28	Willow Creek	76	23	1	0	51	45	4	0
29	Brockman Creek					4	30	65	0
30	Corral Creek	100	0	0	0				
31	Corral Creek	97	3	0	0	100	0	0	0
		Main-stem Snake River drainage							
32	Snake River	1	31	54	14	4	45	36	15
		South Fork Snake River drainage							
33	Snake River, SF	3	24	51	23	5	22	63	11
34	Snake River, SF	2	19	59	20	6	32	55	7
35	Snake River, SF	2	8	78	13	4	34	59	3
36	Burns Creek	89	11	0	0	96	0	4	0
37	Burns Creek					63	30	7	0
38	Pine Creek	91	9	0	0	98	2	0	0
39	Pine Creek	84	13	3	0	100	0	0	0
40	Pine Creek	97	3	0	0	87	12	1	0
41	Pine Creek	83	14	2	0	94	6	0	0
43	Pine Creek, NF	91	9	0	0				
44	Rainey Creek					73	25	2	0
46	Rainey Creek					41	38	20	1
47	Fall Creek					60	37	3	0
48	Bear Creek	100	0	0	0	94	5	0	1
49	Elk Creek	96	4	0	0	92	8	0	0
50	Big Elk Creek					16	9	53	22
51	Big Elk Creek	12	44	36	8	4	11	62	24
52	McCoy Creek	93	6	0	1	80	16	4	1
53	McCoy Creek	95	5	0	0	93	5	2	0
54	McCoy Creek	94	6	0	0	91	8	1	0
55	Jensen Creek	88	12	0	0				
56	Fish Creek	100	0	0	0	46	53	1	0
57	Fish Creek	94	3	3	0				
58	Barnes Creek	87	13	0	0	93	7	0	0
60	Clear Creek	93	7	0	0	95	5	0	0
61	Iowa Creek	96	4	0	0	100	0	0	0
62	Jackknife Creek	81	16	3	0				
63	Tincup Creek	88	12	0	0	42	47	11	0
64	Tincup Creek	93	7	0	0	80	17	3	0
65	Tincup Creek	97	3	0	0	81	14	5	0

TABLE 4.—Continued.

		Percent of Yellowstone cutthroat trout catch per size category (cm)							
		1980s				1999–2000			
Site	Stream[a]	10–20	20–30	30–40	>40	10–20	20–30	30–40	>40
66	Bear Canyon Creek	100	0	0	0				
67	Stump Creek	86	13	1	0	67	30	2	0
68	Horse Creek	86	14	0	0	90	10	0	0
69	Crow Creek					24	41	34	0
70	Crow Creek	78	22	0	0	83	17	0	0
71	Sage Creek	72	28	0	0	34	64	2	0
72	Deer Creek	80	18	2	0	80	19	1	0
	Teton River drainage								
74	Teton River	45	43	8	5	2	40	39	19
75	Teton River	42	51	5	2	4	15	56	26
76	Teton River	50	43	6	1	9	20	50	22
77	Teton River	53	42	4	1	16	41	32	11

[a] NF = North Fork, SF = South Fork.

decrease in the proportion of fish 10–20 cm long was caused by the large shift observed at the Teton River sites, where the percentage of fish 10–20 cm long decreased from an average of 48% to 8% between the 1980s and 1999–2000, and fish larger than 30 cm increased from an average of 8% to 64%. Excluding these data, the difference between the proportion of fish 10–20 cm in the 1980s (76%) and 1999–2000 (72%) was not statistically significant ($\bar{d} = -5 \pm 6$; $t = -2.17$; $P = 0.04$).

Discussion

Yellowstone cutthroat trout abundance and distribution in Idaho has undoubtedly declined over the last century. For example, we know of only 12 streams in the Henry's Fork Snake River drainage (excluding the Teton River drainage) that currently contain Yellowstone cutthroat trout. Similarly, Yellowstone cutthroat trout are scarce across much of the Raft River, Goose Creek, Bannock Creek, and Rock Creek drainages, although assessing the historical distribution or abundance of Yellowstone cutthroat trout in these drainages is problematic because they currently contain, and probably historically contained, few perennial streams. In the Snake River from Shoshone Falls to Idaho Falls, Yellowstone cutthroat trout are either absent or persisting at low densities. In general, these declines appear to have been the result of displacement by nonnative salmonids (rainbow trout, brook trout, and brown trout) or other nonnative game fish or of major habitat alterations, whether in the main stem of the Snake River or in headwater tributaries. Because our sample sites in the 1980s were selected not at random but as part of IDFG's general inventory sampling, some caution in extrapolating the results of this study throughout southeastern Idaho is warranted. However, the broad geographic nature of our monitoring effort, and the wide array of habitats sampled (from small creeks to large rivers), suggests that in general Yellowstone cutthroat trout abundance over the last 10–20 years in Idaho has remained relatively stable.

The distribution of Yellowstone cutthroat trout in our study sites also remained relatively stable from the 1980s to the present. We failed to capture Yellowstone cutthroat trout longer than 10 cm at only five sites that previously contained them. In 1986, the site on Jensen Creek included a large beaver pond that had breached by 1999, leaving a shallow, uncomplex section of stream that nonetheless contained several Yellowstone cutthroat trout smaller than 10 cm; moreover, Yellowstone cutthroat trout longer than 10 cm were present upstream and downstream of the site. The lower site on Toponce Creek was a degraded section of stream (180 m long) that contained one Yellowstone cutthroat trout in 1986 and none in 2001. In Birch Creek and Cold Creek, Yellowstone cutthroat trout were sparse in 1987; by 2000, the species appeared to have been completely replaced by brook trout. Our study design precluded definitive conclusions regarding changes in Yellowstone cutthroat trout distribution outside the study sites sampled. Indeed, because all sites in our study contained Yellowstone cutthroat trout in the 1980s, we could have detected only range contractions, not expansions.

Despite the implementation of restrictive harvest regulations for Yellowstone cutthroat trout in Idaho, we found no increase in size of Yellowstone cutthroat trout between the two sampling periods except at the Teton River sites. Regulations restricting harvest of Yellowstone cutthroat trout were initially implemented in the South Fork Snake River in 1984. By 1990, some form of angler harvest restrictions were in place for Yellowstone cutthroat trout in all major drainages in Idaho. Restrictions have focused on protecting spawning-size fish and have included size limits, bag limits, slot limits, and delayed openings of the fishing season in spawning streams. Except at the Teton River sites, these changes have not led to an increase in fish size, at least when comparing the sites in our study. Previous studies of size and slot limit strategies have not shown consistent improvements in stock structure (see review in Power and Power 1996).

Because salmonid populations often experience dramatic fluctuations in abundance, both temporally (Platts and Nelson 1988; House 1995) and spatially (Milner et al. 1993), detecting changes or trends in salmonid populations can be difficult (e.g., Rieman and Myers 1997). Such population fluctuations are often the result of environmental fluctuations, such as floods, low flows, or severe winter conditions, which temporally vary in frequency as well. Because our sampling during both periods occurred over multiple years, the potential spatial and temporal fluctuations in fish abundances that make before–after analyses difficult may have been somewhat mitigated by dispersing such environmental fluctuations over more than 1 year of sampling. Platts and Nelson (1988) and Bohlin et al. (1989) suggested that a study design such as ours, with paired comparisons incorporating more than 1 year of sampling, would be more likely to detect changes in trout populations if they occurred. We recommend that these sites be monitored regularly in the future to further elucidate trends in Yellowstone cutthroat trout abundance, distribution, and size structure.

Rainbow trout and hybrids were present in almost half of the comparison sites in 1999–2000. However, we urge caution in extrapolating hybridization results to other areas in Idaho containing Yellowstone cutthroat trout for two reasons. First, most of the expansion was concentrated in the Blackfoot River drainage and in two tributaries of the South Fork Snake River. Outside of these 17 sites, rainbow trout and hybrids were present at 21 of the remaining 60 sites in the 1980s, compared with 22 sites in 1999–2000, making up an average of 9% of the catch in the 1980s and 6% in 1999–2000. Second, recent large-scale random sampling in southeast Idaho suggests that Yellowstone cutthroat trout hybridization may be less widespread than this study would indicate. For example, in this study, rainbow trout and hybrids were captured in 73% of the sites in the Portneuf River drainage and all sites in the Teton River in 1999–2000. But in 2000–2001, when IDFG personnel also sampled 88 randomly distributed sites in the Portneuf River drainage and 90 randomly distributed sites in the Teton River drainage, they found rainbow trout and hybrids in only 17% and 8%, respectively, of the sites that contained Yellowstone cutthroat trout (K. A. Meyer, unpublished data). Such discrepancies may be a reflection of the sampling design used in our present comparison. In general, sites for this study were established in the 1980s in the lower segments of streams with greater angling pressure, where rainbow trout were more often stocked and where subsequent hybridization was more likely to develop. Nevertheless, we agree with the assertion by Kruse et al. (2000) that controlling hybridization is an important factor in assuring the long-term persistence of Yellowstone cutthroat trout. Management activities, such as stocking only sterile triploid rainbow trout in the few places where hatchery stocking within the historical range of Yellowstone cutthroat trout still occurs (Dillon et al. 2000), and large-scale removals of rainbow trout and hybrids through electrofishing, trapping of migrating spawners, and liberalized regulations for rainbow trout and hybrids have been implemented and are being evaluated throughout southeastern Idaho.

Our study design had important limitations.The lack of randomization in site selection makes any extrapolation of Yellowstone cutthroat trout abundance and size structure beyond the areas that we sampled problematic. In addition, the visual identification of hybridization we used at most sites was less reliable than genetic analysis would have been, although the genetic results we report do support our phenotypic identifications, and recent studies have demonstrated the accuracy that can be achieved in identifying Yellowstone cutthroat trout × rainbow trout hybrids with phenotypic characteristics (Kruse 1998; Campbell et al. 2002). Lastly, using block nets at many of the removal sites in 1999–2000 that in the 1980s were not sampled with block nets may have resulted in biased estimates between time periods at these sites. However, we do not believe that the block net differences affected our results appreciably for several reasons. First, site boundaries were placed in riffles where swift streamflow probably discouraged upstream escapement by fish. Second, we saw no indication of a concentration of salmonids in the vicinity of the block nets at the sites where nets were used. Third, the discrepancy involved only 51% of the sites, and we found no pattern of increased or decreased abundance related to whether or not block nets had been used in 1999–2000. Finally, as others have previously suggested, the use of block nets in small streams may not be necessary for territorial salmonids (Bohlin et al. 1989; Simonson and Lyons 1995).

Despite these limitations, our results indicate that Yellowstone cutthroat trout abundance, distribution, and stock structure have remained relatively unchanged from the 1980s to 1999–2000 at a large number of locations across their historical range in Idaho. However, during the study periods, we found that rainbow trout and hybrid distribution expanded in two major drainages. Continued monitoring of trout populations, in the reaches we monitored and in a more widely distributed sample, will be necessary to determine rangewide trends in Yellowstone cutthroat trout populations in Idaho.

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