MAMMOTH CREEK 1999

FISH COMMUNITY SURVEY

Prepared for:

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INTRODUCTION

An important issue in the process of establishing instream flow regimes for Mammoth Creek is protection of the fishery resource. Mammoth Community Water District (MCWD) has conducted comprehensive, quantitative studies of instream flows, habitat availability, and fish populations in Mammoth Creek, resulting in suggestions for a "minimum bypass flow regime" and long-term information on trends in fish numbers and size structures (Hood et al. 1992, 1993, 1994; Jenkins and Dawson 1996, 1997; MCWD 1998).

We report the results of another year of Mammoth Creek fish community monitoring, carried out from 24 to 29 September, 1999. The objectives of this study were: (1) to determine the status of Mammoth Creek trout populations at various locations along its length; (2) to compare current trout densities and size structures at these locations with those of past years; and (3) to correlate interannual changes in Mammoth Creek fish populations with hydrologic conditions.

STUDY AREA

The Mammoth Creek study area extends from Lake Mary downstream to the confluence of Mammoth Creek and Hot Creek, a distance of approximately 10.4 miles (Fig. 1). Fish population studies have concentrated on the lower 8.9 miles, where stream discharge is apparently considered most likely to influence the amount of trout habitat (Bratovich et al. 1992; Hood et al. 1993). This lower stream area has been divided into four contiguous stream *reaches*, each of which contains two randomly located *sampling sections* or *electrofishing sites* for assessment of fish populations (one high riparian cover, one low riparian cover, Bratovich et al. 1990).

The downstream boundaries of all but one sampling section have remained the same through all surveys from 1988 on. The lowermost section was not accessible after 1994, so we established an alternate site extending 300 feet downstream from the boundary of U.S. Forest Service land, just upstream from the confluence of Mammoth and Hot Creeks (Fig. 1). This section is most nearly comparable to Section 5 in Deinstadt et al. (1985). The 1988 sections covered 100 feet of channel and the 1992 and subsequent sections have been 300 feet in length (Bratovich et al. 1990; Hood et al. 1992).

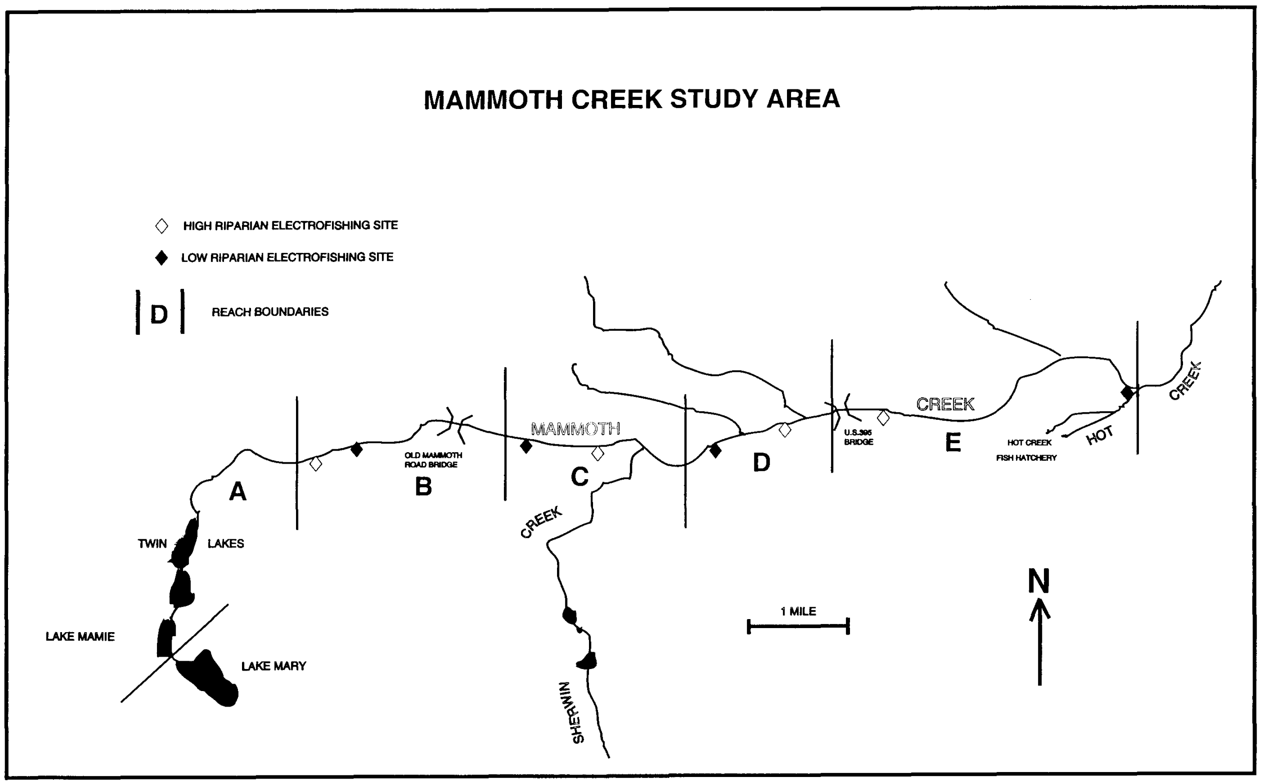

Figure 1. Electrofishing sites on Mammoth Creek, September,1999 (modified from Hood et al. 1993).

METHODS AND MATERIALS

Selection of Sampling Sites

For compatibility with previous studies, we utilized the same "representative" electrofishing sites established by Beak Consultants Incorporated (Beak), the firm that designed and carried out population studies on Mammoth Creek until 1995 (see Bratovich et al. 1990 for rationale of site selection). One day prior to operations, we relocated the sites and sank lengths of 0.5 inch rebar in the banks at the upstream and downstream ends to help anchor block nets.

Collection Methods

On census days, we simultaneously placed block nets of 0.19 inch mesh at the upstream and downstream ends of a section to prevent fish from moving across the boundaries. We captured fish with one or two Smith-Root Type 12 portable electrofishers (depending on stream width), our crew typically consisting of one person operating each electrofisher, a netter flanking each operator, one person receiving and transporting fish, and a person maintaining the block nets and processing fish. We collected fish in a series of "passes", each consisting of shocking across the downstream net, proceeding to the upper net with each electofisher covering half the stream, shocking across the upper net, then passing once again across the lower net to capture any fish that were impinged there by the current. Because multiple-pass depletion estimates of populations assume equal "effort" on each pass, we standardized the technique and elapsed time as much as possible.

We collected fish in 3 gallon buckets and transferred them to submerged mesh bags outside the electrofishing field until time was available for processing. Underyearling (age 0+) fish were stored separately to prevent cannibalism. As time permitted, we slowed the fish with dissolved CO_2, identified them to species, measured their fork length to the nearest millimeter and weighed them to the nearest 0.1 gram. Fish were then allowed to recover in the mesh bags and were dispersed along the section when electrofishing was concluded. Fish of hatchery origin were tentatively distinguished from wild fish by deformation of dorsal fin rays and other, more subjective, aspects of their appearance.

Population Estimates

For consistency with previous Mammoth Creek studies (Hood et al. 1993, 1994; Jenkins and Dawson 1996, 1997), we estimated brown trout numbers in sampling sections by a multiple-pass depletion method. Statistics were computed on Microfish software (Van Deventer and Platts 1986), then extrapolated to fish/mile densities for comparison with prior censuses (Bratovich et al. 1990; Hood et al. 1992, 1993, 1994; Jenkins and Dawson 1996, 1997). We also estimated rainbow trout population densities and compared them with similar data from past MCWD research.

By means of length-frequency analysis (see below), we divided fish from each electrofishing pass into age 0+ and age ≥1+ components and estimated their numbers by the depletion method noted above. Since there were often too few adults to support a separate analysis, we estimated their numbers by subtracting underyearling estimates from the total population estimates. Although trout were not aged directly, separation of 0+ from older fish on the basis of length appeared unambiguous within individual sampling sections. That is, the first (presumptive underyearling) and second length categories rarely overlapped.

Analysis of Size Distribution and Estimation of Age Structure

We sorted fork lengths of trout into 10 millimeter size intervals and plotted them on frequency histograms. In this manner, we compared size (and inferred age) distributions of brown and rainbow trout among reaches for 1999 and among years for the four reaches. Separation of size classes and inference of ages was more ambiguous for larger fish than it was for underyearlings, because they were fewer in number and their average sizes were more similar.

RESULTS

Species Composition and Relative Abundance in Samples

We captured 1186 fish from four species, ranking in abundance: brown trout (821, 69%), rainbow trout (308, 26%), Owens sucker (51, 4%), and tui chub (6, 0.5%) (Table 1). Suckers were found only in electrofishing sections DH and EL, and tui chubs were found only in electrofishing section EL. The proportion of brown trout was down from 81% in 1997 (the last year censused), but the proportion of rainbow trout was up from 19% . If we eliminate hatchery fish from the analysis because they are temporary residents, brown trout comprised 75% of the sample, and rainbow trout 16%. Tui chubs and suckers were scarce, but their numbers were up from virtual absence in 1997.

Table 1. Electrofishing results in Mammoth Creek, Mono County, California, 24-29 September, 1999.

COMMON NAME	SCIENTIFIC NAME	REACH	COVER HIGH	COVER LOW	TOTAL
brown trout	*Salmo trutta*	B	257	66	323
		C	91	17	108
		D	116	34	150
		E	122	118	240
		TOTAL	586	235	821
rainbow trout (presumed wild)	*Oncorhynchus mykiss*	B	7	23	30
		C	31	66	97
		D	32	29	61
		E	19	11	30
		TOTAL	89	129	218
rainbow trout (presumed hatchery)	*Oncorhynchus mykiss*	B	0	2	2
		C	9	50	59
		D	3	2	5
		E	23	1	24
		TOTAL	35	55	90
brook trout	*Salvelinus fontinalis*	B	0	0	0
		C	0	0	0
		D	0	0	0
		E	0	0	0
		TOTAL	0	0	0
tui chub	*Gila bicolor*	B	0	0	0
		C	0	0	0
		D	0	0	0
		E	0	6	6
		TOTAL	0	6	6
Owens sucker	*Catostomus fumeiventris*	B	0	0	0
		C	0	0	0
		D	2	0	2
		E	0	49	49
		TOTAL	2	49	51
			GRAND TOTAL		1186

We found "wild" rainbow trout in all sections, and they were accompanied by apparent hatchery plants except in section BH. Most larger rainbow trout appeared to be of hatchery origin, except in Reach E (Fig. 2). Fifty-nine percent of the presumed wild rainbow trout and 61% of the presumed hatchery rainbow trout were living in "low riparian" habitats (Table 1). In contrast, only 29% of the brown trout were found in "low riparian" habitats.

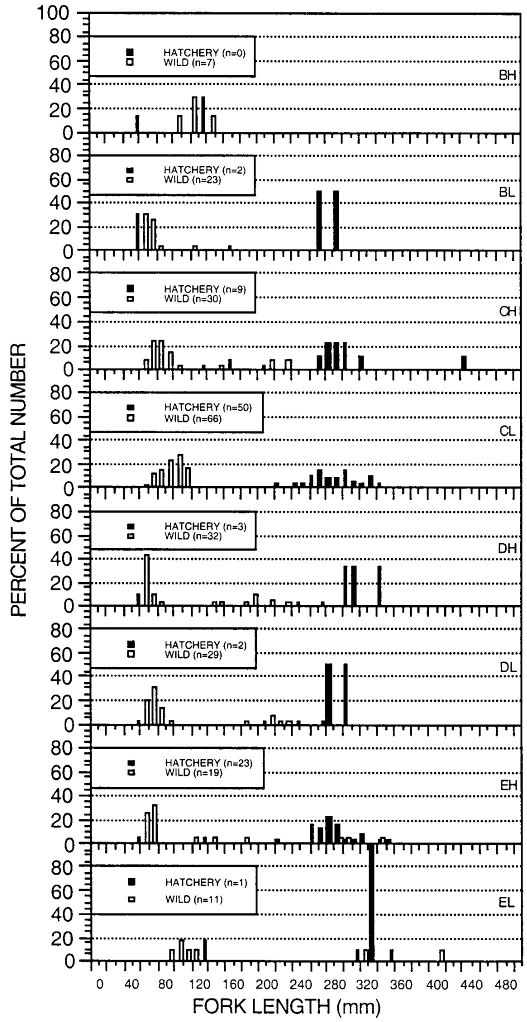

Figure 2. Length distributions of "wild" and "hatchery" rainbow trout in Mammoth Creek, 24-29 September , 1999. Tick marks are the upper boundaries of size intervals. For example, 200 is the upper boundary of the size class >190 mm but ≤200 mm.

Trout Population Estimates

Estimated brown trout population densities varied from 299 to 5333 fish/mile in the sampling sections (average 1951), with the greatest number occurring in the highest elevation section (Table 2 and Appendix A). Density averaged 2790/mile in the "high riparian" sections and 1113/mile in the "low riparian" sections. If we exclude data from the new Section EL, which has extensive cover in the form of undercut banks, brown trout from low riparian sections averaged only 751/mile.

Table 2. Estimated numbers, by section, and extrapolated densities (trout/mile) of brown and presumed wild rainbow trout captured by electrofishing in Mammoth Creek, Mono County, California, 24-29 September, 1999.

SECTION	BROWN TROUT PER SECTION	BROWN TROUT PER MILE	RAINBOW TROUT PER SECTION	RAINBOW TROUT PER MILE
BH	303	5333	7	123
BL	76	1338	38	669
CH	82	1443	31	546
CL	17	299	67	1179
DH	125	2200	39	686
DL	35	616	29	510
EH	124	2182	19	334
EL	125	2200	11	194

Presumed wild rainbow trout were less abundant than brown trout in all sections but CL, with densities ranging from 123 to 1179/mile (average 530, Table 2). Wild rainbow trout density averaged 422/mile in the "high riparian" sections and 638/mile in the "low riparian" sections.

Trout Size Distribution and Growth Rates

All Reaches Combined: We counted fish in a size/age class by examining distributions from individual sections and pooling the results. This was necessary because variability in growth rates among sections shifted length distributions up or down the size scale, enhancing the appearance of overlap among size groups (Fig. 3). Fish in the most numerous brown trout size class ranged from 40 to 129 mm fork length and accounted for 68% of the 821 brown trout captured; presumably all of these fish were underyearlings (age 0+). The next larger size class, ranging from 108 to 190 mm fork length and accounting for 13% of the total, were presumably one-year-old fish. A third size class (8% of the total) ranged from 172 to 247 mm FL, and probably consisted primarily of 2-year-olds. The remaining 91 individuals (11%) ranged from 210 to 340 mm fork length, and undoubtedly varied in age from 3 to several years. The wild rainbow trout population contained a slightly higher proportion of 0+ fish than the brown trout population (76%), and like brown trout 0+, rainbow trout fry were collected in all 8 sections (Fig. 2).

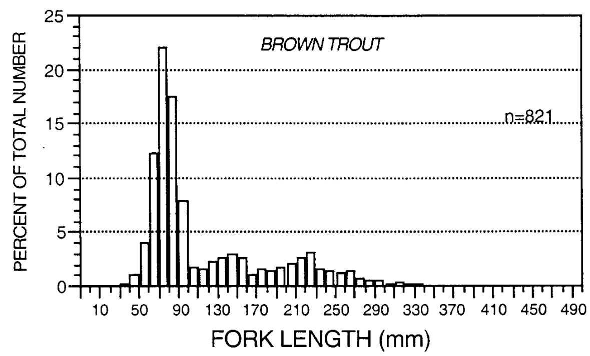

Figure 3. Length distribution of all brown trout captured at 8 electrofishing sites in the Mammoth Creek study area, 24-29 September, 1999. Size intervals are 10 millimeters.

Individual reaches and sections: The majority of brown trout in all reaches were underyearlings, although fish of this age were relatively least abundant in Reach C (56% of sample, Fig. 4). Analysis by individual sections (Fig. 5) found underyearling brown trout proportionally least abundant in section DL (35% of sample). Six of 11 brown trout over 300 mm long resided in EL, the lowermost section; all of the presumed wild rainbow trout over 300 mm (4 of 4) resided in that section.

DISCUSSION

Species Composition in Samples

Among native and non-native fishes in the Mammoth Creek study area, the European brown trout (*Salmo trutta*) evidently finds conditions most favorable. Introduced rainbow trout (*Oncorhynchus mykiss*) have fared less well, although their numbers have been relatively stable in recent years (Table 3). Possibly rainbow trout have difficulty spawning during spring snowmelt (brown trout spawn in the fall), or the size advantage of brown trout when both species are most vulnerable (age 0+) might give them a survival edge. Nevertheless, both species appear to be reproducing in all of the sampling sections (Figs 2, 5). Brook trout (*Salvelinus fontinalis*) from the eastern U.S. were again not found in the study reaches this year. Native Tui chubs and suckers were collected only in the downstream reaches of the creek, and their numbers were small (Table 1).

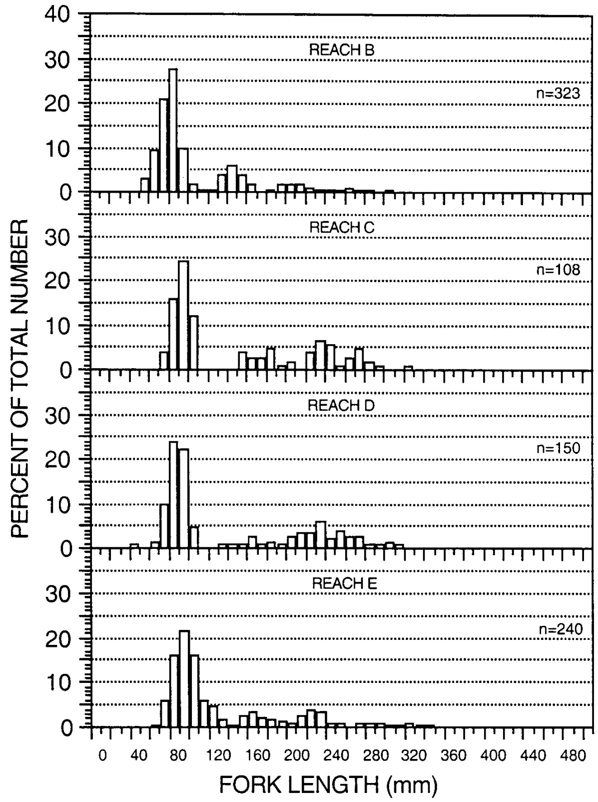

Figure 4. Length distributions of brown trout captured by electrofishing in Reaches B, C, D, and E of Mammoth Creek, 24-29 September, 1999. Size intervals are 10 millimeters.

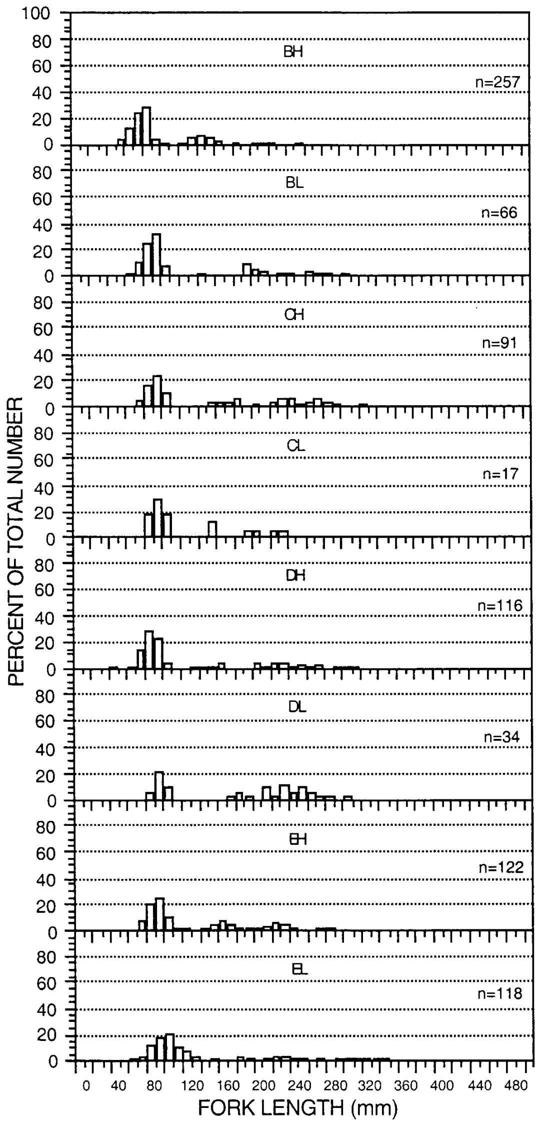

Fig. 5. Length distributions of brown trout captured in 8 sampling sections on Mammoth Creek, 24-29 September 1999.

Table 3. Estimated average population densities for brown and presumed wild rainbow trout in Mammoth Creek, on 8 sampling dates over 12 years. Numbers in parentheses exclude data from section EL, a location somewhat downstream from that used by Beak in 1988-1994 studies. Either EL site could include temporary migrants from Hot Creek.

YEAR	BROWN TROUT PER MILE	RAINBOW TROUT PER MILE
1999	**1951(1916)**	**530(578)**
1997	**2385(2469)**	**568(636)**
1996	**1379(1413)**	**588(591)**
1995	**592 (528)**	**78 (61)**
1994	2079	437
1993	1289	57
1992	1681	222
1988	2290	60

Brown and Rainbow Trout Populations

Trout numbers in Mammoth Creek were depressed in 1995 relative to most other years for which data are available (Jenkins and Dawson 1996), but they have since recovered (Table 4). Brown trout density is presently 82% of the highest recorded level in 1997, and rainbow trout are at 90% of their high in 1996 (Table 3). Brown trout continue to dominate the trout community with 79% of the total, although their proportion was even higher during the first 5 census years (83-99%, Table 3).

Size and Age Structure of Trout Populations

In addition to the expected numerical dominance of underyearling brown trout throughout the stream, at least two additional age groups were present in every reach, and possibly many more (Fig. 4). The number of wild fish over 300 mm (11.8 inches) was negligible in both species (<2%), presumably due to a combination of short life span and insufficient resources for sustained growth in later years.

Possible Reasons for Population Fluctuations

Year-to-year changes in the Mammoth Creek brown trout population have consisted largely of variations in reproductive success, with the adult population remaining relatively stable (Fig. 6). In 1988, 1992, 1994, 1996 and 1999, brown trout underyearlings were relatively abundant compared to older fish, whereas in 1991, 1993

Table 4. Population estimates (trout/mile) and 95 percent confidence limits for brown trout captured by electrofishing Mammoth Creek, Mono County, California, 2-4 November, 1988, 21-28 October, 1992, 11-19 October, 1993, 4-11 October, 1994, 1-7 November, 1995, 3-8 October, 1996, autumn 1997 (date unknown), and 24-29 September, 1999. From data in Hood et al. 1994, Jenkins and Dawson 1995, Jenkins and Dawson 1996, MCWD 1997, and the present study.

SITE	YEAR	LOWER CONFIDENCE BOUNDARY	POPULATION ESTIMATE	UPPER CONFIDENCE BOUNDARY
BH	1988	2904	3168	3617
	1992	2992	3045	3128
	1993	2558	2957	3356
	1994	3915	4171	4427
	1995	1654	1760	1901
	1996	3942	4840	5738
	1997	8200	8589	8977
	1999	4789	5333	5877
BL	1988	4488	4699	5028
	1992	1830	1848	1895
	1993	2570	2658	2770
	1994	2235	2253	2309
	1995	528	546	616
	1996	158	158	158
	1997	669	704	789
	1999	1162	1338	1582
CH	1988	1109	1109	1202
	1992	546	563	621
	1993	475	510	609
	1994	722	810	980
	1995	299	334	453
	1996	1250	1302	1390
	1997	1637	1690	1784
	1999	1426	1443	1494
CL	1988	1848	1901	2069
	1992	827	845	906
	1993	1038	1232	1514
	1994	528	528	567
	1995	88	88	100
	1996	158	158	194
	1997	211	211	232
	1999	299	299	330
DH	1988	2006	2006	2124
	1992	1338	1390	1482
	1993	1056	1056	1089
	1994	4268	4418	4567
	1995	563	616	737
	1996	1778	1901	2059
	1997	546	616	771
	1999	2042	2200	2383

Table 4 (concluded).

SITE	YEAR	LOWER CONFIDENCE BOUNDARY	POPULATION ESTIMATE	UPPER CONFIDENCE BOUNDARY
DL	1988	1056	1056	1122
	1992	1584	1584	1611
	1993	510	510	551
	1994	1514	1584	1696
	1995	-[a]	18	-[a]
	1996	563	634	792
	1997	1619	1654	1725
	1999	598	616	678
EH	1988	4171	4277	4493
	1992	3925	3978	4053
	1993	1197	1232	1302
	1994	2006	2464	2929
	1995	299	334	458
	1996	810	898	1056
	1997	3749	3819	3910
	1999	2147	2182	2255
EL	1988	106	106	479
	1992	194	194	209
	1993	158	158	169
	1994	405	405	412
	1995	1038	1038	1062
	1996	1144	1144	1162
	1997	1742	1795	1879
	1999	2076	2200	2349

[a]Due to a capture pattern of 1-0-0, estimate is assumed to be exactly correct, with no confidence limits.

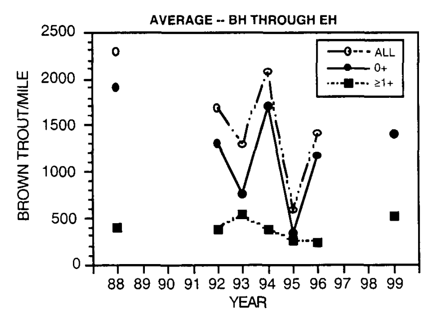

Figure 6 Average estimated numbers of young-of-year and older brown trout in Sections BH through EH during the census years 1988, 1992-1996, and 1999. Adult numbers were obtained by subtraction of separate YOY estimates from total estimates. Note that data are not available for 1989-1991, and 1997-1998. Data from EL were eliminated because a new location somewhat downstream of previous years was used in 1995-1997 and 1999.

and 1995 the proportions of underyearlings were down (Fig. 7). There is a hint that parallel changes in the reproductive success of rainbow trout occurred during the same period, perhaps resulting from the same environmental conditions. However, the 1988 year class of rainbow trout appears to have been surprisingly small (or small fish were poorly sampled), and we have no data for 1991 (Fig. 8).

In the survey year with highest flow, 1995, brown trout population density in 7 of the 8 sampling sections ranked lowest of the 8 census years, and in the second highest discharge year, 1993, density ranked second lowest in 4 of 8 sections (Table 3, Figs. 9, 10). This apparent negative response of populations to high flows is better defined in juvenile fish, perhaps because they have poor swimming ability and meager energy reserves during much of the snowmelt runoff (Fig. 11). Older brown trout seem less susceptible to all but the highest flows, presumably because they can negotiate virtually any current, and they have large quantities of stored energy (see Fig. 12).

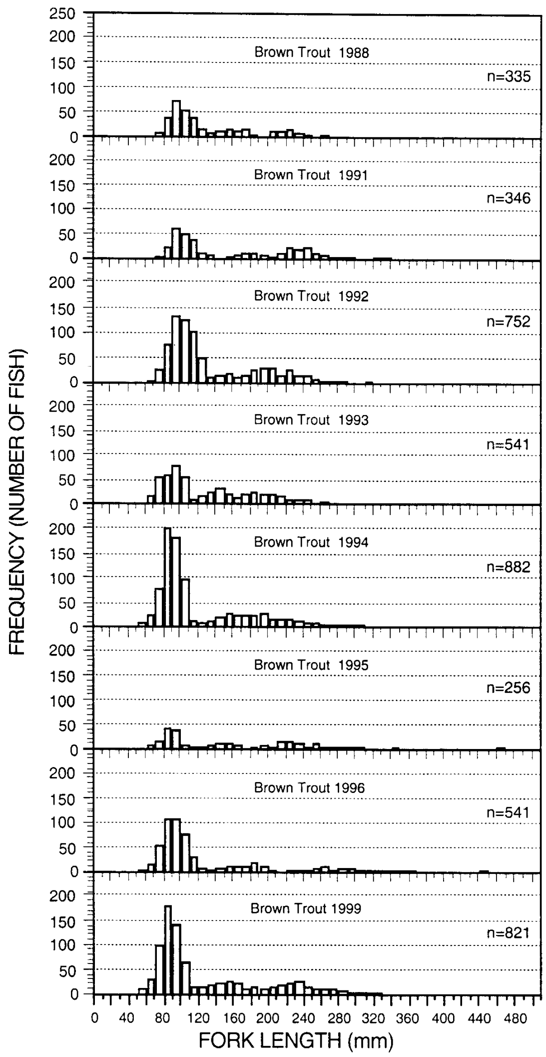

Figure 7. Length-frequency distributions of brown trout captured in Mammoth Creek during the censuses of 1988, 1991-1996 and 1999. Note that the 1988 samples covered one-third the distance of those in subsequent years, so comparable bars would be about 3 times as high.

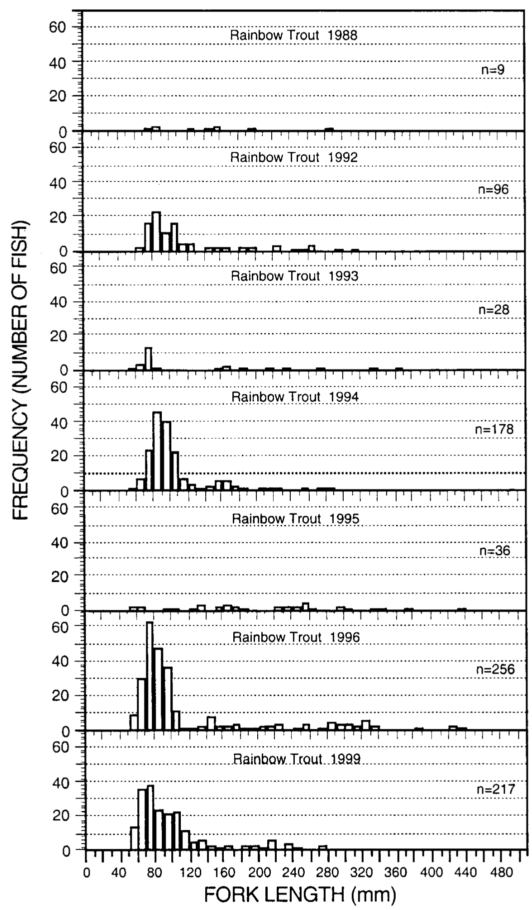

Figure 8. Length-frequency distributions of "wild" rainbow trout captured in Mammoth Creek during the censuses of 1988, 1992-1996, and 1999. Note that the vertical scale is different from Fig. 7.

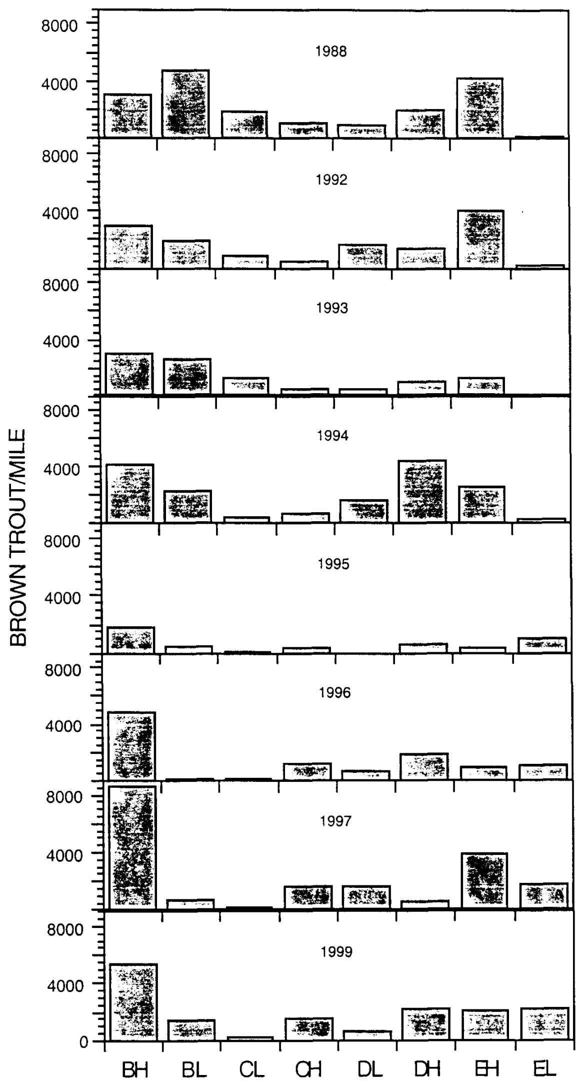

Figure 9 Population density (fish/mile) of brown trout at 8 sites on Mammoth Creek, as determined by census in the years 1988, 1992-1997, and 1999. EL was at a different location after 1994 than it was in previous years).

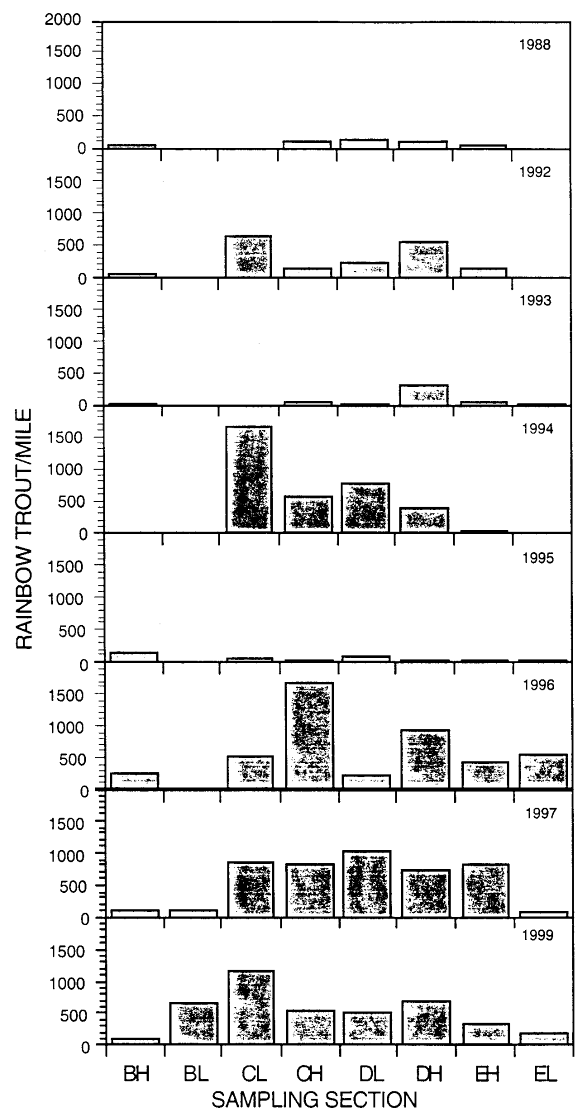

Figure 10. Population density (fish/mile) of presumed wild rainbow trout at 8 sites on Mammoth Creek, as determined by census in the years 1988, 1992-1997 and 1999.

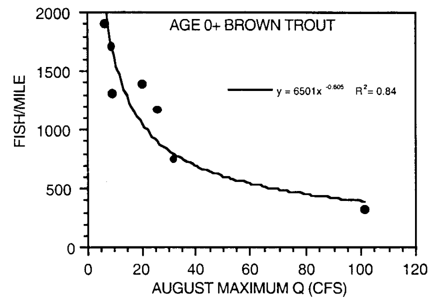

Figure 11. Average estimated density of underyearling (age 0+) brown trout in the upper 7 sampling sections relative to August maximum discharge, measured at the Old Mammoth Road gage. Years covered are 1988, 1992-1996, and 1999. All data from section EL were omitted because the 1995-96 and 1999 location was different from that used in earlier years.

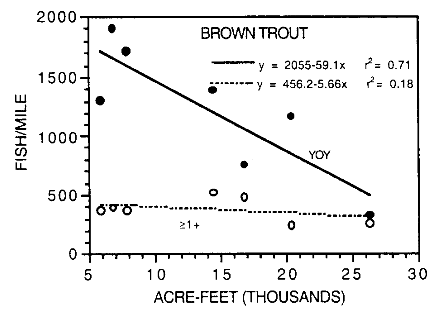

Fig. 12. Estimated average densities of 0+ and older (≥1+) brown trout in the Mammoth Creek study area, relative to total discharge (at Old Mammoth Road gage) from January through October, 1988, 1992-1996, and 1999.

CONCLUSIONS

By reasonable criteria, both the brown and rainbow trout populations of Mammoth Creek are in "good" condition. Reproduction of both species was within "normal" levels of variation for Mammoth Creek, and adequate numbers of trout are surviving to at least their third year (i.e., to reproductive maturity). In 1999, the average density of brown trout in Mammoth Creek ranked fourth highest out of 8 census years, at 79% of the highest density (in 1997). The average density of rainbow trout ranked third highest out of 8 years, at 90% of the highest observed density (in 1996).

Brown and rainbow trout populations of Mammoth Creek are undergoing natural variation in population density, almost certainly in synchrony with other snowmelt-dominated Eastern Sierra Nevada streams. If minimum flows are not decreased beyond what has occurred in census years (e.g., to the point of exposing spawning gravels), and if the stream is not physically altered, we expect that the future trajectory of Mammoth Creek trout populations will depend primarily on the negative relationship between high stream flows and survival of juvenile trout.

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Appendix A

Maximum-Likelihood
Catch Statistics

Stream: **MAMMOTH CREEK - SITE BH**
Species: Brown Trout

Removal Pattern: 145 66 46	
Total Catch	= 257
Population Estimate	= 303
Chi Square	= 2.084
Pop Est Standard Err	= 15.686
Lower Conf Interval	= 272.098
Upper Conf Interval	= 333.902
Capture Probability	= 0.465
Capt Prob Standard Err	= 0.045
Lower Conf Interval	= 0.376
Upper Conf Interval	= 0.553

Stream: **MAMMOTH CREEK - SITE BL**
Species: Brown Trout

Removal Pattern: 38 16 12	
Total Catch	= 66
Population Estimate	= 76
Chi Square	= 1.013
Pop Est Standard Err	= 6.968
Lower Conf Interval	= 66.000
Upper Conf Interval	= 89.880
Capture Probability	= 0.485
Capt Prob Standard Err	= 0.086
Lower Conf Interval	= 0.313
Upper Conf Interval	= 0.657

Stream: **MAMMOTH CREEK - SITE CH**
Species: Brown Trout

Removal Pattern: 59 19 3	
Total Catch	= 81
Population Estimate	= 82
Chi Square	= 1.038
Pop Est Standard Err	= 1.463
Lower Conf Interval	= 81.000
Upper Conf Interval	= 84.911
Capture Probability	= 0.743
Capt Prob Standard Err	= 0.052
Lower Conf Interval	= 0.640
Upper Conf Interval	= 0.846

Stream: **MAMMOTH CREEK - SITE CL**
Species: Brown Trout

Removal Pattern: 11 2 3 1	
Total Catch	= 17
Population Estimate	= 17
Chi Square	= 2.562
Pop Est Standard Err	= 0.815
Lower Conf Interval	= 17.000
Upper Conf Interval	= 18.728
Capture Probability	= 0.607
Capt Prob Standard Err	= 0.118
Lower Conf Interval	= 0.357
Upper Conf Interval	= 0.858

Stream: **MAMMOTH CREEK - SITE DH**
Species: Brown Trout

Removal Pattern: 74 26 16	
Total Catch	= 116
Population Estimate	= 125
Chi Square	= 1.460
Pop Est Standard Err	= 5.239
Lower Conf Interval	= 116.000
Upper Conf Interval	= 135.373
Capture Probability	= 0.577
Capt Prob Standard Err	= 0.057
Lower Conf Interval	= 0.464
Upper Conf Interval	= 0.690

Stream: **MAMMOTH CREEK - SITE DL**
Species: Brown Trout

Removal Pattern: 23 7 4	
Total Catch	= 34
Population Estimate	= 35
Chi Square	= 0.691
Pop Est Standard Err	= 1.744
Lower Conf Interval	= 34.000
Upper Conf Interval	= 38.543
Capture Probability	= 0.654
Capt Prob Standard Err	= 0.094
Lower Conf Interval	= 0.463
Upper Conf Interval	= 0.845

Stream: **MAMMOTH CREEK - SITE EH**
Species: Brown Trout

Removal Pattern: 88 27 7		
Total Catch	=	122
Population Estimate	=	124
Chi Square	=	0.208
Pop Est Standard Err	=	2.095
Lower Conf Interval	=	122.000
Upper Conf Interval	=	128.148
Capture Probability	=	0.722
Capt Prob Standard Err	=	0.044
Lower Conf Interval	=	0.635
Upper Conf Interval	=	0.809

Stream: **MAMMOTH CREEK - SITE EL**
Species: Brown Trout

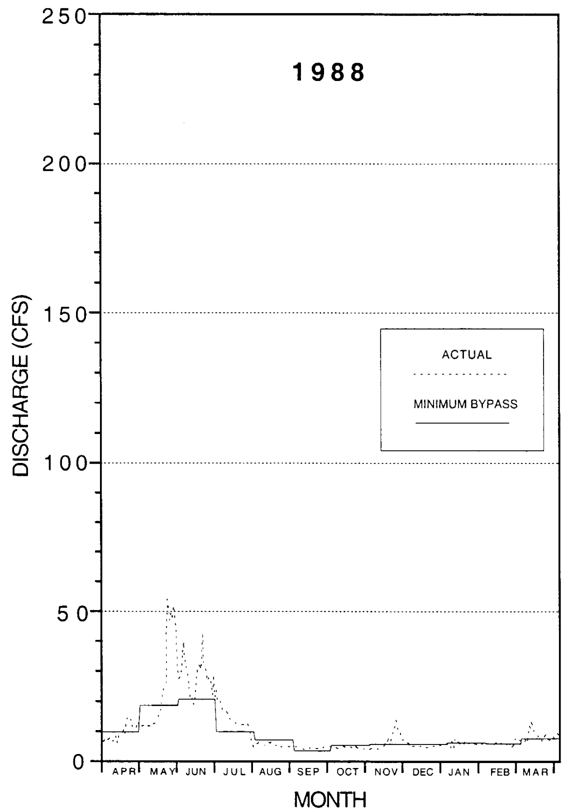
Removal Pattern: 75 32 11		
Total Catch	=	118
Population Estimate	=	125
Chi Square	=	0.231
Pop Est Standard Err	=	4.274
Lower Conf Interval	=	118.000
Upper Conf Interval	=	133.462
Capture Probability	=	0.611
Capt Prob Standard Err	=	0.054
Lower Conf Interval	=	0.505
Upper Conf Interval	=	0.718

The population estimate lower confidence intervals for seven of the sites were set equal to the total catches. Actual calculated lower CIs were as follows:

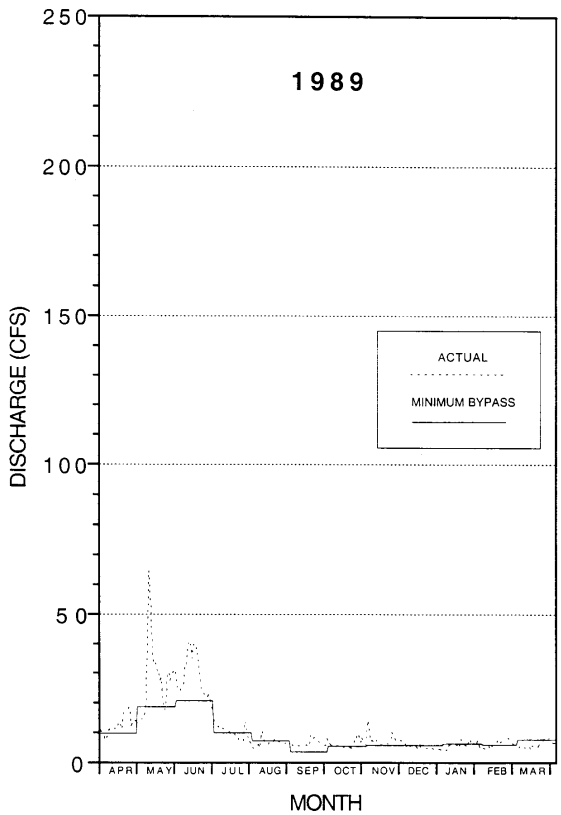
SITE	CALCULATED LCI
BL	62.120
CH	79.089
CL	15.2725
DH	114.628
DL	31.457
EH	119.852
EL	116.538

Appendix B

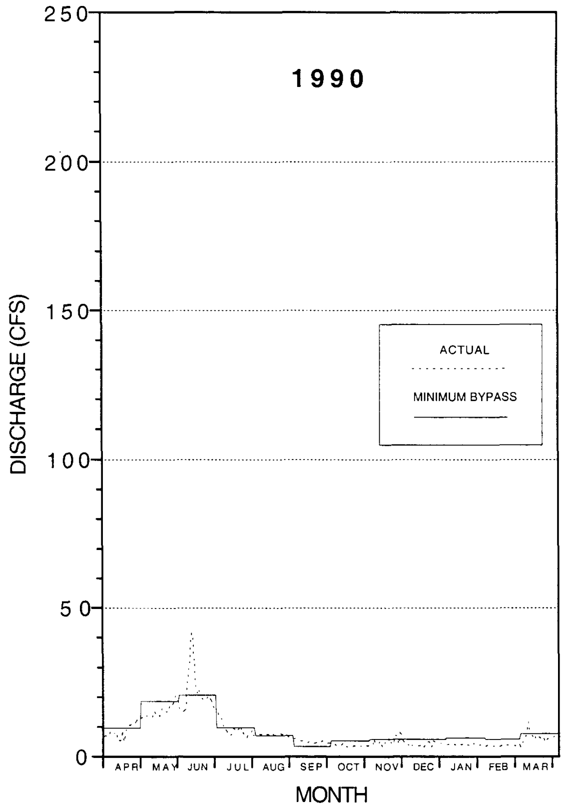
Mammoth Creek
Hydrographs
1988-1999



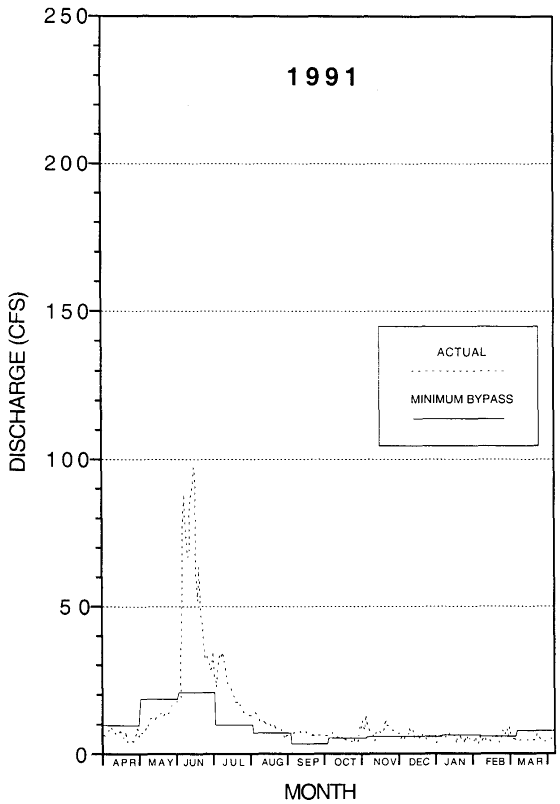
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1988, and the recommended operational minimum mean daily bypass flow regime.



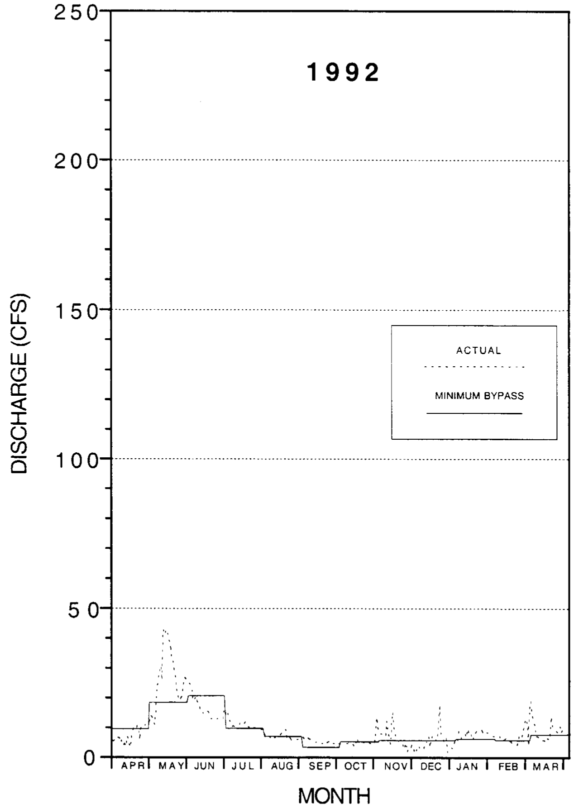
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1989, and the recommended operational minimum mean daily bypass flow regime.



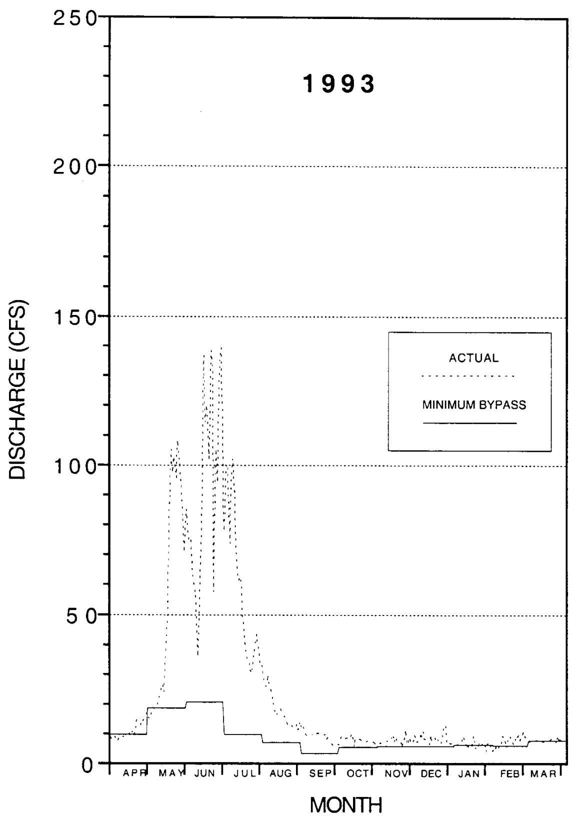
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1990 and the recommended operational minimum mean daily bypass flow regime.



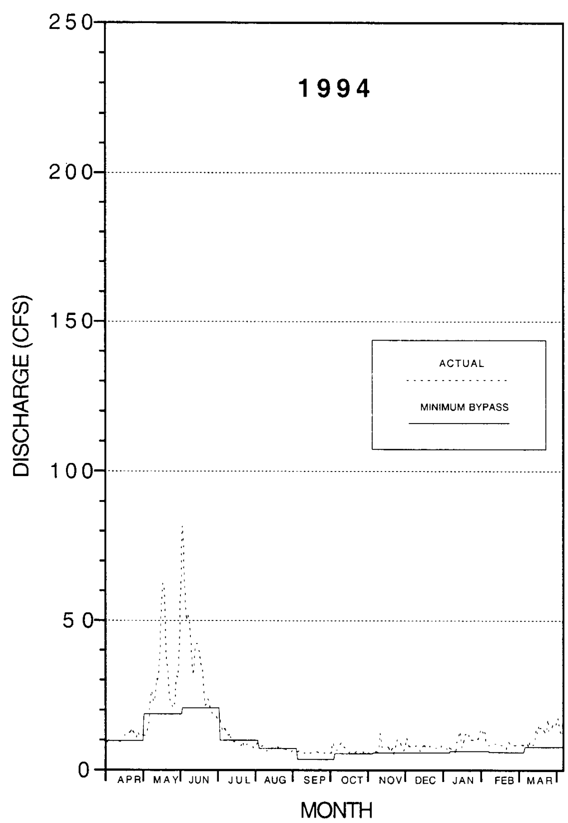
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1991, and the recommended operational minimum mean daily bypass flow regime.



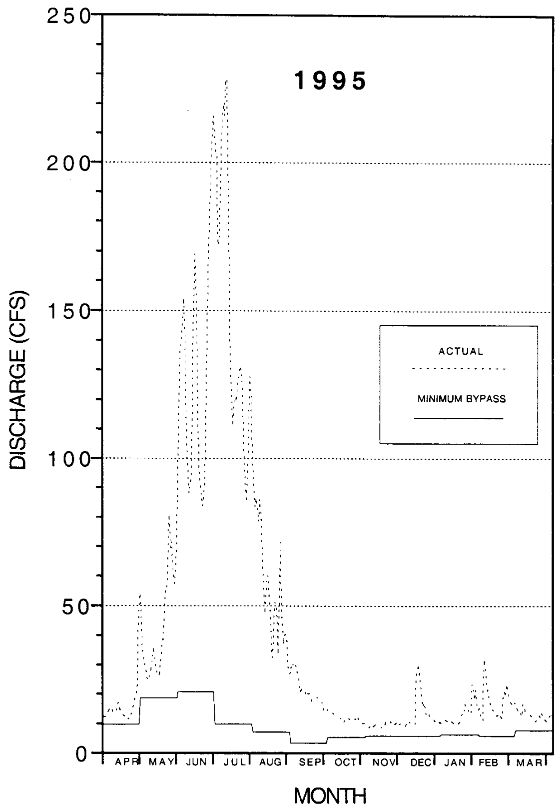
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1992 and the recommended operational minimum mean daily bypass flow regime.



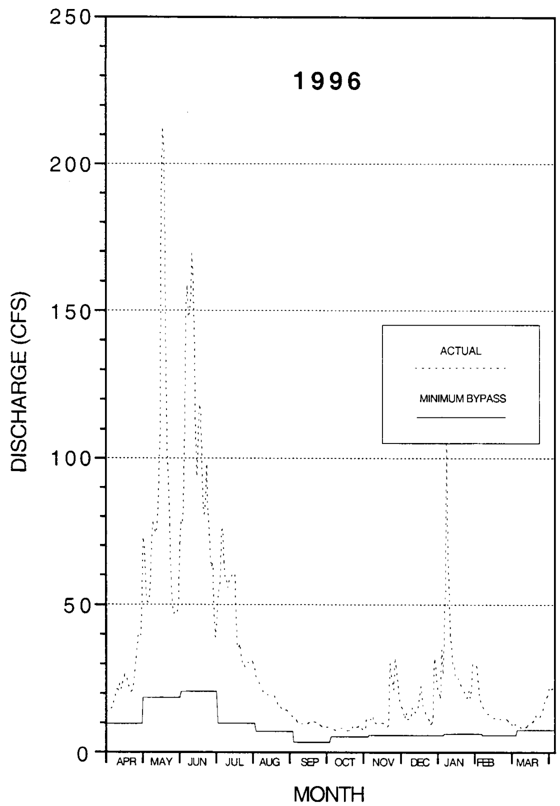
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1993, and the recommended operational minimum mean daily bypass flow regime.



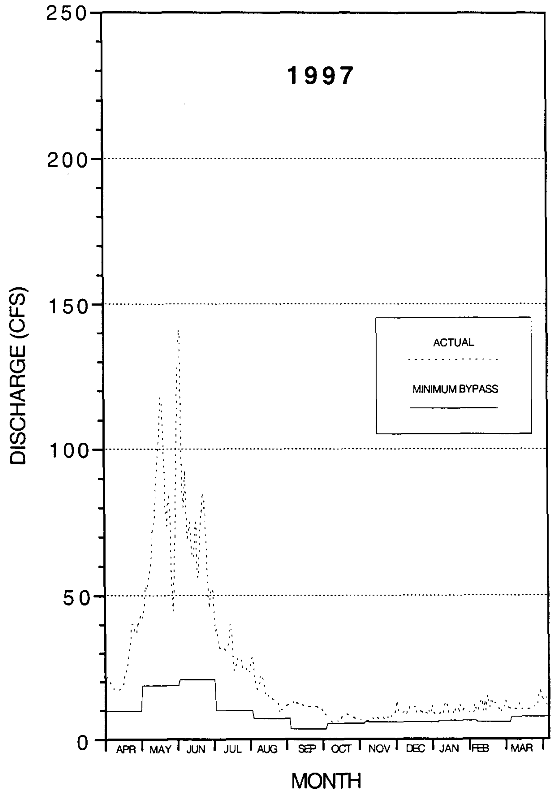
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1994, and the recommended operational minimum mean daily bypass flow regime.



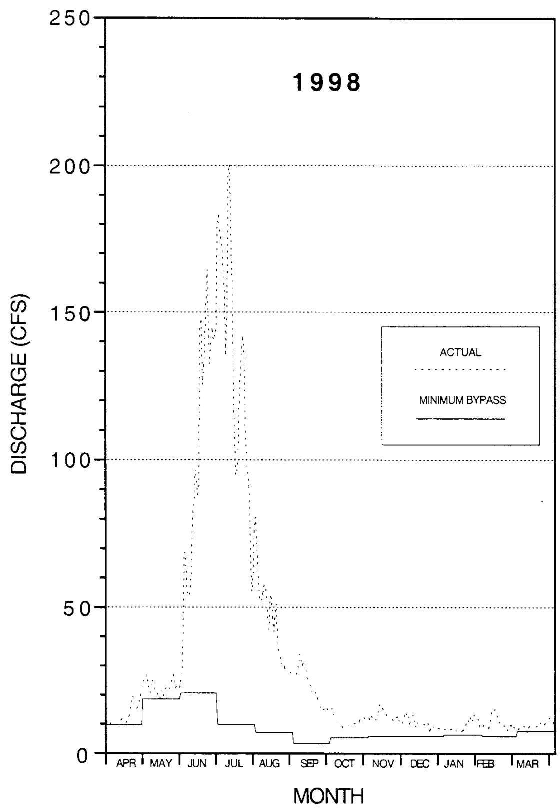
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1995, and the recommended operational minimum mean daily bypass flow regime.



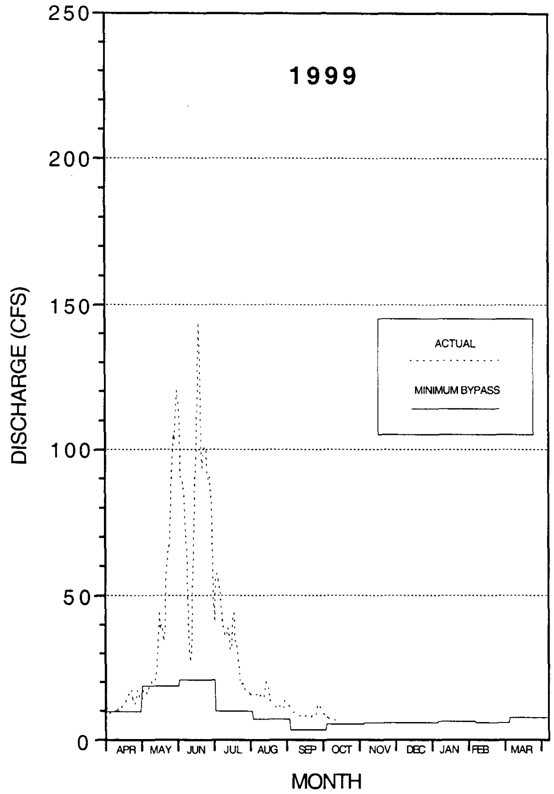
Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1996, and the recommended operational minimum mean daily bypass flow regime.



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1997, and the recommended operational minimum mean daily bypass flow regime.



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1998, and the recommended operational minimum mean daily bypass flow regime.



Mean daily flow (cfs) in Mammoth Creek (measured at the Old Mammoth Road Gage) during runoff year 1999, and the recommended operational minimum mean daily bypass flow regime.